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ORIGINAL ARTICLES

REVIEW ARTICLES

PATH-BREAKING CASES

THE IMAGES

STUDENTS' CORNER



Successful Resuscitation and Survival in a Preterm Infant Following Cardiorespiratory Arrest: The Case of 'Baby Max'

On 6th February 2026 at approximately 10:47 AM, an abandoned preterm male neonate (approximately 33 weeks' gestation), weighing 1.5 kg, was brought to Max Super Speciality Hospital by Sector 29 Police, Gurugram. The infant had reportedly been found inside a cement bag in a secluded area in DLF Phase IV, Gurugram.

On arrival, the umbilical cord and placenta were intact. The neonate was cold to touch with severe hypothermia, limp, and cyanosed, with no spontaneous respiration, no detectable cardiac activity, and unrecordable oxygen saturation, consistent with cardiorespiratory arrest.

Immediate assessment was initiated by Dr. Camelia Nongrum, Head of Emergency, and advanced neonatal resuscitation was commenced without delay in coordination with the neonatology team, including Dr. Sachin Jain, Senior Consultant, Neonatology. Resuscitative efforts were sustained for approximately 30 minutes as per established neonatal life support protocols, resulting in the return of spontaneous circulation (ROSC).

Following stabilisation, the neonate was intubated and placed on mechanical ventilation, and subsequently shifted to the Neonatal Intensive Care Unit (NICU) for ongoing intensive monitoring and management. The initial 48 hours remained critical, requiring continuous ventilatory and haemodynamic support. The infant was successfully extubated to non-invasive positive pressure ventilation (NIPPV) on Day 3 and transitioned to room air by Day 5, with stable respiratory parameters.

Nutritional support was initiated in a graded manner, progressing from enteral feeding to full feeds, and subsequently to paladai feeding. Throughout the NICU stay, close monitoring of neurological status, growth parameters, and metabolic stability was maintained. The neonate demonstrated gradual and sustained clinical improvement, with consistent weight gain and stabilisation of vital parameters. The baby was fondly named '**Baby Max**' by the treating staff.

In parallel, as per statutory protocol for abandoned infants, formal intimation was provided to the Child Welfare Committee (CWC) and the Chief Medical Officer (CMO), Gurugram, with regular updates shared during the course of hospitalisation.

By the time of discharge on 10th March 2026, the infant weighed 2.56 kg, was neurologically stable, active, and maintaining normal physiological parameters without respiratory support. Following medical clearance and in accordance with directives from the CWC and CMO, the infant was transferred to Civil Hospital, Gurugram in the presence of the local police and the investigating officer for further care and statutory procedures.

This case underscores the importance of rapid recognition and protocol-driven management of neonatal cardiorespiratory arrest, particularly in extreme presentations complicated by hypothermia and delayed presentation. The successful outcome reflects the coordinated, multidisciplinary efforts across emergency and neonatology teams, supported by structured critical care and adherence to clinical and statutory protocols.

Contents

Editorial 02–03

Original Articles 05–60

- 6 Impact of Body Mass Index and Tumour-Infiltrating Lymphocytes on Survival and Recurrence in Triple-Negative Breast Cancer among South Asian Women – **Devavrat Arya, Poorvee Mathur, Atul Thatai, Pragya, Ayuj Kaushik, Shivam Sharma**
- 14 Is the Negative Appendectomy Rate a Key Factor in the Diagnostic Accuracy of Various Scoring Systems? – **Vinod Kumar Nigam, Siddharth Nigam**
- 19 Understanding Self-Care in Type 2 Diabetes: Insights from the Diabetes Self-Management Questionnaire – **Andrea Fonseca, Sampada Tambe**
- 23 Surgical Minimalism in Neurosurgery: The “Keyhole” Concept – **Sumit Sinha**
- 37 Virtual Reality in Robotic Surgery: Training, Skill Transfer, and Preoperative Planning – A Narrative Review – **Shavez Ahmad**
- 42 A Paradigm Shift in Respiratory Syncytial Virus Prevention in Infants – **Ashu Sawhney**
- 47 Role of Interventional Radiology in Hepatocellular Carcinoma: Transarterial Chemoembolisation and Beyond – **Ishiqua Vinay Patil, Albert Paul Varghese, Ginesh Job M**
- 54 Arthrodesis or Arthroplasty: Where Do We Stand? - **H. N. Bajaj, Sunil Katoch, Sameer Anand**

Review Articles 61–88

- 62 Towards Universal Adult Immunisation: Review of the 2026 Global and Indian Schedules – **Aryan Arora, Monica Mahajan**
- 78 The Neurovascular Conflict Syndromes – Part I: A Review of Anatomy and Pathophysiology – **Harjinder S Bhatoe**

Case Studies 89–156

- 90 A Rare Case of Gastric Volvulus with Paraoesophageal Hernia – **Vikas Panwar, Vedant Rai, Rittik Chakravorty**
- 94 Scrub Typhus Causing Encephalitis, Myositis, and Polyneuropathy: A Case Report – **Nitin Dambhare, Nikhil Dongre, Pavan Kale**
- 98 Bifid Renal Pelvis in a Single Kidney: A Different Approach to Managing Renal Calculi in a Partially Duplex Collecting System – A Case Report – **Sanjay S. Nabar, Sachin V. Pahade, Vrushabh B. Petkar**
- 101 Safe Application of Robotic Colorectal Surgery in an Elderly High-Risk Patient: A Case Report – **Abhinav Deshpande, Kawadu Jawade, Kapilnath, Nimish Ganvir**
- 105 Iron Infusion-Induced Kounis Syndrome Presenting as Inferior ST-Segment Elevation Myocardial Infarction with Normal Coronaries: A Case Report – **Shashi Bhushan, Pallavi Sehgal, Dheeraj Bhaskaran Nair**
- 108 Delayed Presentation of Post-Traumatic Hepatic Artery Pseudoaneurysm Following Blunt Abdominal Injury – **Nishit Mashru, Aaditya Yadav, Chintala Sai Venkata Chiranjeevi, Dheeraj Bhaskaran Nair**
- 112 The Rash That Followed the Remedy: Phenytoin-Induced Drug Reaction with Eosinophilia and Systemic Symptoms Syndrome – **Nitin Wadaskar, Sumit Hajare, Nikhil Dongre, Vivek Rathore**
- 116 Bilateral Vertical Sacral Fracture, a Highly Unstable Pelvic Injury in a Case of Accidental Fall from Height – **Krittika Bhatia, Niranjani V, Paresh Bang, Manoj Pahukar**

- 121 Peroral Endoscopic Myotomy Followed by Antireflux Mucosectomy for Gastroesophageal Reflux in Identical Twins with Allgrove Syndrome – **Gaurav Patil, Ankit Dalal, Amol Vadgaokar**
- 124 Severe Acute-on-Chronic Hypercapnic Respiratory Failure in Long-Standing Bronchiectasis: A Case Report – **Azhar Khan, Sanjay Kriplani, Manoj Pethe**
- 127 Integrating Chrono-Nutrition with Oral Semaglutide Therapy in the Management of Extreme Obesity: A Case Report – **Purva Singh, Swati Waghdhare, Chahat Arora, Vinita Jha**
- 131 An Unusual Spontaneous Porto-Systemic Shunt Between the Left Portal Vein and Pericardial Venous System in Decompensated Chronic Liver Disease: Radiological and Intraoperative Correlation – **Soumyadip Sain, Karisangal Ramaswamy Vasudevan, Piyush Kumar Sinha, Rohit Saini, Manmohan Singh Rajput, Saurabh Kumar**
- 135 Management of Conversion of Atrioventricular Block to Complete Heart Block During One-Lung Ventilation in Thoracic Surgery: A Case Report – **Priya Singla, Abhilasha Mishra, Sachidanand Jee Bharti**
- 139 Uncommon Presentation of Cervical Abscess Causing Melioidosis due to *Burkholderia pseudomallei* Infection in a Patient with Uncontrolled Diabetes Mellitus: A Case Report – **Nitin Rathod, Andrea Janice Fonseca, Snehal Sadanandan, Priyal Shah**
- 143 Reconstruction of Synchronous Bilateral Buccal Mucosa Defects with a Single Free Anterolateral Thigh Flap with Intraoral Anastomosis – **Bharat Saxena, Raj Lakshmi Pandey, Devendra Chaukar**
- 147 A Case Report of Metallosis-Related Aseptic Loosening of a Primary Total Knee Arthroplasty Implant Managed with Revision Total Knee Arthroplasty – **Debasish Sarkar, Pradeep Bhosale**
- 151 Elastofibroma Dorsi in a Patient with Right Breast Carcinoma: A Potential Diagnostic Pitfall – **Manish Chetwani, Zainul Abedeen, Niraj Kanchankar**
- 154 Total Skin Electron Therapy : Basic Technical Aspects for Radiation Therapists – **Priyanka Kumari, Manish Mangal, Anusheel Munshi, Akash Goyal**

The Images 157–164

- 158 Beyond Direct Leak Visualisation: Magnetic Resonance Imaging as a Surrogate Marker in Spontaneous Cerebrospinal Fluid Rhinorrhoea – **Mohit Tamakuwala, Mitusha Verma, Deepak Patkar**
- 161 Beyond Adenoma: Imaging Clues to Pituitary Involvement in Systemic Sarcoidosis – **Mohit Tamakuwala, Mitusha Verma, Deepak Patkar**

Students' Corner 165–172

- 166 Clinical Signs – The Forgotten Art! (Part II) – **Narinder Pal Singh**

MIME Announcements 173–176

Office of Research 177

Scope of the Journal 184

Author Guidelines 185

THIRTY-ONE



“

Act now:

You, Me, Community

”

— World Health Organization (WHO),
Fight against Rabies

One of those rare evenings when the air quality in Delhi was bearable, I decided to step out for a stroll. The next thing I knew was that I was attacked by a Great Dane and my leg was bleeding profusely. Mercifully, the femoral artery had escaped injury by a few centimetres. What left me aghast was that the dog owner got her dog to step in to her car and drove away. No apology offered, no assistance provided. While I was limping back home, the only questions ravaging my mind were as to how many patients have survived rabies and how many have ended up getting Guillain-Barré syndrome (GBS) as a side effect of the vaccine?

So here is some of the World Health Organization (WHO) data. Rabies is a ‘Neglected Tropical Disease’ (NTD) with cases all across the globe except in Antarctica. Though the numbers are grossly under-reported, an estimated 59,000 victims die of rabies annually, one-third of these being Indians. 99% of rabies is caused by dog bites whereas other mammals like cats, raccoons, coyotes and bats contribute to the rest of the pool. Nearly 40% of patients who die are children. This is a disease with 100% case fatality. Yet, there are ‘thirty-one’ miraculous survivors of rabies over the years, of whom 17 are from India. This is also because we have the highest number of cases of rabies in the world in our country. The two names that stand out are those of Jeanna Giese-Frassetto and Sai Kiran, as they are the only ones that made a meaningful recovery.

It is ironical that we have billions of dollars of research that goes into developing potent antivirals against Human Immunodeficiency Virus (HIV), Hepatitis B and Hepatitis C, but very little

breakthrough has been achieved in fighting rabies. As far as the treatment goes, once the symptoms develop, there is zero probability of surviving. Doctors experimented with the ‘Milwaukee protocol’ in 2004 and put Jeanna Giese into a medically induced coma with ketamine and used antiviral drugs like ribavirin and amantadine. They were inspired by an idea suggested by Dr. GR Gode, an anaesthetist at All India Institute of Medical Sciences (AIIMS), Delhi, who suggested that anaesthesia would cut out the exaggerated autonomic nervous system inputs that cause fatality. Later on, the team at the University of Wisconsin used this concept in Jeanna’s case. She had been bitten by a bat she was trying to save. She had not been vaccinated as she never realised how lethal that bite could be. She survived, is happily married and is now a proud mother of twins. The Milwaukee protocol is, however, considered controversial and failed in studies conducted recently at Sawai Man Singh (SMS) Medical College, Jaipur.

17-year-old Sai Kiran from Telangana was bitten by a rabid dog while walking home from school in 2018. He received two doses of the vaccine before the local government hospital ran out of stock, and the vaccination series was left incomplete. His father, being a vegetable vendor, could not afford to take him to another town for vaccines. A few days later, he developed aerophobia and hydrophobia and then slipped into a coma. After three years of ventilatory support, rehabilitation and physiotherapy, he is now one of the rare global survivors and back to studying in high school. Perhaps the two doses of the vaccine did contribute to saving his life. Most other survivors are less fortunate and have remained in a

vegetative state or lived with severe neurological deficits. The cost of prolonged hospitalisation results in bankruptcy. Others are just left to die without any dignity.

The challenge is in diagnosing the disease before it is too late. The incubation period for rabies ranges from 6 days to 6 years. The furious form of rabies, which causes hyperactivity, hydrophobia, aerophobia and hallucinations, may be diagnosed more often, whereas the dumb form with paralysis and coma may be misdiagnosed frequently. There may be inadvertent exposure to hospital staff. There is no documented case of human-to-human transmission through a bite. Post-transplant rabies is an extremely rare entity. In 2025, the Centers for Disease Control and Prevention (CDC) reported a case of a kidney transplant recipient in Ohio who died of rabies after 51 days of transplant. The deceased donor had undiagnosed rabies from a scratch from a skunk. The three individuals who received corneal tissue grafts from the same donor were tested. As a precautionary measure, the corneas were removed, post-exposure prophylaxis (PEP) was administered, and all three individuals survived. Risk assessment was done for possible exposure to 357 possible contacts, and PEP was provided to 46 of them. Rabies ribonucleic acid (RNA) was detected in one corneal graft.

Once the bullet-shaped virus reaches the central nervous system, it is a death sentence for the victim. There is no cure, only a very effective vaccine for prevention. The only hope lies in PEP. Louis Pasteur was experimenting with a vaccine in dogs and rabbits. He used an untested rabies vaccine way back in 1885, and Joseph Meister became the first person to be saved by administering the vaccine. 12 doses of the rabies vaccine were given to him every day for ten days. He survived despite 14 bites from a rabid dog and history was created. People travelled long distances to get the vaccine at the Institut Pasteur. Yet, most cases nowadays occur purely due to a lack of awareness or a lack of availability of the vaccine. The monoclonal antibodies are much safer and have replaced the rabies immunoglobulin. Gene therapy for rabies remains experimental. The disease is fully preventable with proper toileting of the wound and timely vaccination.

This severe zoonotic disease is prevalent in over 150 countries. The WHO has aimed at ending human deaths from rabies by 2030 by the 'One Health Approach'. This encompasses mass vaccination of stray dogs, easy access to vaccines, creating awareness, surveillance and training health care providers. We are amongst the countries with the largest population of free-roaming dogs (FRD), semi-owned and owned dogs. There is inadequate knowledge of vaccination amongst owners.

Non-pedigreed mongrels are often adopted and allowed to roam freely. There is no adoption policy for history sharing and vaccination of adopted dogs. Leash laws need to be enforced. The veterinary department and the rapid response team may not be notified if a rabid animal dies, and post-mortem rabies testing of the animal's brain is not conducted in a number of instances. Bite wounds are sutured, whereas they are meant to be left as such. The low vaccination coverage amongst dogs makes rabies endemic in India, especially in the north-eastern states. Dog bites also spread rabies in the livestock. The cold chain for vaccines is poorly maintained during transportation. Young children have died in Maharashtra and Kerala recently despite completing rabies vaccination, raising concerns about the potency, cold chain and genuineness of the vaccines. The older neural rabies vaccines were associated with GBS, but the newer chick embryo cell-derived vaccines do not increase the risk of this post-vaccination complication. Increased vigilance for this immune-mediated acute neuropathy due to the vaccine is required.

Survival from the disease, albeit with neurological sequelae, is extremely rare, but it is a 100% vaccine-preventable disease. One of the tenets of medicine has been that a rabies patient dies within a few days of the disease onset; if he survives, he does not have rabies.

There is a need for better coordination and cooperation between the various stakeholders. The One Health Approach has been successfully adopted and has eradicated rabies from the United Kingdom, Japan, Ireland and Australia. Goa has adopted a mass vaccination policy and is recognised as the first rabies-controlled state in India. Rabies Day is celebrated on 28th September each year. The theme in 2025 was 'Act now: You, Me, Community'. I hope it does not remain a mere slogan but becomes a ground reality.

I am a proud dog parent, but I learned my lesson the hard way. After completing my vaccination schedule for a category 3 bite, I have realised that it is much safer to work out indoors. It saves my lungs and saves my life.

Dr. Monica Mahajan

Editor-in-chief,
The Max Medical Journal

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ORIGINAL ARTICLES

6 Impact of Body Mass Index and Tumour-Infiltrating Lymphocytes on Survival and Recurrence in Triple-Negative Breast Cancer among South Asian Women – **Devavrat Arya, Poorvee Mathur, Atul Thatai, Pragya, Ayuj Kaushik, Shivam Sharma**

14 Is the Negative Appendicectomy Rate a Key Factor in the Diagnostic Accuracy of Various Scoring Systems? – **Vinod Kumar Nigam, Siddharth Nigam**

19 Understanding Self-Care in Type 2 Diabetes: Insights from the Diabetes Self-Management Questionnaire – **Andrea Fonseca, Sampada Tambe**

23 Surgical Minimalism in Neurosurgery: The “Keyhole” Concept – **Sumit Sinha**

37 Virtual Reality in Robotic Surgery: Training, Skill Transfer, and Preoperative Planning — A Narrative Review – **Shavez Ahmad**

42 A Paradigm Shift in Respiratory Syncytial Virus Prevention in Infants – **Ashu Sawhney**

47 Role of Interventional Radiology in Hepatocellular Carcinoma: Transarterial Chemoembolisation and Beyond – **Alshiqua Vinay Patil, Albert Paul Varghese, Ginesh Job M**

54 Arthrodesis or Arthroplasty: Where Do We Stand? – **H. N. Bajaj, Sunil Katoch, Sameer Anand**

Impact of Body Mass Index and Tumour-Infiltrating Lymphocytes on Survival and Recurrence in Triple-Negative Breast Cancer among South Asian Women

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Abstract:

Breast cancer remains the leading cause of cancer-related mortality worldwide, with a rising burden in India, where it often presents at a younger age and at more advanced stages. Triple-negative breast cancer (TNBC), lacking targeted therapeutic options, places greater emphasis on host immune factors such as stromal tumour-infiltrating lymphocytes (sTILs) for prognostication. Elevated sTIL levels have been linked to improved overall survival (OS) and higher rates of pathological complete response (pCR) following neoadjuvant chemotherapy. Obesity, a modifiable risk factor, may influence tumour biology through hormonal, metabolic, and inflammatory mechanisms, potentially impairing anti-tumour immune responses. However, the interplay between body mass index (BMI) and sTILs in determining TNBC outcomes among South Asian women remains underexplored. This retrospective study evaluated 100 South Asian women diagnosed with TNBC between January 2017 and December 2021 at a tertiary cancer centre. Eligible patients had confirmed TNBC, documented BMI at diagnosis, available tumour-infiltrating lymphocyte assessment, and follow-up data. Clinical, demographic, tumour-related treatment, and outcome variables were extracted from electronic health records and cross-verified. Survival outcomes, including disease-free survival (DFS) and OS, were analysed using Kaplan-Meier method, while Cox proportional hazards models were applied to estimate the impact of variables on recurrence and mortality. The analysis demonstrated that BMI at diagnosis did not independently affect survival outcomes, with comparable survival observed across weight categories. In contrast, higher sTIL levels were significantly associated with improved survival and reduced recurrence risk. However, the beneficial prognostic effect of high sTILs appeared attenuated in patients with higher BMI. Notably, increased body weight did not correlate with reduced immune cell infiltration within tumours but may impair the functional effectiveness of these immune cells in controlling disease progression. In conclusion, while BMI alone is not a predictor of survival in TNBC, obesity-related metabolic alterations may weaken the prognostic advantage conferred by tumour-infiltrating lymphocytes. These findings suggest that immune functionality, rather than mere presence, is compromised in obese patients. Tumour immune status remains a key determinant of outcomes, but its impact is modified by host metabolic factors. Integrating weight management strategies alongside standard treatments may help preserve immune-mediated tumour control and improve clinical outcomes.

Key words: Triple-Negative Breast Cancer, Disease-Free Survival, Overall Survival, Body Mass Index, Tumour-Infiltrating Lymphocytes.

Introduction

The leading cause of cancer-related mortality for women globally is breast cancer. It accounts for more than 25% of all cancer cases in women.¹ In recent years, breast cancer has become more widespread in India, surpassing cervical cancer as the most prevalent malignancy in urban areas. In India, breast cancer develops at an earlier age before menopause compared to Western countries, and most patients present with advanced local or distant disease. Breast cancer testing usually includes three biomarkers, which are oestrogen receptor (ER), progesterone receptor (PR), and human epidermal growth factor receptor (HER2), because these biomarkers serve as essential prognostic indicators and determine treatment paths. About 75% of breast cancer patients show ER presence in their tumours. The oestrogen-regulated gene PR shows expression in almost 50% of tumours that test positive for ER.²

Unlike hormone receptor (HR)-positive disease, triple-negative breast cancer (TNBC) lacks targeted therapies, making prognosis heavily dependent on host immune factors such as stromal tumour infiltrating lymphocytes (sTIL). In an Indian cohort, a high sTIL ($\geq 30\%$) corresponded with dense immune infiltrates, Th1-dominant gene signatures, smaller tumours, and superior overall survival (OS), defining an “Immunotype-1” that parallels findings in Western TNBC. Moreover, the distribution of these immunotypes in Indian patients mirrors the Cancer Genome Atlas (TCGA) and Molecular Taxonomy of Breast Cancer International Consortium (METABRIC) cohorts, underscoring a shared immune landscape across ethnicities.³

The recent study confirmed that sTIL has prognostic value in patients who have untreated early-stage TNBC. Higher levels of sTIL also predict pathological complete response (pCR) to neoadjuvant chemotherapy in patients from all molecular subtypes (TNBC, HER2-positive, and ER-positive/HER2-negative), but only longer survival in TNBC and HER2-positive breast cancer, according to a large, pooled analysis. The World Health Organization (WHO) now includes sTIL in its breast cancer classification system because research shows consistent results for sTIL in TNBC, and the St. Gallen International Consensus Guidelines 2019 for TNBC have recommended testing sTIL.⁴

Obesity is a potentially modifiable risk factor that can influence breast cancer biology through hormonal, metabolic and inflammatory pathways. Excess adipose tissue elevates leptin and insulin-like growth factor-1, and promotes chronic low grade inflammation. Changes in the gut microbiome may impair cytotoxic T-cell function, thereby attenuating anti-tumour immunity. Understanding how elevated body mass index (BMI) interacts with sTIL density could clarify why some obese TNBC patients experience poorer disease-free survival (DFS) and guide personalised therapeutic

strategies, including the selection of immunotherapy based regimens.^{5,6}

Despite these insights, no retrospective Indian study has examined whether BMI modifies the prognostic advantage conferred by high sTIL. Western series report inconsistent associations between BMI and TNBC outcomes, and East Asian work suggests adverse effects of overweight status on DFS, the combined impact of adiposity and tumour immunity remains uncharacterised in South Asian women.

Obesity at the time of cancer diagnosis or before diagnosis predicts bad outcomes for all types of breast cancer, according to research findings.^{7,8} The connection between weight changes and prognosis outcomes becomes especially important for TNBC because there are limited treatment options and unknown prognostic factors. Weight control provides an opportunity to improve survival rates through this clarification process. Existing literature either isolates BMI or sTIL as prognostic markers, and no retrospective Indian cohort has evaluated their combined effect on survival and recurrence.

By extracting BMI, quantitative sTIL, and clinical outcomes from Indian TNBC patients treated with standard therapy, the study will determine whether obesity modifies the prognostic benefit of high sTIL. This will refine risk stratification, identify patients who may require intensified or immunotherapy-based approaches, and address the critical evidence void for South Asian TNBC management.

Objectives

Primary objective

To determine the prognostic significance of BMI at the time of diagnosis and features of the tumour immune-microenvironment, including the extent of tumour-infiltrating lymphocytes (TILs), in relation to recurrence-free survival and OS among South Asian women with TNBC.

Secondary objective

- To assess the association between BMI at diagnosis and key immunologic components of the tumour microenvironment, including TIL density and available immune biomarkers such as cluster of differentiation 8-positive (CD8⁺), cluster of differentiation 20-positive (CD20⁺), and forkhead box P3-positive (FOXP3⁺) cell populations.
- To evaluate the relationship between tumour immune microenvironment characteristics and survival outcomes across BMI.
- To examine potential effect modification by BMI on the association between tumour immune features and clinical outcomes in TNBC.

- To provide hypothesis-generating insights into the interaction between metabolic status, as reflected by BMI, and tumour immune contexture in TNBC, to inform future prospective and translational research.

Materials and Methods

Study design and setting

This retrospective study was performed at the Max Super Speciality Hospital, New Delhi. Women who were diagnosed with TNBC between January 2017 and December 2021 were included.

Study population

Participants were female patients treated at the institute during the study period with histopathologically confirmed TNBC. TNBC was defined according to the American Society of Clinical Oncology (ASCO) criteria as ER and PR expression < 1%, with no HER2/neu overexpression by fluorescence in situ hybridisation (FISH) analysis.

Inclusion required tumour pathology reports that included TIL assessment, BMI measured at or close to the time of diagnosis, and related follow-up and outcome data. Patients with non-TNBC molecular subtypes or those lacking critical clinical or follow-up data were excluded.

Methodology

Data was retrieved from electronic health records using the standard data collection framework. Clinical, laboratory, and pathology records were cross-validated to ensure the data were accurate and complete.

Variables collected

Among the demographic factors were comorbidities, age, and menopausal status. Anthropometric parameters included blood pressure and BMI at diagnosis (classified using standard or South Asian-specific cut-offs). Tumour grade, stage (as per the American Joint Committee on Cancer [AJCC] guidelines), TILs, and immunological markers (CD8⁺, CD20⁺, and FOXP3⁺) were among the pathological and tumour characteristics. The kind of surgery, chemotherapy schedules, and reaction to neoadjuvant therapy were all considered treatment-related variables. Recurrence, disease progression, mortality, and last follow-up status were among the outcome measures.

Definition of TIL categories

STILs were evaluated as percentages. A high TIL group was defined as > 15%, consistent with the median TIL distribution in large TNBC cohorts (e.g., Leon-Ferre *et al.*⁷ reported a median of ~15% in a pooled TNBC cohort).⁷

Statistical analysis

The initial analysis comprised the demographic and clinical characteristics of the patients, including age, BMI, blood pressure, tumour grade, stage, and comorbidities. Quantitative variables (age, BMI, and blood pressure) were summarised using mean and standard deviation, while qualitative variables (comorbidities, grade, and stage) were presented as counts and percentages. The primary analysis evaluated DFS and OS using the Kaplan-Meier (KM) method to assess survival patterns and estimate median survival time.

Hazard ratios (HR) for recurrence and death were analysed for factors including age, comorbidities, BMI, and type of surgery using Cox proportional hazards regression models. Separate models were constructed for DFS and OS. Statistical significance of factors associated with survival outcomes was assessed at a 5% level of significance. All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) version 26.

Results

1. Baseline demographic and clinical characteristics

We analysed data from 100 South Asian women diagnosed with TNBC. The mean age at diagnosis was 53 years, with a range of 31 to 81 years. Most patients presented with high-grade tumours: 89% had Grade 3 tumours, while 11% had Grade 2 tumours. The most common stage at presentation was Stage IIA, accounting for 47% of cases, followed by Stage IIB (25%) and Stage IIIC (13%) (Table 1).

Variable	Metric/Category	Value (n = 100)
Age	Mean ± SD	53.0 ± 12.8 years
BMI	Mean ± SD	27.7 ± 5.6 kg/m ²
BMI category	Obese	57% (Majority)
	Normal weight	13%
	Overweight	9%
	Underweight	3%
	(Missing Data)	(17%)
Tumour grade	Grade 3 (High grade)	89%
	Grade 2	11%
Stage	Stage IIA	47%
	Stage IIB	25%
	Stage IIIC	13%
Comorbidities	Hypertension	19%

Table 1: Baseline demographic and clinical characteristics of the study population (n = 100), with continuous variables expressed as mean ± SD and categorical variables as percentages; BMI is reported in kg/m² and missing data are indicated where applicable.

Abbreviations: BMI: Body Mass Index; SD: Standard Deviation.

Metabolic and comorbidity profile

The mean BMI of the cohort was 27.7 ± 5.6 kg/m². Among patients with available BMI data, obesity was highly prevalent, with approximately 57% classified as obese, followed by normal weight (13%), overweight (9%), and underweight (3%). BMI data were missing for 17% of patients.

Hypertension was the most common comorbidity, present in 19% of patients at diagnosis.

2. Survival outcomes

At the end of follow-up, median OS and median DFS were not reached, indicating that more than half of the cohort remained alive and recurrence-free. A total of 23 deaths and 22 recurrence events were recorded during follow-up.

The dataset demonstrated biologically plausible survival durations, validating all subsequent survival analyses.

3. Primary survival analysis

Predictors of overall survival

Cox proportional hazards regression identified TILs as the only statistically significant independent predictor of OS.

Each 1% increase in TILs reduced the risk of death by approximately 4%–6%, confirming the prognostic importance of the tumour immune microenvironment (Table 2).

Variable	HR	95% CI	P-value	Interpretation
Age	0.99	0.96–1.03	0.78	Not significant
BMI	0.98	0.90–1.06	0.63	Not significant
TILs (%)	0.96	0.91–1.00	0.035	Protective

Table 2: Cox regression analysis.

Abbreviations: BMI: Body Mass Index; CI: Confidence Interval; HR: Hazard Ratios; TILs: Tumour-Infiltrating Lymphocytes.

4. Impact of BMI on survival

BMI at diagnosis was not an independent predictor of survival.

- Univariate Cox analysis showed no association between BMI and OS (HR = 0.98, $p = 0.63$).
- KM survival curves comparing obese and non-obese patients demonstrated significant overlap, with no difference in OS or DFS.
- These findings remained consistent after correction of survival data.

5. Impact of tumour-infiltrating lymphocytes:

TILs emerged as a strong prognostic factor. Higher TIL levels were significantly associated with improved OS ($p = 0.035$) (Figure 1) as well as improved DFS ($p = 0.019$) (Figure 2). Patients with high TILs (> 15%) showed a consistent trend toward superior survival compared to those with low TILs.

This confirms the protective role of anti-tumour immunity in TNBC.

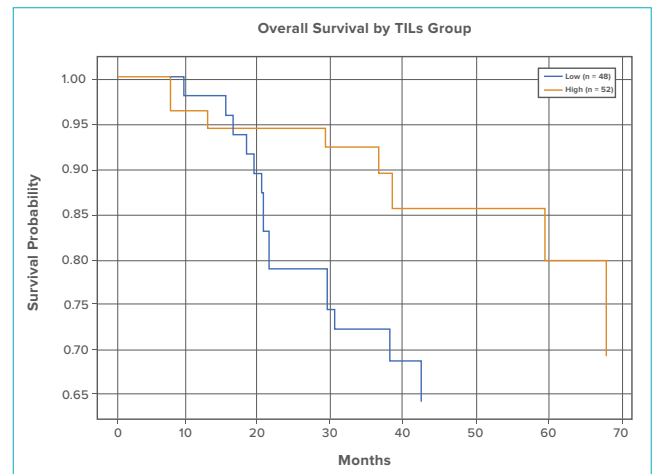


Figure 1: Overall survival by tumour-infiltrating lymphocytes (TILs) group.

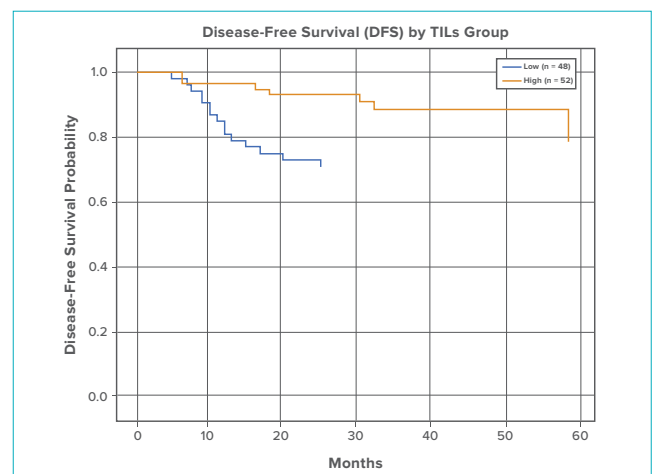


Figure 2: Disease-free survival by tumour-infiltrating lymphocytes (TILs) group.

6. Secondary analysis - Immune–metabolic interplay

Effect of BMI on immune cell quantity

There was no evidence that obesity influenced immune cell recruitment to the tumour.

- No significant correlation between BMI and:
 - o TIL percentage
 - o CD8⁺, CD20⁺, or FOXP3⁺ cell counts
- No significant difference in mean TIL levels across BMI categories (Kruskal–Wallis; $p = 0.43$).

This shows that obesity does not reduce the quantity of immune infiltration.

BMI–TIL interaction effect

A multivariate Cox regression revealed a borderline significant interaction between BMI and TILs ($p = 0.056$).

The finding shows that:

- Main TIL effect: Strongly protective ($HR \approx 0.79$)
- Interaction term: Positive coefficient, indicating attenuation of benefit
- As BMI increases, the protective survival advantage conferred by high TILs diminishes

Biological implication

Although obese patients recruit immune cells to the tumour, obesity-associated metabolic dysregulation may impair immune effectiveness, reducing the survival benefit typically seen with high TILs.

7. Final integrated interpretation

In this cohort of South Asian women with TNBC:

- BMI at diagnosis does not independently predict OS or DFS
- TILs are a strong, independent protective prognostic factor
- Obesity does not affect immune cell quantity, but reduces immune efficacy
- The survival benefit of high TILs is attenuated in obese patients

Discussion

Our retrospective cohort of South Asian women with TNBC confirms that sTIL are a powerful independent prognostic factor (each 1% increase in TILs reduced the risk of death by $\approx 5\%$ (Table 2). Patients with high sTIL ($> 15\%$) experienced significantly longer OS ($p = 0.035$) and DFS ($p = 0.019$) compared with low TIL counterparts, mirroring large Western pooled analyses in which a

10% rise in sTIL improved DFS, distant-DFS (D-DFS) and OS ($HR \approx 0.22$), and high sTIL ($> 30\%$) yielded three year invasive disease-free survival (iDFS) $\approx 92\%$ and OS $\approx 99\%$.^{9,10}

Western neoadjuvant trials (e.g., KEYNOTE 522, IMpassion 130) have demonstrated that elevated sTIL predicts higher pCR rates and, when combined with programmed death-ligand 1 (PD-L1) positivity, translates into survival benefits.¹¹

In contrast, BMI did not emerge as an independent predictor of OS or DFS in our cohort ($HR \approx 0.98$, $p = 0.63$) (Figure 1), a finding consistent with several Western series where obesity failed to retain significance after multivariate adjustment. However, the interaction between BMI and sTIL observed in western datasets — where high sTIL markedly increased pCR and event free survival in lean patients but not in overweight/obese individuals (Odds ratio [OR] ≈ 4.24 , $HR \approx 0.22$) suggests that adiposity may blunt immune mediated tumour control.¹² Indian transcriptomic work identified three immune immunotypes, with Immunotype-1 (Th1-dominant, dense TIL) associated with smaller tumours, premenopausal status and better prognosis, a pattern that aligns with Western immunotype classifications.¹

Molecular profiling of Indian TNBCs identified three immune immunotypes. Immunotype-1 exhibited Th-1 dominant signatures, dense TILs, smaller tumours, and superior prognosis, paralleling the Th1-enriched, high-TIL subgroup reported in Western datasets. This cross population consistency suggests that intrinsic tumour immunity operates similarly across ethnicities, yet obesity related metabolic dysregulation may impair its efficacy. Elevated leptin, insulin-like growth factor-1 and chronic low grade inflammation in adipose tissue can suppress cytotoxic T-cell function and promote immunosuppressive macrophages, potentially explaining the observed interaction.¹³

We identified a borderline BMI $\times$ TIL interaction ($p = 0.056$), indicating that the survival advantage of high TILs diminishes as BMI rises. This pattern echoes Takada *et al.*, who observed that obesity attenuates the protective effect of TILs despite no reduction in immune-cell quantity. Our data therefore support the hypothesis that metabolic dysregulation in obesity impairs lymphocyte function rather than recruitment.¹⁴

Losurdo *et al.* also reported similar higher TILs in younger, lower BMI patients, but did not find a survival correlation, likely because most tumours were early stage. The discrepancy underscores that the prognostic impact of TILs becomes evident in more advanced or heterogeneous cohorts, such as ours. Together, these findings reinforce TILs as a robust biomarker for risk stratification, while highlighting BMI related modulation of immune efficacy that warrants further mechanistic investigation.¹⁵

In Western populations, similar null associations between BMI and survival have been reported. In a large US series, obesity was not retained as a prognostic variable after multivariate adjustment, and BMI showed no independent impact on OS or DFS. European data also indicate that BMI alone does not predict outcome in early stage TNBC, although higher BMI is often linked to poorer chemotherapy tolerance.⁴

Conversely, several western studies emphasise TILs as a strong, independent biomarker: each 10% increase in stromal TILs improves DFS, D-DFS and OS, and patients with sTIL > 30% achieve > 90% three year iDFS. The Italian cohort of 159 early stage TNBCs reported higher TIL levels in younger, lower BMI patients but did not observe a survival correlation, likely because most tumours were stage I–II.¹⁶

Thus, our findings align with Western evidence that BMI is not prognostic, yet they add nuance by demonstrating that obesity may impair the functional efficacy of TILs, a pattern also hinted at in the Japanese preoperative cohort, where obese patients had lower TIL density and poorer outcomes in TNBC.^{4,15} Together, the data suggest that while BMI is not an independent risk factor across ethnicities, its metabolic effects can modulate the immune microenvironment and attenuate the survival advantage conferred by robust TIL infiltration.

Our South Asian series reinforces several themes emerging from Western cohorts while adding ethnic nuance. BMI alone failed to predict OS or DFS (HR $\approx$ 0.98, p = 0.63) and survival curves for obese versus non obese patients overlapped, mirroring the null BMI effect reported in large western TNBC series and in the Black female cohort, where BMI was dropped from the multivariate model (Table 2).¹⁴

Stromal TILs remained a powerful independent prognosticator; a 1% rise in TILs reduced the risk of death by $\sim$ 4%, and patients with > 15% TILs enjoyed markedly better OS/DFS, consistent with pooled Western data showing each 10% increase in sTILs improves DFS, D-DFS and OS.⁹

We observed a borderline BMI $\times$ TIL interaction (p = 0.056), indicating that the survival advantage of high TILs wanes as BMI rises. This functional attenuation

echoes Italian preoperative data where obesity lowered TIL density and was linked to poorer outcomes in TNBC, and mechanistic work showing obesity reduces cytotoxic CD3⁺ lymphocytes and skews macrophage/PD-L1⁺ populations.¹⁶

Age-related patterns persisted. Younger patients had higher TILs and lower BMI, echoing findings from an Italian early stage cohort.¹⁵

Taken together, obesity does not diminish immune cell recruitment but appears to impair effector function, limiting the benefit of a TIL rich microenvironment. Clinically, BMI should be considered when interpreting TIL scores and when selecting patients for immune checkpoint blockade or dose intense neoadjuvant regimens. Prospective studies integrating metabolic profiling, TIL functional assays, and ancestry specific subtyping will be essential to refine risk stratification and therapeutic decision making across diverse populations.

Collectively, our data reinforce the prognostic centrality of sTIL, highlight BMI as a modifier rather than a direct driver of outcome, and propose that weight management interventions could preserve immune mediated tumour control, especially when combined with optimal chemotherapy intensity and emerging immunotherapies.

Declarations

Data availability

De-identified data underlying this study are available from the author on reasonable request.

Authors' contributions

Conceptualisation: Arya (D), Thatai (A), Mathur (P)

Methodology: Arya (D), Mathur (P)

Formal Analysis: Sharma (S)

Investigation (data collection): Mathur (P), Kaushik (A)

Writing: Original draft:

Pragya, Kaushik (A)

Review and editing: All authors

Conclusion

This retrospective analysis in South Asian women with TNBC demonstrates that sTILs are a strong and independent predictor of survival and recurrence, while BMI at diagnosis does not independently influence outcomes; however, increasing adiposity appears to attenuate the prognostic benefit associated with high sTILs, suggesting impairment of immune function rather than reduced immune cell recruitment in obese patients. These findings support the clinical relevance of incorporating sTIL assessment into routine prognostic evaluation and highlight host metabolic status as an important contextual modifier of tumour immunity.

The study is limited by its single-centre, retrospective design, modest sample size, and relatively few outcome events. Additional constraints include potential interobserver variability in sTIL scoring, reliance on BMI measured only at diagnosis without longitudinal follow-up or metabolic profiling, and the absence of functional immune or molecular analyses, which limits mechanistic insight and generalisability. Because the median OS has not yet been reached and follow-up remains limited, the findings should be considered preliminary, and more mature outcome data with longer follow-up are needed to confirm these observations. Future prospective multicentre studies integrating standardised sTIL evaluation, detailed metabolic phenotyping, longitudinal body composition measures, and functional immune profiling are needed to validate these observations and to determine whether metabolic optimisation or structured weight management interventions can enhance immune-mediated tumour control and improve therapeutic outcomes in TNBC.

Devavrat Arya, Poorvee Mathur, Atul Thatai, Pragya, Ayuj Kaushik, Shivam Sharma. Impact of Body Mass Index and Tumour-Infiltrating Lymphocytes on Survival and Recurrence in Triple-Negative Breast Cancer among South Asian Women. MMJ. 2026, June. Vol 3 (2).

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References

- Korlimarla A, Hari PS, Prabhu J, *et al.* Comprehensive characterization of immune landscape of Indian and Western triple negative breast cancers. *Transl Oncol.* 2022;25:101511.
- Somal PK, Sancheti S, Sharma A, *et al.* A clinicopathological analysis of molecular subtypes of breast cancer using immunohistochemical surrogates: A 6-year institutional experience from a tertiary cancer center in north India. *South Asian J Cancer.* 2023;12(02):104–11.
- Bao PP, Cai H, Peng P, *et al.* Body mass index and weight change in relation to triple-negative breast cancer survival. *Cancer Causes Control.* 2016;27(2):229–36.
- Floris G, Richard F, Hamy AS, *et al.* Body mass index and tumor-infiltrating lymphocytes in triple-negative breast cancer. *J Natl Cancer Inst.* 2021;113(2):146–53.
- Choi Y, Park SK, Ahn KJ, *et al.* Being overweight or obese increases the risk of progression in triple-negative breast cancer after surgical resection. *J Korean Med Sci.* 2016;31(6):886–91.
- Ademuyiwa FO, Groman A, O'Connor T, *et al.* Impact of body mass index on clinical outcomes in triple-negative breast cancer. *Cancer.* 2011;117(18):4132–40.
- Leon-Ferre RA, Jonas SF, Salgado R, *et al.* Tumor-infiltrating lymphocytes in triple-negative breast cancer. *JAMA.* 2024;331(13):1135–44.
- Lohmann AE, Soldera SV, Pimentel I, *et al.* Association of obesity with breast cancer outcome in relation to cancer subtypes: a meta-analysis. *J Natl Cancer Inst.* 2021;113(11):1465–75.
- Zhou Y, Tian Q, Wang BY, *et al.* The prognostic significance of TILs as a biomarker in triple-negative breast cancer: what is the role of TILs in TME of TNBC? *Eur Rev Med Pharmacol Sci.* 2021;25(7).
- Dawood S, Lei X, Litton JK, *et al.* Impact of body mass index on survival outcome among women with early stage triple-negative breast cancer. *Clin Breast Cancer.* 2012;12(5):364–72.

11. Dieci MV, Bisagni G, Bartolini S, *et al.* Interaction between tumor-infiltrating lymphocytes and BMI in early HER2-positive breast cancer: analysis of the ShortHER trial. *ESMO open*. 2025;10(11):105832.
12. Abuhadra N, Sun R, Yam C, *et al.* Predictive roles of baseline stromal tumor-infiltrating lymphocytes and Ki-67 in pathologic complete response in an early-stage triple-negative breast cancer prospective trial. *Cancers*. 2023;15(13):3275.
13. Hossain F, Danos D, Zabaleta J, *et al.* Immunogenomic diversity of triple-negative breast cancers in obese and non-obese black and white women. *NPJ Breast Cancer*. 2025;11(1):126.
14. Takada K, Kashiwagi S, Asano Y, *et al.* Clinical verification of body mass index and tumor immune response in patients with breast cancer receiving preoperative chemotherapy. *BMC Cancer*. 2021;21(1):1129.
15. Losurdo A, De Sanctis R, Fernandes B, *et al.* Insights for the application of TILs and AR in the treatment of TNBC in routine clinical practice. *Sci Rep*. 2020;10(1):20100.
16. Gennari A, Amadori D, Scarpi E, *et al.* Impact of body mass index (BMI) on the prognosis of high-risk early breast cancer (EBC) patients treated with adjuvant chemotherapy. *Breast Cancer Res Treat*. 2016;159(1):79–86.

Is the Negative Appendicectomy Rate a Key Factor in the Diagnostic Accuracy of Various Scoring Systems?

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Abstract:

Acute appendicitis remains one of the most common surgical emergencies, requiring prompt and accurate diagnosis to prevent potentially serious or even fatal complications. This study evaluates the diagnostic accuracy of different scoring systems for acute appendicitis in relation to the negative appendicectomy rate (NAR). Particular emphasis is placed on Nigam's Scoring System (NSS), which relies solely on clinical history, physical examination, and basic laboratory investigations, making it especially suitable for use in resource-limited and primary care settings. Conducted at a single primary care hospital, the study is limited by its single-centre design. The findings demonstrate that NSS achieves very high diagnostic accuracy, with a reported NAR of zero, in contrast to other scoring systems that show higher NAR values, reaching up to 7.5% in some cases. Histopathological examination of all removed appendices confirmed acute appendicitis at varying stages of inflammation. Overall, NSS emerges as a highly sensitive and practical diagnostic tool that outperforms other systems in minimising unnecessary appendicectomies.

Key words: Acute Appendicitis, Appendicectomy, Negative Appendicectomy Rate (NAR), Diagnostic Accuracy, Nigam's Scoring System (NSS).

Introduction

Acute appendicitis is a surgical emergency requiring appendicectomy. Urgent attention and prompt treatment are essential to prevent complications which sometimes become serious and even fatal. Acute appendicitis usually starts with pain near the umbilicus, which migrates to the right iliac fossa. Nausea and vomiting follow the pain with loss of appetite and mild fever. Acute appendicitis is most commonly caused by obstruction of the lumen of appendix by hard faecal matter called faecolith, or by lymphoid hyperplasia.¹ Acute appendicitis can occur at any age, but tends to be highest in the 10–20 age group.²

Obstruction of the lumen of the appendix leads to congestion within the appendix, resulting in increased

luminal pressure due to the secretion of inflammatory exudate and mucus. This obstructs lymphatic drainage, leading to further oedema, ulceration, bacterial growth and formation of pus.³ Acute appendicitis is one of the most common causes of acute abdominal pain in adults and children, with a lifetime risk of 8.6% in males and 6.7% in females.⁴ In the United States alone, approximately 300,000 hospital visits are reported annually related to appendicitis.⁵

The negative appendicectomy rate (NAR) validates the diagnostic accuracy of scoring systems for acute appendicitis. The lower the NAR, the higher the accuracy of a scoring system. NAR indicates the capability of a scoring system to accurately diagnose acute appendicitis and differentiate it from other causes of abdominal pain.

An NAR of 0% by Nigam's Scoring System (NSS) surpasses all other scoring systems in diagnostic accuracy. In this study, we compared three important scoring systems for acute appendicitis i.e. Alvarado, Raja Isteri Pengiran Anak Saleha Appendicitis (RIPASA), and NSS, with respect to their diagnostic accuracy as measured by NAR. NAR of 5%–10% is usually accepted as normal by any scoring system, but in this study, high NAR values are not accepted. NAR should be as low as possible, as it directly reflects the ability of a scoring system to diagnose acute appendicitis accurately. A low NAR helps to avoid unnecessary appendicectomies and potential complications such as ileus, incisional hernias and increased cost to the patient.⁶ Negative explorations can lead to longer hospital stays, higher costs, and increased morbidity and mortality as well.⁷

Materials and Methods

This study was conducted at Max Hospital, Gurgaon, Haryana, India, which is a primary healthcare hospital. The study was performed from April 2014 to April 2026. A total of 85 cases were included in this research work. All cases of acute abdominal pain with suspicion of acute appendicitis were included in this single-centre study. Patients with abdominal pain without suspicion of acute appendicitis were not included in this study. All patients were treated on the basis of the score obtained by NSS. Demographics of all patients were recorded. A proper history and detailed physical examination were carried out for all patients along with basic laboratory tests. Scoring was done according to the variables in Table 1 and diagnosed as per Table 2.

Variables	Score
Symptoms	
Migratory right iliac fossa pain	1
Anorexia	1
Nausea/vomiting	1
Pain precedes vomiting	1
Vomiting precedes pain	-1
Signs	
Tenderness in RIF (mild)	2
Tenderness in RIF (moderate)	3
Tenderness in RIF (severe)	4
Rebound tenderness in RIF	2
Guarding in RIF	2
Elevated temperature	1
Laboratory findings	
Leucocytosis 10000–12000 per microlitre of blood	2
Leucocytosis 12000–15000 per microlitre of blood	3
Leucocytosis more than 15000 per microlitre of blood	4
Maximum score	17

▼
Table 1: Nigam's Scoring System (NSS)-distribution of points.
Abbreviation: RIF: Right Iliac Fossa.

NSS	Interpretation	Guidelines for treatment
6 and less than 6 score	Probably not acute appendicitis	Discharge with symptomatic treatment
7 to 10 score	Probably acute appendicitis	Admit to the hospital for observation and further decision
11 and more score	Confirmed diagnosis of acute appendicitis	Direct appendicectomy

▼
Table 2: Interpretation of Nigam's Scoring System (NSS) and guidelines for treatment.

After scoring, the patients were treated according to NSS guidelines.

Results

Out of 85 patients, 68 (80%) were male and 17 (20%) were female. The age of the patients varied from 15 to 72 years. Most of the patients had a normal body mass index (BMI). There were 6 (7.1%) patients who scored 6 or less than 6, 11 (12.9%) patients scored between 7–10, and 68 (80%) patients scored 11 and above. The patients who scored 6 or less were discharged with symptomatic treatment. Patients who scored 7–10 points were admitted for observation in the hospital and were operated on with laparoscopic appendicectomy when they did not improve. 68 patients who earned 11 and above were admitted, prepared for surgery and underwent appendicectomy without a period of observation in the ward. All samples of the excised appendix were sent for histopathological examination. All histopathology reports confirmed the diagnosis of acute appendicitis with various stages of inflammation. Thus, the NAR was 0% (Table 3).

Scoring system	NAR
Alvarado scoring system (Francisco AR <i>et al.</i>) ⁸	11.7%
RIPASA scoring system (Singh A <i>et al.</i>) ⁹	17.5%
NSS (Nigam V, Nigam S) ¹⁰	0%

Table 3: Comparative study of NAR with various scoring systems.
Abbreviations: NAR: Negative Appendectomy Rate; RIPASA: Raja Isteri Pengiran Anak Saleha Appendicitis; NSS: Nigam's Scoring System.

Discussion

Christian GP *et al.* suggested that NAR is accepted as the measure of diagnostic accuracy of a scoring system for appendicitis. Clinical scoring systems to aid diagnosis have been described for acute appendicitis, but the cited studies are either computer-based or retrospective.^{11–13} Now, NSS has addressed this concern, as NSS diagnoses acute appendicitis with a high degree of accuracy rate without NAR (Figures 1 and 2).



Figure 1: Nigam's Scoring System (NSS) Point 9, probably acute appendicitis.

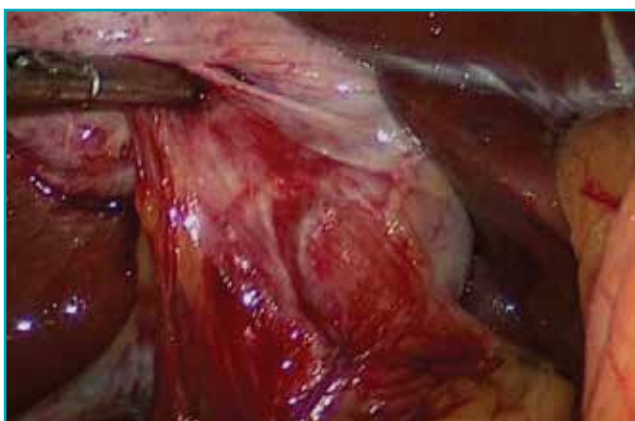


Figure 2: Nigam's Scoring System (NSS) Point 15, confirmed diagnosis of acute appendicitis.

Among the 249 patients from Australia (M = 113 and F = 136), the NAR was 9.7% in males and 3.9% in females.¹⁴ Another study from Bangalore reported NAR of 9% among 230 specimens.¹⁵ The NAR was 8.7% in a Finnish study.¹⁶ These rates of NAR are considered to be high and therefore, the diagnostic criteria or scoring systems used may need to be reconsidered and, if required, replaced with more effective methods. NSS has zero NAR, which should be the aim of all clinicians, even if more investigations and imaging techniques are used.

NAR is a key quality metric and parameter for evaluating the diagnostic accuracy of appendicitis scoring systems. A lower NAR indicates higher accuracy, with ideal systems aiming for < 15% or even lower with imaging. An ideal scoring system should aim for zero NAR, like NSS.

Low scores in various scoring systems where surgeries are performed due to fear of delay leading

to perforation, are one of the main causes of high NAR. However, if these scoring systems are used cautiously and properly, then NAR can be reduced. Scoring systems are developed to diagnose acute appendicitis correctly and reduce the NAR or unnecessary appendectomies. Newer scoring systems have higher accuracy and lower NAR.¹⁷

The annual appendicectomy volume cited in the United States in 1997 was 250,000 cases with a negative NAR of 15%.¹⁸ In 2007 there were 3,26,000 appendicectomies.¹⁹ Several recent papers have reported a declining NAR, including large database studies and meta-analyses with NAR as low as 6%–8%,^{20,21} and single-institution studies with NARs as low as 1.7%–7%,^{22,23} coinciding with increased use of computed tomography (CT) and laparoscopy.²⁴

NAR is the best parameter for assessing the diagnostic accuracy of a scoring system in acute appendicitis:

1. A high NAR is commonly due to diagnostic errors.
2. NAR clearly indicates the efficacy of a scoring system.
3. A high NAR is usually due to the use of an imperfect scoring system.
4. A high NAR is also due to over-cautious practice or fear of complications, such as perforation of the appendix.
5. A high NAR is also due to the fact that many surgeons accept a higher NAR than risk complications. They should devote more time and re-examine the patient after a few hours while the patient is kept under observation in hospital.
6. Appendicectomy in suspected cases without diagnostic confirmation is one of the reasons for a high NAR.

Declarations

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Declaration of patient consent

Informed consent was taken from the patients.

Financial support and sponsorship

None.

Conflicts of interest

The authors declare no conflicts of interest.

Conclusion

NAR is a key factor in analysing the diagnostic accuracy of the scoring system for acute appendicitis. It should be the goal of every surgeon to keep the NAR as low as possible to maintain the diagnostic accuracy of scoring system used. In this study, NSS achieved a zero NAR, which should be the aim of every surgeon. A low NAR improves the diagnostic accuracy of a scoring system.

Vinod Kumar Nigam, Siddharth Nigam. Is the Negative Appendicectomy Rate a Key Factor in the Diagnostic Accuracy of Various Scoring Systems? MMJ. 2026, June. Vol 3 (2).

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References

1. Fitz RH. Perforating inflammation of the vermiform appendix with spinal reference to its early diagnosis and treatment. *Am J Med. Sci.* 1886;92:321–46.
2. Konstantakos A K, Zollinger RM. Repair of McBurney incisional hernias after open appendectomy. *Curr surgery.* 2000;57(1):79–80.
3. Chandrasekharan TV, Johnson N. Acute appendicitis Surgery. *Oxford.* 2014;32(8):413–7.
4. Syndr MJ, Guthrie M, Cagle S. Acute Appendicitis: Efficient Diagnosis and Management. *Am Fam Physician.* 2018;98(1):25–33.
5. Address DG, Shaffer N, Fowler BS, et al. The epidemiology of appendicitis and appendectomy in the United States. *Am J Epidemiol.* 1990;132(5):910–25.
6. Schover KWB, Wichtrup B, Rothmud M, et al. Ultrasonography is the diagnosis of acute appendicitis: a prospective study. *Gastroenterol.* 1989;97:630–9.
7. Chrsthi MM, Surendran A, Narayanan JT. RIPASA and air scoring systems are superior to Alvarado Scoring in acute appendicitis: Diagnostic accuracy study. *Ann Med Surg (Lond).* 2020;59:138–42.
8. Rodriguez-Garcia FA, Rodríguez-Sánchez CE, Naranjo-Chávez JC, et al. Assessment of negative appendectomy in acute appendicitis diagnoses. *Surg Pract Sci.* 2025;21:100281.
9. Singh A, Parihar US, Kumwat G, et al. To determine validation of RIPASA score in diagnosis of suspected acute appendicitis and histopathological correction with applicability of Indian population: A single institute study. *Ind J Surg.* 2018;80(2):113–7.
10. Nigam VK, Nigam S. Nigam's Scoring System for acute appendicitis with high accuracy surpassing Alvarado Scoring System. *Int Surg J.* 2022;9(4):835–40.
11. Tiecher I, Landa B, Cohen M, et al. Scoring system to aid in diagnoses of appendicitis. *Ann Surg.* 1983;198(6):753–59.
12. Van Way CW, Murphy JR, Dunne L, et al. A feasibility study of computer aided diagnosis in appendicitis. *Surg Gynecol Obstet.* 1982;155(5):685–8.
13. Christian F, Christian GP. A simple scoring system to reduce the negative appendectomy rate. *Ann R Coll Surg Engl.* 1992;74(4):281–5.
14. Chin KC, Arad A, Chen KC, et al. The clinical value of pathology tests and imaging study in the diagnosis of acute appendicitis. *Postgrad Med J.* 2016;92:611.
15. Siyatha R, Anushree CN, Singh N. Histopathological spectrum of appendectomy specimens - a prospective study. *Ind J Pathol Oncol.* 2017;4:638–42.
16. Sammalkorpi HE, Mentula P, Savolainen H, et al. The introduction of adult appendicitis score reduced negative appendectomy rate. *Scand J Surg.* 2017;106:196–201.
17. Nigam VK, Nigam S. Negative Appendectomy - Relevance of Scoring Systems - Alvarado, Modified Alvarado, Ripasa, Air and Nigam's Scoring System (NSS). *Int J Gastro.* 2025;9(2):148.
18. Flum DR, Koeprell T. The clinical and economic correlates of misdiagnosed appendicitis and appendectomy in United States. *Am J Epidemiol.* 1990;132:910–25.
19. Hall MJ, DeFrances CJ, Williams S N, et al. National Hospital Discharge Survey. 2007 summary. *Natl Health Stat Report.* 2010;(29):1–24.
20. Cushieri J, Florence M, Flum DR, et al. Negative appendectomy and imaging accuracy in the Washington State Surgical Care and Outcomes Assessment Program. *Ann Surg.* 2008;248:557–63.
21. Guller U, Rosella L, McCall J, et al. Negative appendectomy and perforation rates in patient undergoing laparoscopic surgery for suspected appendicitis. *Br J Surg.* 2011;98(4):589–95.
22. Rao PM, Rhea JT, Rattner DW, et al. Introduction of appendiceal CT: impact on negative appendectomy and appendiceal perforation rates. *Ann Surg.* 1999;229:344–9.
23. Rhea JT, Halpern EF, Ptak T, et al. The status of appendiceal CT in an Urban medical center 5 years after its introduction: experience with 753 patients. *Am J Roentgenol.* 2005;184:1802–8.
24. Mariadson JG, Wang WN, Wallack MK, et al. Negative appendicular rate as a quality metric in the management of appendicitis: impact of computed tomography, Alvarado score and the definition of negative appendectomy. *Ann R Coll Scorg Engl.* 2012;94(6):395–401.

Understanding Self-Care in Type 2 Diabetes: Insights from the Diabetes Self-Management Questionnaire

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Abstract:

Type 2 Diabetes Mellitus (T2DM) requires consistent patient involvement in daily self-care practices to achieve effective management and better glycaemic outcomes. Understanding how well patients adhere to these practices is essential for identifying gaps and improving care strategies. In this context, a cross-sectional observational study was carried out among 500 T2DM patients attending an outpatient department in a tertiary care setting. Self-care behaviours were evaluated using the Diabetes Self-Management Questionnaire (DSMQ), which measures adherence across four key domains: glucose management, dietary control, physical activity, and healthcare utilisation. The overall mean DSMQ score was 1.45 ± 0.49 , indicating a moderate level of adherence among participants. Among the 500 patients, 54% exhibited partial adherence, 42% demonstrated good adherence, and only 4% showed poor adherence. Domain-wise analysis revealed that physical activity was the weakest area of adherence, while dietary control and glucose management showed moderate consistency. Healthcare utilisation emerged as the strongest domain, reflecting relatively better adherence in seeking medical support and follow-up care. Despite a reasonable level of awareness about diabetes management, adherence to self-care practices remains suboptimal. These findings highlight the importance of implementing structured patient education programmes along with continuous behavioural support to enhance long-term adherence and improve glycaemic control outcomes.

Key words: Type 2 Diabetes Mellitus, Diabetes Self-Management Questionnaire (DSMQ), Self-care, Glycaemic Control, Patient Adherence.

Introduction

Type 2 Diabetes Mellitus (T2DM) continues to be a leading global public health concern, with a rising prevalence and a multifactorial impact on morbidity and mortality. The World Health Organization (WHO) projects a significant increase in global diabetes prevalence, particularly in low and middle-income nations where healthcare access and adherence to treatment are inconsistent.¹

Maintaining glycaemic control in T2DM remains a challenge, and inadequate self-care contributes to chronic complications such as retinopathy, neuropathy, nephropathy, and cardiovascular diseases.^{2,3}

Medical treatment, lifestyle change, and self-management are important means of achieving glycaemic control and preventing complications in diabetes.⁴

Self-care consists of multiple interrelated behaviours, including medication adherence, dietary planning, regular physical activity, glucose monitoring, and consistent medical consultations.²

Research underscores that successful disease control requires integrating pharmacological treatment with continuous patient involvement in daily self-management.⁵

A wide range of measuring instruments are available for diabetes self-management. According to several studies, a relatively new instrument, the diabetes self-management questionnaire (DSMQ), shows a consistent relationship with outcomes of diabetes treatment as well, such as glycated haemoglobin (HbA1c).⁶

Tools such as DSMQ provide an objective framework to evaluate how these behaviours correlate with overall glycaemic outcomes.⁵

Building upon prior findings, this study expands the focus to 500 participants to better capture the diversity of adherence patterns in a clinical setting. The aim was to assess the magnitude of engagement in diabetes self-care behaviour using the DSMQ and to identify domains in which patients require more targeted interventions.

Methodology

Study design and setting

This cross-sectional observational study was conducted among 500 adults diagnosed with T2DM who were attending the outpatient department at Nanavati Max Super Speciality Hospital, Mumbai, India, between January and February 2025. Eligible participants were ambulatory patients aged 20–60 years with a confirmed T2DM diagnosis and regular follow-up attendance; individuals with type 1 diabetes, those currently hospitalised, or patients outside the specified age range were excluded to focus on stable, community-managed cases suitable for self-care assessment.

Self-care behaviours were evaluated using the DSMQ, a validated 16-item instrument with established reliability (Cronbach's $\alpha > 0.84$) that measures adherence across four key domains: glucose management (e.g., frequency of blood glucose monitoring and medication adherence), dietary control (e.g., planning and consistency of healthy eating), physical activity (e.g., regular exercise engagement), and healthcare utilisation (e.g., frequency of provider consultations). Each item is scored on a 0–2 scale, where higher scores reflect stronger adherence, and overall

scores were categorised as poor (< 1), partial (1–1.5), or good (> 1.5) based on mean thresholds established in prior validation studies. The tool's reliability and validity have been established in previous studies.¹

Data analysis

Data were analysed using descriptive statistics, including means, standard deviations, frequencies, and percentages, to characterise adherence patterns and demographic distributions. Domain-specific scores were visualised through bar and pie charts for clarity. The study protocol received institutional ethical approval, and written informed consent was obtained from all participants prior to data collection.

Results

Demographic characteristics

Of the 500 participants, the majority (72%) were within the 40–60-year age range, with 8% aged 20–40 years and 20% over 60 years. The sample included 256 males (51.2%) and 244 females (48.8%), reflecting near parity between sexes.

DSMQ score distribution

A total of 270 participants (54%) indicated that DSMQ statements “applied to some degree,” reflecting partial adherence, while 210 participants (42%) achieved “a considerable degree” of adherence. 20 participants (4%) demonstrated minimal engagement in self-care behaviours (Figure 1). The mean DSMQ score was 1.45 ± 0.49 , with scores ranging from 0 to 2. The consistency of adherence patterns across this expanded dataset confirms previous trends observed in smaller cohorts (Figure 2).⁵

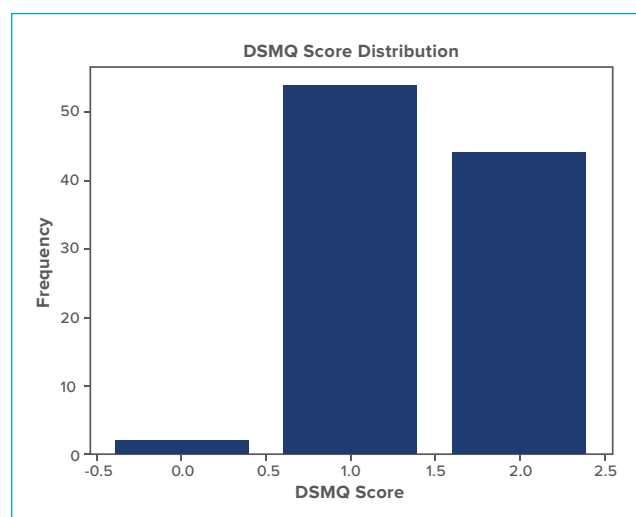


Figure 1: Diabetes Self-Management Questionnaire (DSMQ) score distribution bar chart.

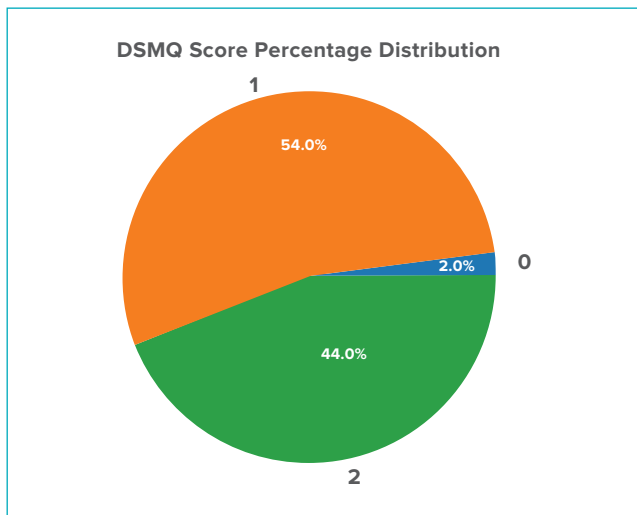


Figure 2: Diabetes Self-Management Questionnaire (DSMQ) percentage distribution pie chart.

Domain-wise findings

- **Glucose management:** Moderate adherence, with patients generally adhering to medication schedules but showing inconsistency in self-monitoring of blood glucose.^{2,5}
- **Dietary control:** Variable adherence, influenced by socio-economic factors and cultural dietary habits.^{2,3}
- **Physical activity:** Lowest adherence; a large proportion of participants reported sedentary lifestyles, echoing findings of previous studies.²
- **Healthcare use:** Highest adherence; most patients maintained regular contact with healthcare providers, although translation of advice into behaviour was inconsistent.⁷

Discussion

This large-scale cross-sectional analysis substantiates the observation that while T2DM patients demonstrate awareness of recommended self-care practices, consistent behavioural adherence remains limited. The expanded dataset of 500 participants provides a stronger statistical foundation for these findings.

The moderate mean DSMQ score (1.45 ± 0.49) aligns with previous investigations, signifying that knowledge does not necessarily equate to practice.² The predominance of participants within the middle-aged cohort (40–60 years) corroborates epidemiological data from the WHO, highlighting this group as particularly vulnerable due to lifestyle and occupational factors.¹

The weakest adherence was observed in the physical activity domain, consistent with evidence suggesting that insufficient exercise contributes to poor glycaemic regulation and higher complication risks. This finding highlights an urgent need for structured exercise promotion programmes tailored to patient capacity and cultural context.

Dietary adherence varied substantially, likely due to socio-economic disparities and ingrained cultural eating patterns. Healthcare utilisation, on the other hand, remained relatively robust, confirming that patients actively seek medical care, but struggle to implement continuous lifestyle modifications. This reinforces the recognised knowledge practice gap described in chronic disease management.⁷

Though biochemical correlation with HbA1c was beyond this study's scope, prior research has verified an inverse relationship between DSMQ scores and HbA1c, validating DSMQ as a practical surrogate for behavioural adherence assessment.¹

Overall, these findings indicate that effective diabetes control requires not only access to medical care but also sustained education and psychosocial support to enhance behavioural adherence.

Recommendations

- Develop patient-centred diabetes education programmes emphasising sustained behavioural adherence.⁷
- Promote structured physical activity programmes integrated into clinical settings.⁷
- Utilise digital monitoring platforms to enhance motivation and track adherence metrics.⁷
- Strengthen follow-up systems with multidisciplinary teams, including educators, dietitians, and physiotherapists.⁷
- Conduct periodic DSMQ assessments as part of standard diabetes management to track progress.⁷

Limitations

- Cross-sectional design limits causal inference.
- Self-reported data introduce potential recall bias.
- HbA1c levels were not correlated with DSMQ scores.
- Findings reflect one tertiary centre and may not generalise across regions.

Future studies should include a longitudinal design with metabolic outcome correlations to validate behavioural clinical associations.

Conclusion

The study highlights that while patients with T2DM possess moderate awareness and partial engagement in self-management, overall adherence remains inadequate. Increasing emphasis on behavioural modification, structured educational programmes, and continuous follow-up is essential to achieving optimal glycaemic outcomes. The larger sample confirms the persistence of these challenges across a broader demographic spectrum.

Andrea Fonseca, Sampada Tambe. Understanding Self-Care in Type 2 Diabetes: Insights from the Diabetes Self-Management Questionnaire. MMJ. 2026, June. Vol 3 (2).

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References

1. Diabetes. World Health Organization. Available at: <https://www.who.int/news-room/fact-sheets/detail/diabetes>. Accessed on: 14th March 2026.
2. Shrivastava SR, Shrivastava PS, Ramasamy J. Role of self-care in management of diabetes mellitus. *J Diabetes Metab Disord*. 2013;12(1):14.
3. Simegn W, Mohammed SA, Moges G. Adherence to Self - Care Practice Among Type 2 Diabetes Mellitus Patients Using the Theory of Planned Behavior and Health Belief Model at Comprehensive Specialized Hospitals of Amhara Region, Ethiopia: Mixed Method. *Patient Prefer Adherence*. 2023;17:3367–89.
4. Márkus B, Hargittay C, Iller B, *et al*. Validation of the revised Diabetes Self-Management Questionnaire (DSMQ-R) in the primary care setting. *BMC Prim Care*. 2022;23:2.
5. Schmitt A, Gahr A, Hermanns N, *et al*. The Diabetes Self-Management Questionnaire (DSMQ): development and evaluation of an instrument to assess diabetes self-care activities associated with glycaemic control. *Health Qual Life Outcomes*. 2013;11(1):138.
6. Vincze A, Losonczy A, Stauder A. The validity of the diabetes self-management questionnaire (DSMQ) in Hungarian patients with type 2 diabetes. *Health Qual Life Outcomes*. 2020;18(1):344.
7. Powers MA, Bardsley J, Cypress M, *et al*. Diabetes Self-Management Education and Support in Type 2 Diabetes: A Joint Position Statement of the American Diabetes Association, the American Association of Diabetes Educators, and the Academy of Nutrition and Dietetics. *J Acad Nutr Diet*. 2015;115(8):1323–34.

Surgical Minimalism in Neurosurgery: The “Keyhole” Concept

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Abstract:

Keyhole neurosurgery is a surgical technique that allows neurosurgeons to perform complex procedures through small “keyhole” incisions, often with the aid of specialised instruments and advanced imaging technology. Unlike traditional open surgery, which involves large incisions and causes manipulation and damage to surrounding tissue, minimally invasive neurosurgical (MIN) techniques minimise trauma to the patient's body and reduce the risk of complications. One of the primary benefits of keyhole neurosurgery is a reduced risk of postoperative complications, including less tissue damage, lower pain levels, shorter recovery time, reduced blood loss, lower infection rates, and a decreased risk of nerve damage. With the aid of advanced imaging and navigation technology, neurosurgeons can not only visualise but also locate the target area with greater accuracy, enabling them to perform highly complex procedures with increased safety and efficacy. This precision also allows for smaller incisions, which can further reduce the risk of complications and promote a faster recovery. Keyhole techniques can be used for a wide range of neurosurgical procedures, including brain tumours, spinal cord tumours, aneurysms, and other conditions. It is a highly promising approach to treating complex neurosurgical conditions. With continued advancements in technology and surgical techniques, it is likely that we will see an even greater adoption of MIN approaches in neurosurgery in the future. The current article focuses on these keyhole approaches used in the treatment of neurosurgical pathologies with the aim of achieving excellent surgical outcomes with minimal morbidity and risks to the patients.

Key words: Surgical Minimalism, Neurosurgery, Keyhole Neurosurgery, Supraorbital Keyhole, Keyhole Kawase.

Introduction

Skull base surgery has traditionally involved extensive, often invasive approaches designed to achieve maximal tumour resection or lesion access, such as transcranial or transfacial routes. These extensive approaches, including the pterional, fronto-orbitozygomatic, and subtemporal craniotomies, provided excellent exposure but were associated with significant morbidity, longer recovery times, and complex surgical corridors.

In recent decades, advances in imaging, instrumentation, and endoscopic techniques have catalysed a shift towards less invasive, “keyhole” approaches — minimally invasive corridors that access

lesions through smaller craniotomies or even natural openings. These approaches aim to reduce morbidity while maintaining or improving surgical efficacy.

The concept of the keyhole approach emerged from neurosurgery's broader movement toward minimally invasive techniques. In skull base surgery, the development of the super- and supraorbital approaches, including the “eyebrow” and “eyelid” routes, exemplifies this trend. These approaches leverage natural corridors (e.g., cribriform plate, sphenoid sinus) or minimal bony openings to reach deep-seated lesions with less soft tissue disruption. These corridors — supraorbital, pterional, retrosigmoid, and endonasal — are strategically selected based on tumour location,

morphology, and adjacent neurovascular anatomy.¹ These tailored approaches enhance outcomes by reducing brain retraction, operative time, blood loss, and hospital stay — all while preserving oncologic safety even in large to giant intracranial tumours.¹⁻³

Keyhole approaches often involve:

- Smaller, strategically placed craniotomies
- Use of endoscopic visualisation
- Neuro-navigation systems
- Specialised instrumentation

The Term “Keyhole”: Explanation

The term keyhole refers to viewing the entire room through a small keyhole in the room door, using multiple viewing angles. This is a much more elegant and minimally invasive means of looking into the contents of the room rather than opening the entire door at the hinges. A smaller incision has several definite advantages as compared to a larger traditional craniotomy; however, this remains a subject of large randomised controlled trials, and most of the patients prefer smaller incisions in view of the following putative advantages:⁴⁻⁷

- i) Lesser damage to the cutaneous nerves and vascular supply of the scalp, hence less postoperative pain (leading to lesser postoperative hospital stay and analgesia requirement) and better wound healing
- ii) Smaller incisions are mostly relatively simple and linear and require less time to open and close
- iii) Better cosmesis
- iv) Lesser exposure of the cortical tissue during the entire surgery with less attendant thermal damage
- v) Less muscular dissection and lesser chances of temporalis muscle atrophy in the postoperative period
- vi) Repeat surgery is technically much easier with keyhole, with lesser area of the dura and brain tissue that is required to expose
- vii) Wound healing is faster, and radiation can be given early in the postoperative period as compared to traditional craniotomies

The “Keyhole” Concept

Operating through a keyhole is not much different from operating through a larger incision. However, before proceeding with keyhole surgery, it is prudent to understand the keyhole concept and learn the basic principles of the keyhole approach.⁴⁻⁷

The following are the properties of a keyhole:

- i) The term “keyhole” relates to a concept and not to any size. The neurosurgeons should learn to think about how to make their incisions as small as possible, as is necessary to achieve their surgical goals.
- ii) The keyhole is immovable and should be meticulously planned before surgery. Therefore, neuro-navigation is mandatory to plan a keyhole placement. There is very little room for error in keyhole surgery, and mistakes are not forgiving.
- iii) It is impossible to look at the back of the keyhole. The pathology located at the depths is best visualised; however, superficially located diseases are not very good for a keyhole (Figure 1).
- iv) A single viewing trajectory is not enough to work through a keyhole. The view can be enhanced significantly by frequently changing the viewing angles of the microscope and the position of the patient during surgery (Figure 2).
- v) The best view through a keyhole is down the centre of the opening, which usually lies along the long axis of the lesion.

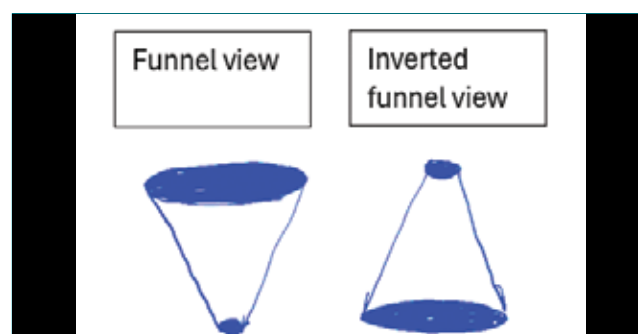


Figure 1: Schematic illustration showing the view through the microscope (funnel view) as opposed to the vision through a keyhole (reverse-funnel view).

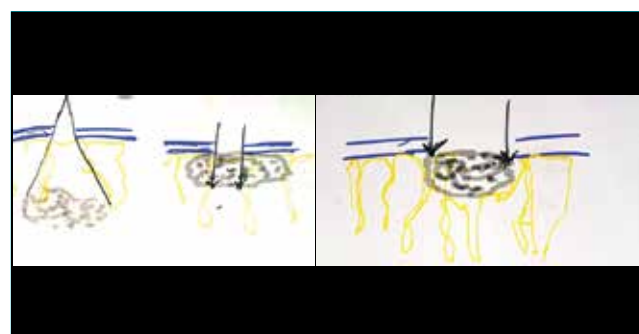


Figure 2: Schematic illustration showing the effectiveness of the keyhole in deeply situated lesions, as opposed to those that lie superficially.

Planning of a Keyhole

The thinking process and planning for a keyhole surgery are critical for the success of surgery and should start by carefully studying the radiographic images of the patient. The surgeon should be physically present in the operating room from the very beginning of the surgery, for the planning, execution and placement of the keyhole and should himself plan and execute these steps, rather than leaving them over to some resident or anyone else and showing up in the operating room after the opening of the dura. The margin of error is absolutely small in keyhole surgeries, and this is the most common reason this approach is not very popular among most of the neurosurgeons.⁴⁻⁷

The basic principles in planning a keyhole are elaborated below and should be followed to avoid any problems during surgery.

1. Cerebrospinal fluid (CSF) should be drained early after the dural opening. One must be extremely patient after opening the dura and the first step is the drainage of as much CSF as possible from the CSF spaces. This relaxes the brain, allowing surgery to proceed without retraction, even if it appears intimidating immediately after dural opening, particularly in the presence of brain bulge. Sometimes, especially in large tumours, one may electively choose to insert a lumbar drain before the surgery for draining the CSF either before opening the dura or during the surgery.
2. Cisternal spaces and trans-sulcal corridors should be used whenever possible for approaching the lesion.
3. The working trajectory is best along the long axis of the tumour. Hence, the keyhole is best placed in the area where the long axis of the lesion intersects the surface. This rule is obviously not followed when any eloquent or important area falls in the trajectory of the long axis (Figure 3A and B).
4. The approach to any lesion is prioritised by the location and anatomical relationships of the most difficult-to-access portion of the lesion, because it is this critical part of the lesion that requires utmost careful planning and meticulous skills, rather than the majority of the lesion. Sometimes, it necessitates a change in the approach while at other times it requires the use of an endoscope. Hence, it is a good practice always to compartmentalise the lesion into an easily accessible portion and a difficult-to-access portion.
5. The keyhole surgery is to be performed under super high microscopic magnification. Under this extreme magnification, the focal length adjustments need to be done at frequent intervals, especially with the changes in the angle of view. These focal length adjustments can be made by the assistant. The use of a mouthpiece is very handy in a keyhole approach and is a good microscope accessory to have.
6. The use of an endoscope should be considered in every keyhole surgery, especially in skull base surgery. The endoscope complements the keyhole in viewing difficult to access areas of the lesion and increases the visibility without increasing the size of the exposure or without adding any extensive skull base approaches (e.g., orbitotomy) to the original approach.

Mini-pterional Craniotomy

The standard pterional craniotomy is the main workhorse for a majority of complex neurosurgical operations. The standard craniotomy entails a larger craniotomy and extensive muscle dissection with the disadvantages of temporalis muscle atrophy, poor cosmesis and jaw pain in the postoperative period (Figures 4–6).²

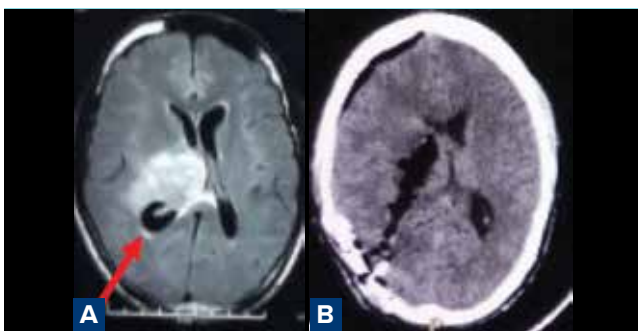


Figure 3: A. Preoperative magnetic resonance imaging (MRI) of a patient showing right-sided thalamic glioma, demonstrating the working trajectory along the long axis of the tumour; B. Immediate postoperative computed tomography (CT) of the same patient showing gross total tumour resection following keyhole principles.

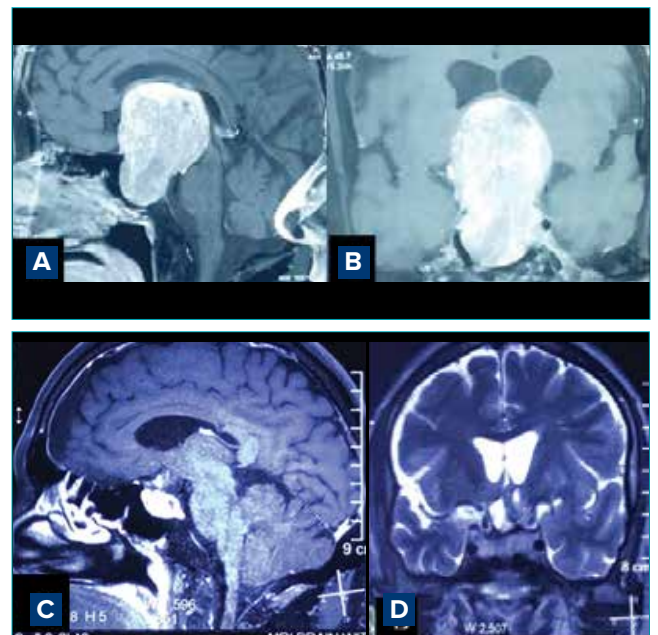




Figure 4A-F: Mini-pterional craniotomy for a giant pituitary adenoma: **A-B.** Preoperative sagittal and coronal contrast magnetic resonance imaging (MRI) of the patient showing a giant pituitary adenoma reaching right up to the third ventricle; **C-D.** Follow-up 2 years postoperative sagittal contrast and T2-weighted coronal MRI of the same patient. Note the presence of a small residual tumour in the sella, which is being followed up on a regular basis; **E.** Side and; **F.** Front profile photograph of the patient at follow-up.

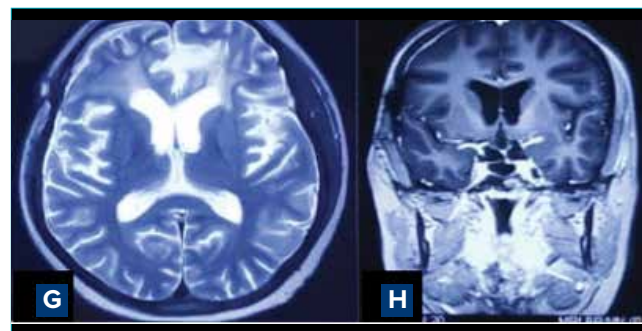
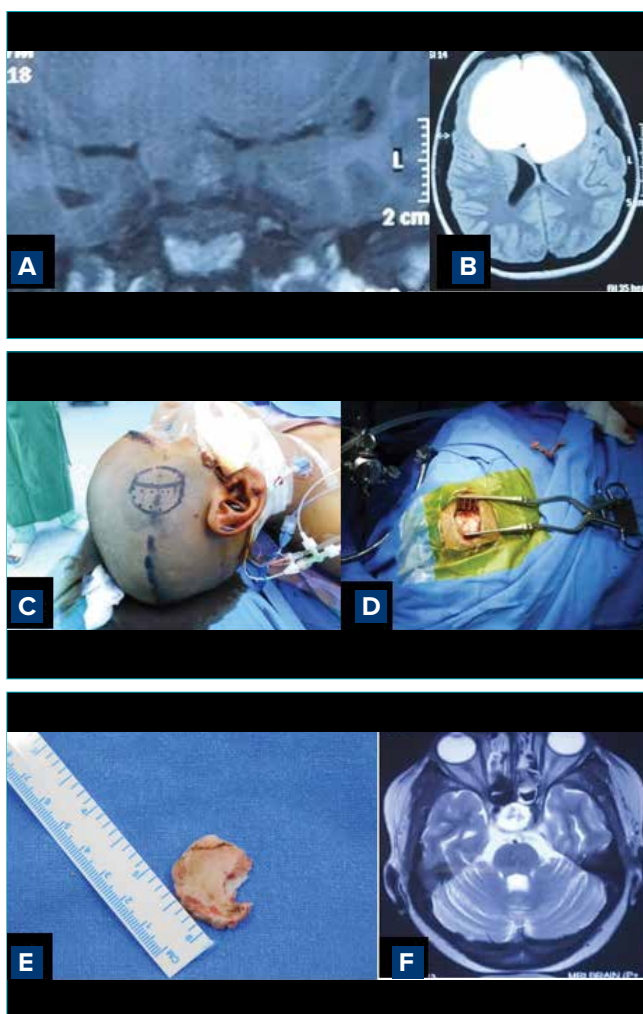
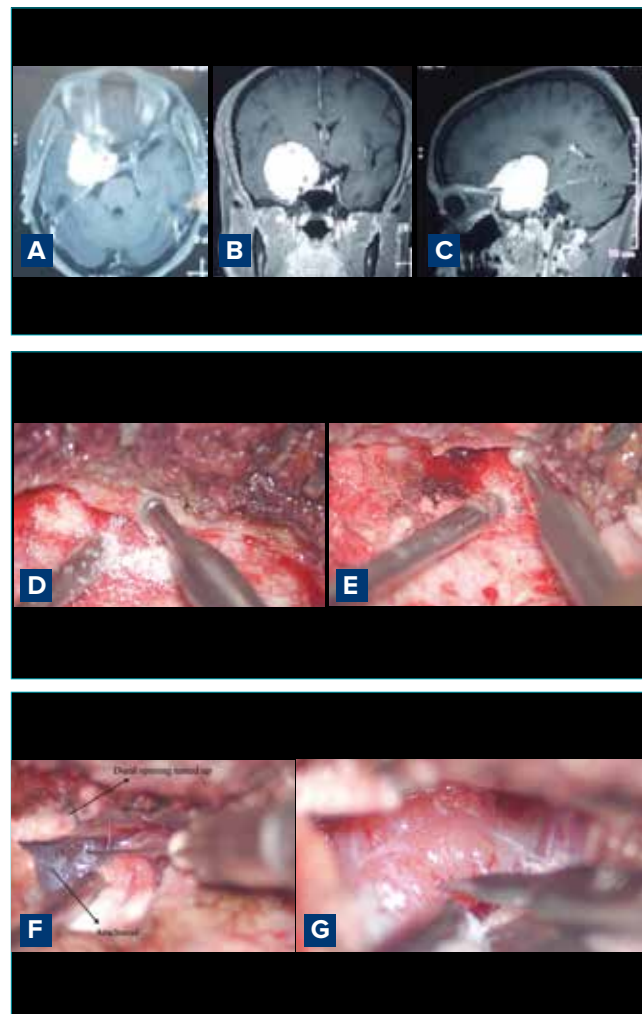


Figure 5A-H: Mini-pterional approach for a giant craniopharyngioma: **A-B.** Preoperative coronal and axial magnetic resonance imaging (MRI) showing the lesion; **C.** The head positioned on a horseshoe headrest, turned 30 degrees contralaterally and slightly extended, with planning of the incision and exposure; **D.** Depicting the extent of exposure; **E.** Showing the size of the bone flap removed; **F-H.** Follow-up postoperative MRI at 2 years showing total excision and no recurrence.



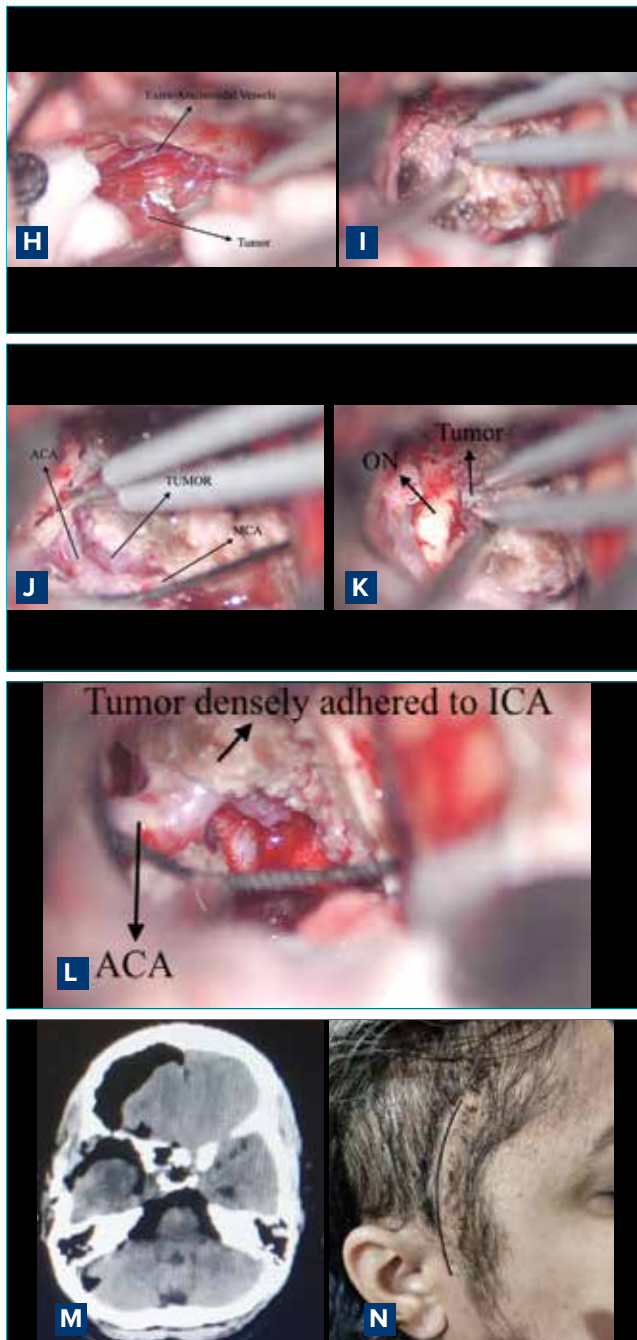


Figure 6A–N: Mini-pterional craniotomy for a right-sided medial sphenoid wing meningioma: **A–C.** Preoperative contrast magnetic resonance imaging (MRI) showing the lesion; **D.** Extra-dural drilling of the temporal base to allow better visual access to the tumour; **E.** Extradural drilling of the outer sphenoid wing to increase the visual angle, for better visualisation of the tumour through the mini-pterional craniotomy; **F.** Draining of cerebrospinal fluid (CSF) by opening the arachnoid cistern. This step helps in gaining access to the tumour. Note that only a part of the overlying dura is incised and opened in line with the Sylvian fissure, so that the whole of the brain does not protrude out; **G.** Tumour visualisation and separation of the arachnoid layer over the tumour; **H.** Dissection of surrounding vessels from the tumour surface by arachnoid dissection to expose as much of the tumour surface through the narrow operating window as possible; **I.** Tumour debulking using bipolar dissection, scissors, and cavitron ultrasonic surgical aspirator (CUSA);

J. After adequate debulking and arachnoid dissection, critical structures start to become visible. The image shows dissection of the arachnoid plane of the tumour from the anterior and middle cerebral arteries; **K.** Dissection and separation of the tumour from the optic apparatus; **K–L.** Near-total excision of tumour. A tiny bit of tumour densely adhered to the main trunk of the internal carotid artery (ICA) has been left; **M.** Immediate postoperative computed tomography (CT) scan; **N.** Patient in the follow-up showing excellent cosmesis of the mini-pterional craniotomy. **Abbreviations:** ACA: Anterior Cerebral Artery; MCA: Middle Cerebral Artery; ON: Optic Nerve; ICA: Internal Carotid Artery.

The mini-pterional craniotomy addresses these concerns associated with the standard pterional craniotomy by reducing the size of the skin incision, lesser muscle dissection and smaller craniotomy without compromising on the versatility of this approach. Figueiredo et al. described a modification of the pterional approach (PT), the mini-pterional craniotomy (MPT), and compared the anatomic exposure provided by these two approaches. These authors concluded that the MPT craniotomy provides comparable surgical exposure to that offered by the PT. The advantages of the MPT include reduction of tissue trauma and bony removal, a decrease in surgical time, and improved cosmetic outcomes.⁸

The skin incision is about 2.5–3 cm long and is a lazy-C shaped, being bisected by a line drawn from the sphenoid ridge. The underlying temporalis fascia is incised and reflected anteriorly with the scalp flap with tacking sutures. The underlying temporalis muscle is then incised and retracted using skin hooks. The electrocautery is not to be used here at all in the muscle dissection in order to avoid later muscle atrophy. The craniotomy is then fashioned, and the sphenoid ridge is drilled with a 2 mm diamond burr, if required. The dura is opened linearly along the Sylvian fissure, particularly in meningiomas, to minimise premature brain bulging prior to tumour removal. The Sylvian fissure is then opened in usual manner thereafter and the CSF letting has to be done patiently from the arachnoid cisterns to relax the brain and continue working even without the need for a retractor at most of the time during the surgical procedure. The closure is similar to that of a standard pterional craniotomy.

Supraorbital Keyhole Approach (SOKHA)

The eyebrow approach is a very versatile approach providing access to a number of differently located pathologies near the optic apparatus, carotid artery, anterior communicating artery, hypothalamus, inferior frontal lobe and proximal Sylvian fissure. It can also provide access to the olfactory groove, interhemispheric fissure, interpeduncular fossa, mesial temporal structures and the middle fossa (endoscope-assisted). The approach

has excellent cosmetic and functional outcomes. The SOKHA approach targets anterior and midline skull base tumours — olfactory groove meningiomas (OGM), tuberculum sellae meningiomas (TSM), craniopharyngiomas, and select pituitary adenomas. Via a small superciliary incision, a minimal craniotomy grants access to the anterior cranial fossa; angled micro-instruments and endoscopy extend visualisation around corners, enabling resection of even large tumours with the same safety, efficiency and lower complication rates.^{9–13}

The patient is positioned supine with head extended so that the frontal lobe falls backwards with gravity away from the orbital floor, and turned slightly to the contralateral side (depending on the location of the pathology), so that it falls away from the temporal lobe. The skin incision is made at the upper border of the eyebrow, extending from just lateral to the supraorbital notch medially to the lateral edge of the eyebrow till the fronto-zygomatic suture. The use of electrocautery is to be minimal in this approach, as it has cosmetic implications for wound healing. The cuff of pericranium is then elevated on the frontal side and retracted down anteriorly towards the face, and the frontal flap is retracted with scalp hooks backwards. A key burr hole is then made laterally under the temporalis muscle, and a keyhole craniotomy is then made flush with the orbital roof, just lateral to the supraorbital nerve and frontal sinus. The concept of ‘cheating’ in the keyhole surgery cannot be better explained than in the eyebrow approach. The orbital margins are then drilled and bevelled, and the undulations in the orbital roof are made flat. This ‘cheating’ increases the angle of vision considerably and allows an uninterrupted line of vision to the pathology during the entire surgery, with minimal or no brain retraction. The dura is then opened in a C-shaped fashion and retracted inferiorly (Figure 7).

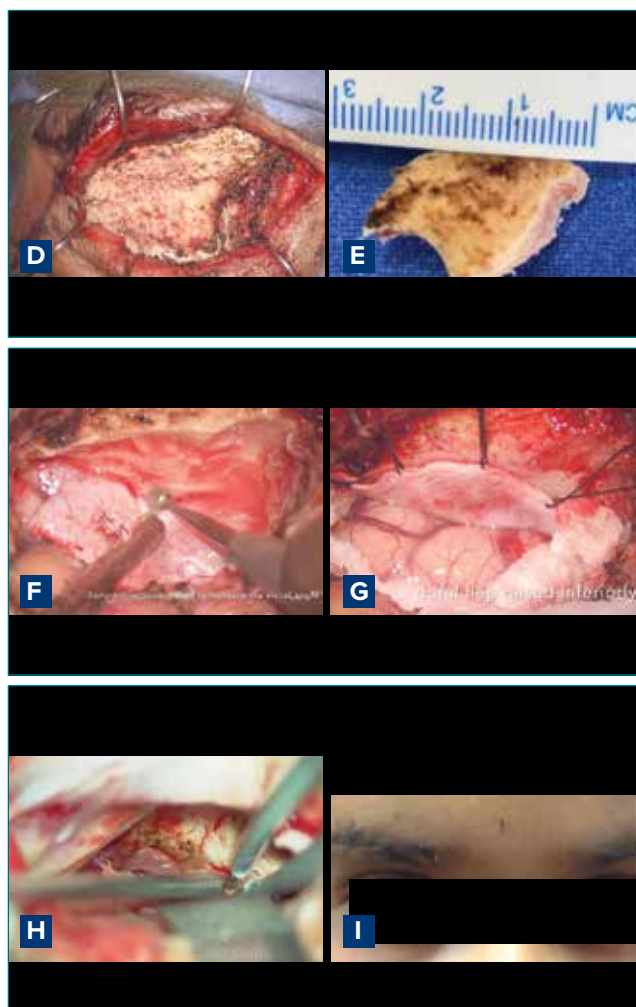
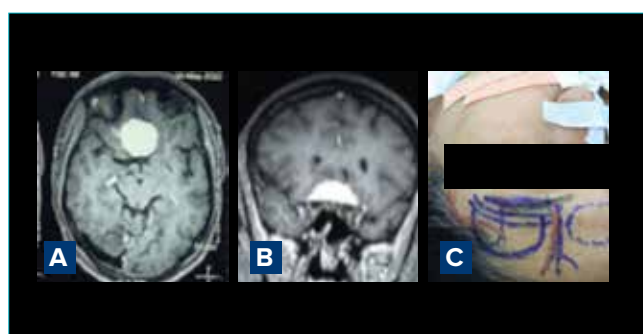


Figure 7A–I: Supra-orbital keyhole approach (SOKHA) for a planum meningioma: **A–B.** Preoperative axial and coronal contrast magnetic resonance imaging (MRI) images showing the extent of the tumour; **C.** Illustrative incision marking and surface marking of the craniotomy to aid in preoperative surgical planning. The head is positioned so that the malar eminence is the highest point, with the head slightly rotated contralaterally and slightly extended. The incision is preferably closer to the upper border of the eyebrow, and extends from slightly medial to the supra-orbital notch to the brow laterally; **D.** Demonstrating the bony exposure after the elevation of the cut end of the frontalis muscle and pericranial flap; **E.** Size of the bone flap; **F.** Showing the drilling of the bony projections in the orbital roof to increase the visual angle; **G.** Durotomy in a C-shaped fashion; **H.** Devascularisation of the tumour done by coagulating the attachment at the skull base; **I.** Postoperative photograph of another patient showing good cosmesis and a minimally visible scar.

The closure of the eyebrow incision must be meticulous to achieve excellent cosmetic outcomes. The frontal sinus, if opened, is carefully waxed and occluded with gel foam pieces. The pericranium is then approximated, and the frontalis muscle is sutured with 3-0 Vicryl sutures. The skin is then approximated using 3-0 nylon subcuticular sutures, which can be removed by pulling, on the 7th postoperative day.

A meta-analysis involving 2,191 tuberculum sellae meningiomas (TSMs) and 1,510 olfactory groove meningiomas (OGMs) in the endoscope-assisted supraorbital keyhole approach (eSKA) with microscopic transcranial approach (mTCA) and expanded endoscopic endonasal approach (EEA). The gross total resection (GTR) rates were 85% (TSM) — 85% (OGM) for eSKA, 90%/91% for mTCA, and 84%/83% for EEA.³ This suggests comparable efficacy, validating keyhole approaches for well-selected lesions.

Safety remains paramount. CSF leak rates were lowest in eSKA (1.6%–2.1%), followed by mTCA (1.6%–6.5%), and highest in EEA (9%–14%).¹² Mortality and arterial injury were consistently under 1% across approaches. Visual improvement for preoperative deficits stood at ~66% (TSM) — 53% (OGM) with eSKA, lagging behind EEA (~82%/55%) yet approaching mTCA (~64%/46%).

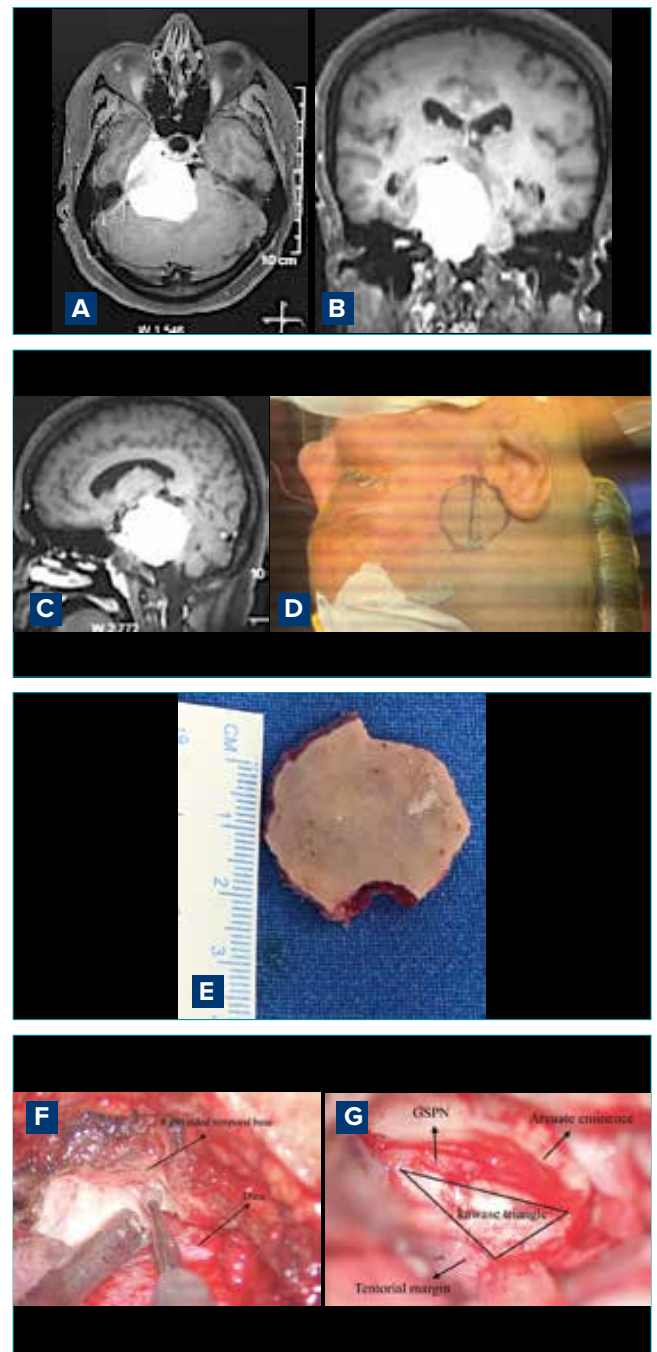
A large single-centre study involving eyebrow SOKHA vs traditional frontotemporal/bifrontal craniotomies for OGMs was reported. Thirty-two supraorbital approach (SOA) and 25 traditional transcranial approach (TTA) patients were included. The mean extent of resection (EOR) was not significantly different by approach (TTA: 99.1% vs SOA: 98.4%, $p = 0.91$). Olfaction was preserved or improved at similar rates (TTA: 47% vs SOA: 43%, $p = 0.99$). The mean length of stay (LOS) was significantly shorter for SOA patients (4.1 ± 2.8 days) than for TTA patients (9.4 ± 11.2 days) ($p = 0.002$). The authors found an association between an increase in postoperative fluid-attenuated inversion recovery (FLAIR) cerebral oedema and TTA ($p = 0.031$). Quality of life (QOL) as assessed by the anterior skull base questionnaire (ASBQ) at last follow-up did not differ significantly between groups ($p = 0.74$).¹⁴

Another retrospective study of 62 patients (64 operations) demonstrated 95% resection for meningiomas, 84% for craniopharyngiomas, 53% for pituitary adenomas, with no mortality and ~4.5% major complications. These findings confirm SOKHA's durable safety and efficacy, particularly for anterior skull base lesions.¹⁵

Subtemporal Keyhole Approach

The patient should be positioned with the head extended and turned maximally to the contralateral side, so that the temporal lobe falls away from the middle fossa floor. The mini-subtemporal craniotomy can be placed anteriorly for lesions of the middle fossa or anterior tentorial incisura, or slightly posteriorly for lesions of the lateral midbrain, tentorium or middle tentorial incisura. The exact location of the craniotomy has to be decided by using image guidance, placing it along the long axis of the lesion, extended to the surface or at least at the centre of the lesion.

The skin incision is a 2–3.5 cm skin incision running coronally and reaching up to the zygoma in case of an anterior craniotomy and running postero-superiorly or diagonally towards the pinna in the posterior approaches. The anterior craniotomies are made flush with the temporal base, while the posterior ones reach the transverse sigmoid sinus junction or are close to the middle fossa. The muscle is then split linearly along the direction of its fibres, retracted, and a 2–3 cm bone flap is then turned flush with the middle fossa floor. The vein of Labbe is to be protected during the subtemporal craniotomy. The mastoid air cells are taken care of by proper waxing if inadvertently opened. The dural opening is based inferiorly (Figures 8 and 9).



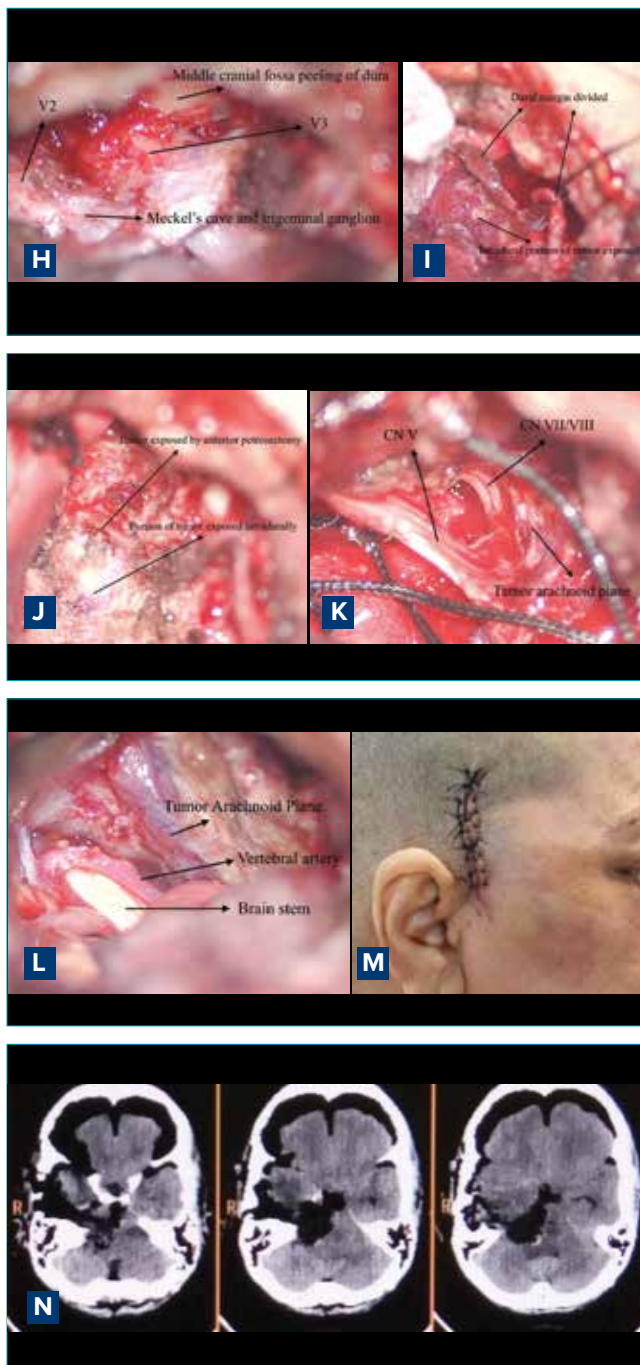


Figure 8: A–C. Contrast magnetic resonance imaging (MRI) of a right-sided petroclival meningioma primarily originating from the petrous apex and extending to the lower clivus; D. Patient placed on a horseshoe headrest. A 4 cm linear incision 1 cm anterosuperior to the tragus. The circular marking around the incision shows the size of the craniotomy; E. Craniotomy flap with size. A larger craniotomy than the incision size can be achieved by undermining the incision with the drill; F. Drilling of the temporal bone to reach the base of the middle cranial fossa. It is essential to make the temporal bone flat with the middle cranial fossa to have a better view during surgery. The reduced vision via keyhole approaches necessitates such steps. Peeling of the dura from the middle cranial fossa. The landmarks for surgery remain the same as in the conventional approach, but the window is smaller. A good understanding of anatomical relations is therefore important to guide direction. Neuro-navigation may assist in the direction of dissection but does not replace experience in anatomy; G. Margins of the Kawase

triangle (region for anterior petrosectomy), the anterior portion of the arcuate eminence, and the greater superficial petrosal nerve are demonstrated; H–J. Post-petrosectomy and exposure of the tumour, the dura is opened and an intradural approach is taken. The figure shows the intradural portion of the tumour. The dura is divided and tented up with sutures, achieving a combined view of the intra- and extradural tumour. Further opening of the anterior petrosectomy with a 1 mm Kerrison punch helps provide a holistic view of the lesion. Occasionally, tumour decompression needs to be started on the visible lesion to create space for this exposure; K. Dissection of the tumour from the cisternal portion of the V nerve and VII/VIII nerve complex; L. Keyhole view towards the end of dissection with exposure of the vertebrobasilar complex and dissection from the brainstem; M. Showing the skin incision; N. Immediate postoperative computed tomography (CT) showing gross total tumour removal with a keyhole craniotomy. **Abbreviations:** GSPN: Greater Superficial Petrosal Nerve; V2: Maxillary division of the Trigeminal Nerve; V3: Mandibular division of the Trigeminal Nerve; CN V: Cranial Nerve V; CN VII/VIII: Cranial Nerves VII and VIII.

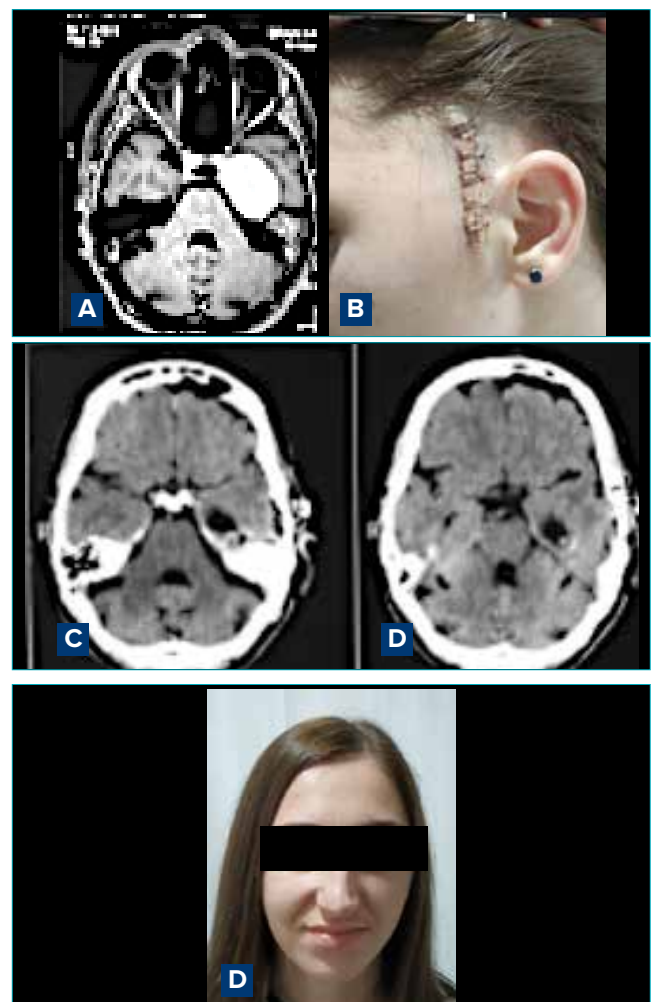


Figure 9A–E: Trigeminal schwannoma operated through a keyhole subtemporal approach: A. Contrast magnetic resonance imaging (MRI) in axial view showing the extent of the tumour; B. About 4 cm long linear incision was enough to remove such a formidable tumour. Such small incisions make the postoperative recovery faster, with minimal pain and excellent cosmesis; C–D. Postoperative computed tomography (CT) showing a good operative cavity; E. Happy patient in follow-up.

Morisako *et al.* described the details of a purely endoscopic subtemporal keyhole ATPA (eATPA) for petrous apex lesions.¹⁶ There have been numerous reports of keyhole approaches being described for petroclival meningiomas.¹⁷

Keyhole Retrosigmoid Approach

The keyhole retrosigmoid approach (KRSA) is similar to the standard conventional craniotomy, with which a neurosurgeon is familiar with. Any deep-seated lesion in the ventral posterior fossa, pons, or lateral cerebellum can be accessed with a keyhole retrosigmoid approach.¹⁸ The KRSA is also a valid choice for removing large vestibular schwannomas > 3 to 4 cm in size. Through this approach, the cerebellopontine angle can be effectively exposed. Skills to protect the facial nerve and extensive experience in microsurgical techniques can significantly improve the total resection rate and postoperative facial nerve function (Figures 10–12).^{18,19}

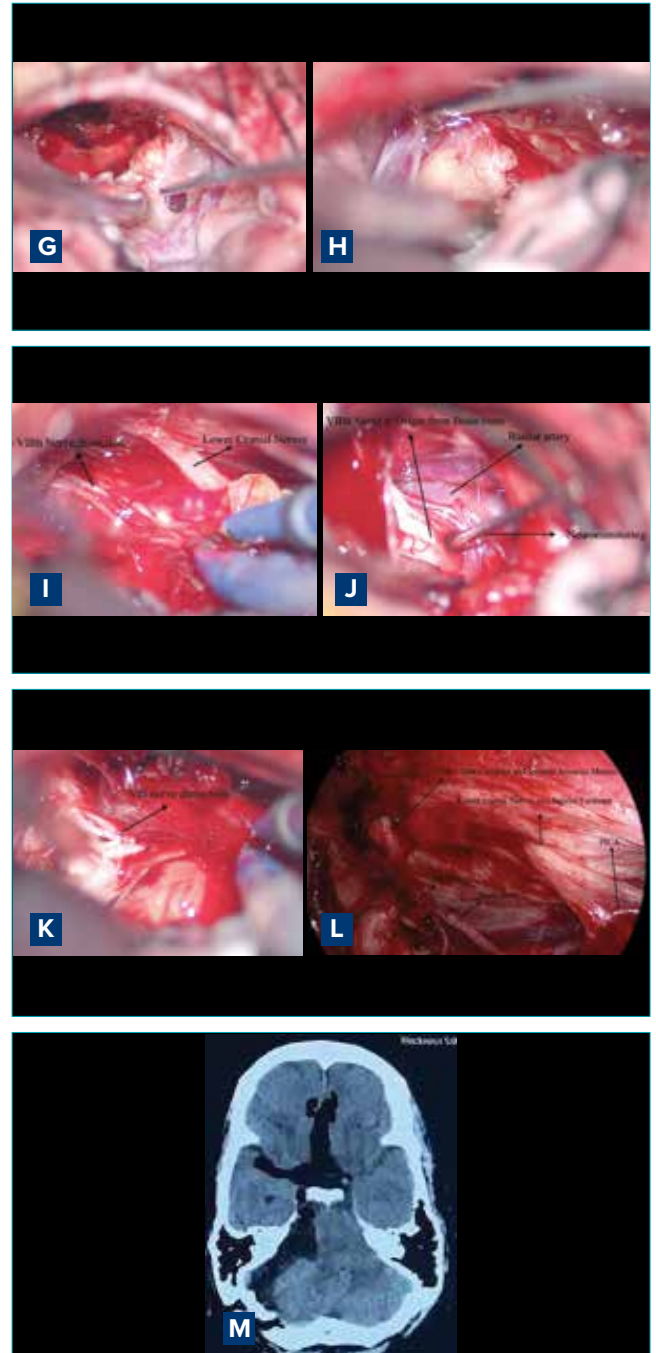
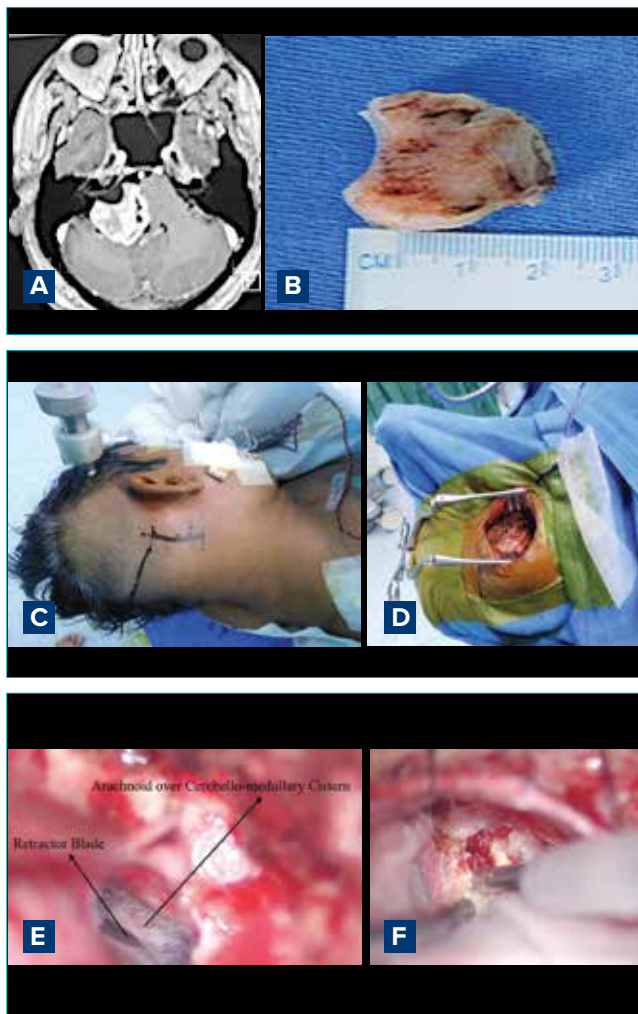


Figure 10: A. Preoperative contrast magnetic resonance imaging (MRI) of the patient showing a right-sided acoustic neuroma; **B.** Size of the craniotomy; **C.** Planning of the incision. The red line runs from the external acoustic meatus to the occipital protuberance and indicates the position of the transverse sinus. The incision is approximately 4 cm long and is lazy C-shaped; **D.** The completed bony exposure — the asterion is visualised, which marks the junction of the transverse and sigmoid sinuses. The burr hole should be placed here for making the craniotomy; **E.** Showing the first step after incising about 1 cm of dura at the lower edge — releasing the cerebrospinal fluid (CSF) from the lateral cerebellomedullary cistern. The dura is tented up with a suture and a retractor blade is inserted to retract the cerebellum and expose the arachnoid. A micro-scissors or needle dissector is then used to release the CSF and create space in the posterior fossa; **F.** Cavitron ultrasonic surgical aspirator (CUSA) decompression of the tumour after the overlying arachnoid has been peeled off the tumour

capsule; **G–H**. Medial and superior dissection of the tumour from the surrounding structures; **I–K**. Intact trigeminal, facial, and lower cranial nerves after gross total tumour removal. Neuromonitoring is used at every step during tumour dissection to detect the facial nerve. The facial nerve is then traced along its course and dissected from the tumour; **L**. Endoscopic view of the tumour cavity after tumour resection showing intact nerves and complete tumour resection; **M**. Immediate postoperative contrast computed tomography (CT) of the patient showing complete tumour resection. **Abbreviation:** PICA: Posterior Inferior Cerebellar Artery.

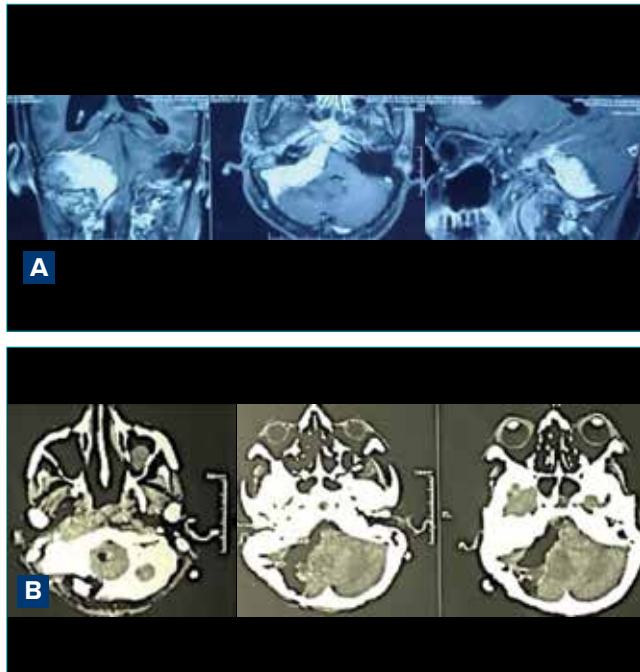


Figure 11: **A.** Preoperative contrast magnetic resonance imaging (MRI) of the patient with a right-sided cerebellopontine angle meningioma; **B.** Immediate postoperative computed tomography (CT) of the same patient showing complete tumour resection. Note the size of the right-sided keyhole retromastoid craniotomy.

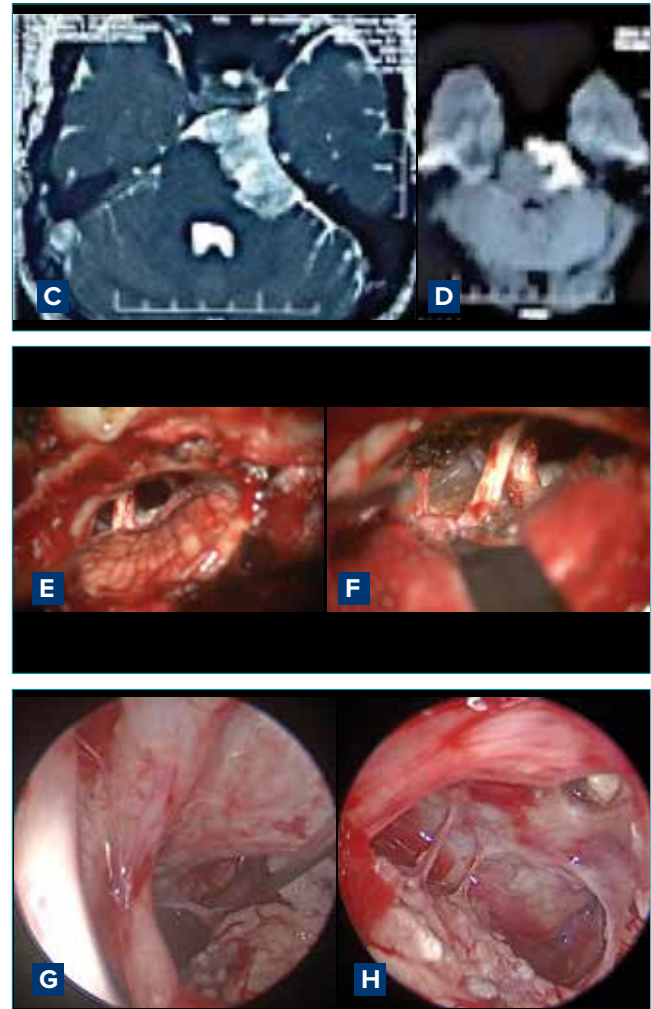
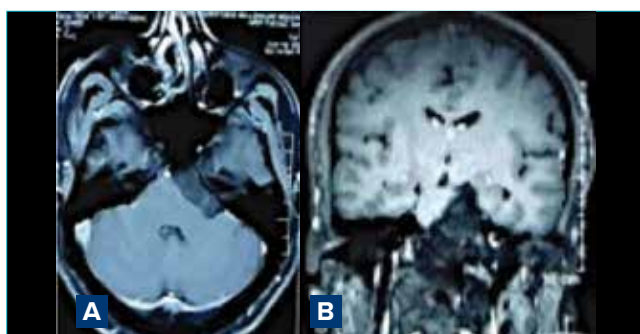


Figure 12A–H: Keyhole approach for a left cerebellopontine (CP) angle epidermoid: **A–C.** Preoperative magnetic resonance imaging (MRI) images showing the tumour in T1, T1 contrast, and T2-weighted sequences; **D.** Depicting diffusion-weighted imaging (DWI) with diffusion restriction, which is characteristic of an epidermoid; **E.** Microscopic image after keyhole retromastoid suboccipital (RMSO) craniotomy and durotomy showing the pearly white tumour located anterior to the VII–VIII nerve complex; **F.** Microscopic debulking of the tumour; **G.** Deployment of an angled endoscope and curved instruments is crucial to remove bits of tumour in the hidden areas; **H.** Endoscopic view of the resection cavity showing important structures after complete resection.

The patient positioning is of absolute paramount importance in performing a retrosigmoid approach. The patient is being positioned laterally with the affected side up. The position of the head with respect to the torso depends upon the diagnosis for which surgery is being performed. In the most used scenario, if the KRSA is being used for any cerebellopontine angle lesion like acoustic schwannomas, then the head is flexed maximally (to open up the cisterna magna), tilted downwards towards the floor about 20–30 degrees, and rotated ipsilaterally (to view the brainstem) or contralaterally (to view the petrous bone).

The ipsilateral shoulder is taped gently downwards, avoiding excessive traction (to prevent inadvertent brachial plexus injury), to open the working space between the head and shoulder.

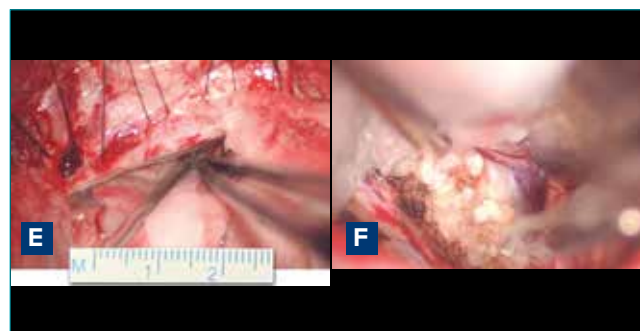
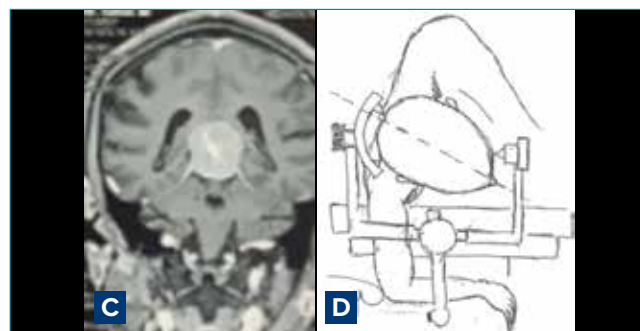
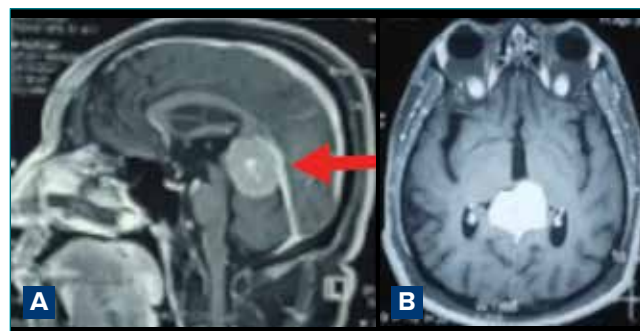
The incision is approximately 4 cm long and is a lazy C-shaped or a lazy S-shaped as depicted in the figure. The transverse–sigmoid sinus junction normally lies at the asterion, but we prefer to use image guidance always, as with all the keyhole craniotomies. A burr hole is fashioned here, and a 2–3 cm diameter craniotomy is made here for cerebellopontine and jugular foramen pathology, and slightly lower for petroclival region and Meckel's cave pathology. The edges of the craniotomy should extend until a portion of the transverse and sigmoid sinuses is seen. A small dural incision of about 0.5 cm is then made at the lower part of the craniotomy, and an attempt is made to reach the cisterna magna and sharply incise the arachnoid here to patiently release the CSF through this small dural opening. Once the cerebellum gets lax with this manoeuvre, a dural incision is then given in an inverted Y-shaped manner to complete the dural opening.

Keyhole Posterior Interhemispheric Approach (Mini-Poppen's Approach)

The minimally invasive techniques avoiding unnecessary tissue injuries were applied to refine traditional approaches for the removal of third ventricular tumours within a limited operative field.²⁰ These approaches allowing access to tumours of the pineal region are — keyhole lateral supracerebellar, midline/paramedian infratentorial supracerebellar, anterior interhemispheric transcallosal and occipital transtentorial. The posterior third ventricular tumours can be accessed through the anterior interhemispheric transcallosal approach. The position of the vein of Galen in the mid-sagittal cut magnetic resonance imaging (MRI) with respect to the tumour dictates the approach. The posterior third ventricular tumours push the vein downwards and posteriorly, while the pineal tumours push it upwards and forwards.

These deep-seated tumours are the best suited for these keyhole approaches. Choosing between the keyhole occipital transtentorial and midline/paramedian infratentorial supracerebellar approach depends upon several factors such as the long axis of the tumour, angle of the tentorium and venous anatomy. The midline/paramedian infratentorial supracerebellar is generally preferred when the long axis of the tumour projects to a point below the inion, while the keyhole occipital transtentorial is chosen when this long axis projects to a point above the inion.

A lateral 3/4th oblique position is preferred for the keyhole occipital transtentorial approach, with the head end elevated and tilted 30° upwards (Figure 13). The incision (generally 4–6 cm in length) is linear and paramedian 1 cm lateral to the midline. The craniotomy is a long, thin one flush with the sagittal sinus. The dural flap is raised based on the sinus. The access to the falco-tentorial junction is achieved through meticulously approaching the interhemispheric cistern, dividing the arachnoid bands and draining the CSF, making the occipital lobe lax, without retraction (aided by gravity), and absolutely avoiding any injury to the lobe. Good anaesthesia is critical for this approach to avoid the occipital lobe from bulging out. Any bridging veins should be absolutely preserved and once the tentorial incisura is reached, an attempt is made to release the CSF, after which occipital lobe is further relaxed, and ample space is achieved even through this keyhole craniotomy. The straight sinus is identified and tentorium is divided. Any brisk bleeding encountered during the cutting of the tent is dealt with by cautery.



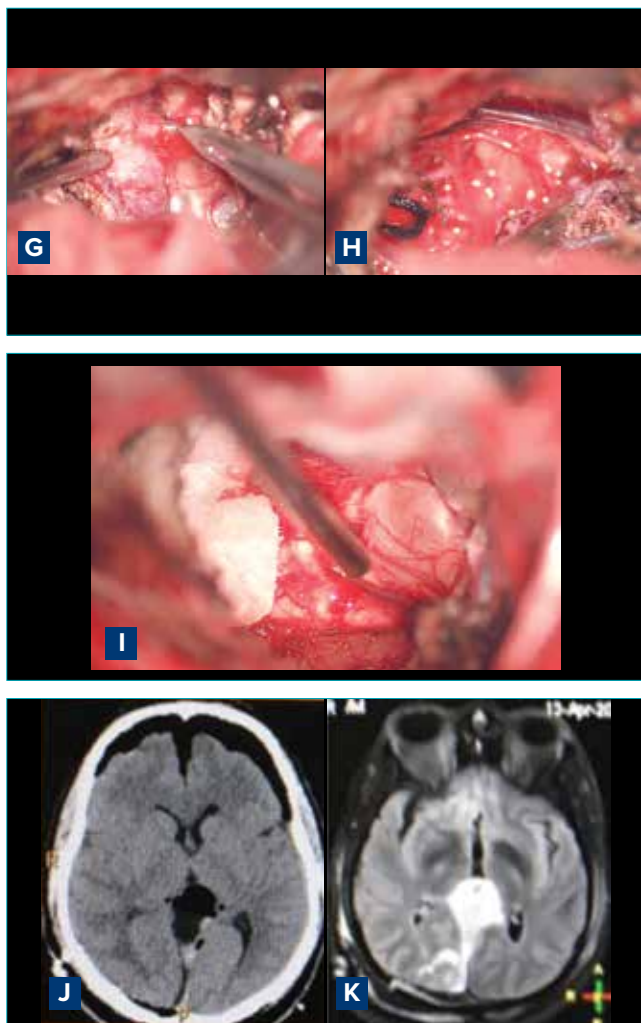


Figure 13A-K: Demonstrating keyhole approach for a falcotentorial meningioma operated via a keyhole occipital transtentorial approach: **A–C.** Preoperative contrast magnetic resonance imaging (MRI) images showing the tumour extent in sagittal, axial, and coronal views; **D.** Pictorial diagram showing the positioning of the patient in a three-quarter prone position with the ipsilateral side down; **E.** Durotomy done based on the superior sagittal sinus. Gravity-aided retraction of the ipsilateral occipital lobe done to expose the tumour; **F–G.** Devascularisation and decompression of the tumour; **H.** Continued tumour decompression and dissection from the vein of Rosenthal and vein of Galen; **I.** Microscopic view of the resection cavity with the posterior wall of the third ventricle seen after total tumour resection; **J.** Immediate postoperative computed tomography (CT) showing a good postoperative cavity; **K.** Follow-up MRI showing gross total resection.

Keyhole Supracerebellar Infratentorial Approach

The sitting position is preferred for this approach (Figure 14). The head is flexed maximally at the occipito-atlantal joint, keeping two finger space between the chin and manubrium. An imaginary line is extrapolated from the outer canthus to the external occipital protuberance. This line marks the surface marking of the tentorium. The head is flexed till this line is parallel to the ground. A pillow is adjusted behind the upper back.

A 4–6 cm vertical skin incision is given in the midline and a craniotomy located just inferior to the transverse sinus is performed using a high-speed drill. The dura is opened in a U-shaped manner and reflected superiorly to expose the space between the cerebellum and tentorium. The draining veins should be preserved as much as possible to prevent venous infarction and postoperative neurological deficits.



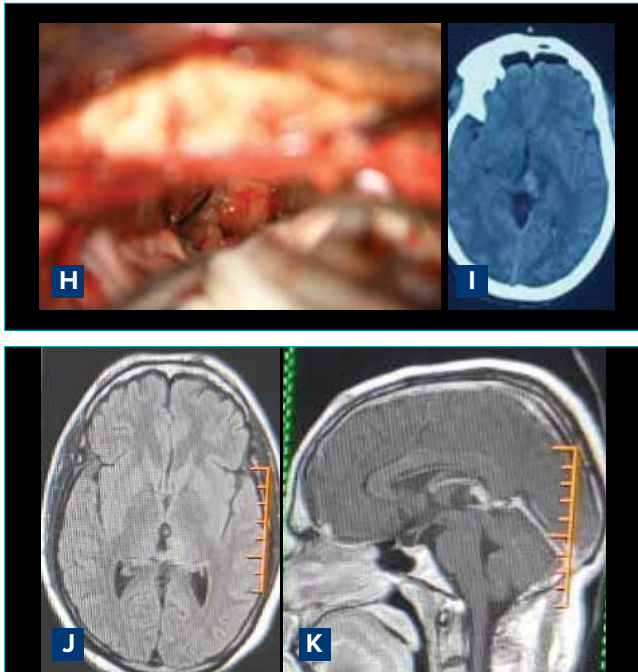


Figure 14A–L: Keyhole midline suboccipital approach for a pineal region tumour operated via the supracerebellar infratentorial (Krause) approach in the sitting position: **A–C.** Preoperative contrast magnetic resonance imaging (MRI) images showing the tumour extent in sagittal, axial, and coronal views; **D–E.** Patient in the sitting position with the head fixed on a Mayfield 3-pin head holder. Adequate padding of all pressure points is essential; **F.** 2 × 3 cm midline suboccipital craniotomy is made, and it is essential to expose the lower margin of the transverse sinus; **G.** Gravity-aided retraction of the cerebellum is done inferiorly. A few bridging veins might have to be sacrificed. The precentral cerebellar vein can also be divided if required; **H.** Tumour seen after the dissection; **I.** Immediate postoperative computed tomography (CT) showing a satisfactory tumour cavity; **J–K.** Follow-up magnetic resonance imaging (MRI) of the patient after 6 months; **L.** Postoperative clinical photograph depicting preserved upgaze eye movements.

Conclusion

Keyhole approaches to skull base tumours represent a paradigm shift in neurosurgical practice, prioritising minimal invasiveness without compromising surgical efficacy. Over the past two decades, growing anatomical knowledge, advanced neuroimaging, neuro-navigation, and endoscopic integration have collectively enhanced the precision and safety of these approaches. Clinical studies have consistently demonstrated that keyhole strategies, such as the supraorbital, retrosigmoid, endonasal endoscopic, and combined mini-craniotomies, can achieve gross total or near-total resections in appropriately selected patients, with complication rates comparable to, or lower than, those of traditional craniotomies.

However, keyhole surgery requires rigorous case selection and a steep learning curve. The limited working corridor demands refined microsurgical skills, detailed anatomical understanding, and experience with endoscopic or microscopic assistance. In conclusion, keyhole approaches are a powerful, evidence-based addition to the skull base surgeon's repertoire. When employed judiciously, they have the potential to replace the time-consuming morbid skull base approaches, can improve outcomes, minimise morbidity, and meet the increasing demand for patient-centred, minimally invasive neurosurgical care.

Sumit Sinha. Surgical Minimalism in Neurosurgery: The “Keyhole” Concept. MMJ. 2026, June. Vol 3 (2).

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References

1. Burks JD, Conner AK, Bonney PA, et al. Management of Intracranial Meningiomas Using Keyhole Techniques. *Cureus*. 2016;8(4):e588.
2. Lan Q, Sughrue M, Hopf NJ, et al. International expert consensus statement about methods and indications for keyhole microneurosurgery from International Society on Minimally Invasive Neurosurgery. *Neurosurg Rev*. 2021;44(1):1–17.
3. Lan Q, Sughrue ME, Briggs RG. Minimally invasive keyhole techniques for resection of giant intracranial tumors. *Chin Neurosurg J*. 2022;8(1):19.
4. Fischer G, Stadie A, Reisch R, et al. The keyhole concept in aneurysm surgery: results of the past 20 years. *Neurosurgery*. 2011;68(1 Suppl Operative):45–51.
5. Perneczky A, Reisch R. Volume 1: Concept and Surgical Technique. Keyhole Approaches in Neurosurgery. Vienna: Springer; 2009.
6. Teo, Charles, Michael E Sughrue. Principles and Practice of Keyhole Brain Surgery. Stuttgart; Thieme, 2015.
7. Reisch R, Stadie A, Kockro RA, et al. The keyhole concept in neurosurgery. *World Neurosurg*. 2013;79(2 Suppl):S17.e9–S17.e13.
8. Figueiredo EG, Deshmukh P, Nakaji P, et al. The minipterional craniotomy: technical description and anatomic assessment. *Neurosurgery*. 2007;61(5 Suppl 2):256–65.
9. Ormond DR, Hadjipanayis CG. The Supraorbital Keyhole Craniotomy through an Eyebrow Incision: Its Origins and Evolution. *Minim Invasive Surg*. 2013;2013:296469.
10. Valerio J, Fernandez Gomez MP, Ayala Arcipreste A, et al. Exploring the Potential Use of Virtual Reality with a Supraorbital Keyhole Craniotomy for Anterior Skull Base Meningiomas: Two Case Reports. *J Pers Med*. 2024;14(11):1074.
11. Khan DZ, Muskens IS, Mekary RA, et al. The endoscope-assisted supraorbital "keyhole" approach for anterior skull base meningiomas: an updated meta-analysis. *Acta Neurochir (Wien)*. 2021;163(3):661–76.
12. Cai M, Ye Z, Ling C, et al. Trans-eyebrow supraorbital keyhole approach in suprasellar and third ventricular craniopharyngioma surgery: the experience of 27 cases and a literature review. *J Neurooncol*. 2019;141(2) 363–71.
13. Igressa A, Pechlivanis I, Weber F, et al. Endoscope-assisted keyhole surgery via an eyebrow incision for removal of large meningiomas of the anterior and middle cranial fossa. *Clin Neurol Neurosurg*. 2015;129:27–33.
14. Bander ED, Pandey A, Yan J, et al. Olfactory groove meningiomas: supraorbital keyhole versus orbitofrontal, frontotemporal, or bifrontal approaches. *J Neurosurg*. 2023;140(6):1568–75.
15. Lin YJ, Chen KT, Lee CC, et al. Anterior Skull Base Tumor Resection by Transciliary Supraorbital Keyhole Craniotomy: A Single Institutional Experience. *World Neurosurg*. 2018;111:e863–e870.
16. Morisako H, Sasaki T, Ikegami M, et al. Purely endoscopic subtemporal keyhole anterior transpetrosal approach to access the petrous apex region: surgical techniques and early results. *J Neurosurg*. 2024;141(3):752–61.
17. Zhu W, Mao Y, Zhou LF, et al. Keyhole approach surgery for petroclival meningioma. *Chin Med J (Engl)*. 2006;119(16):1339–42.
18. Daming C, Yiwen S, Bin Z, et al. Large vestibular schwannoma resection through the suboccipital retrosigmoid keyhole approach. *J Craniofac Surg*. 2014;25(2):463–68.
19. Hoshida R, Faulkner H, Teo M, et al. Keyhole retrosigmoid approach for large vestibular schwannomas: strategies to improve outcomes. *Neurosurg Focus*. 2018;44(3):E2.
20. Lan Q, Dong J, Huang Q. Minimally invasive keyhole approaches for removal of tumors of the third ventricle. *Chin Med J (Engl)*. 2006;119(17):1444–50.

Virtual Reality in Robotic Surgery: Training, Skill Transfer, and Preoperative Planning — A Narrative Review

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Abstract:

Robotic surgery demands a high level of psychomotor coordination, cognitive processing, and visuospatial ability, making effective training essential for safe and proficient practice. Traditional apprenticeship-based training models face limitations, including restricted operative exposure, variability in case availability, and concerns regarding patient safety. In response, virtual reality (VR) simulation has been increasingly adopted as an innovative tool to supplement surgical education. VR platforms provide a controlled, reproducible, and risk-free environment for trainees to develop and refine technical skills, while offering opportunities for objective performance assessment. Beyond training, VR has expanded into preoperative planning and intraoperative navigation, enabling enhanced anatomical visualisation and procedural rehearsal. As the body of evidence supporting these applications continues to grow across multiple surgical specialities, there is a need to synthesise current findings to better understand the clinical relevance and potential integration of VR technologies into structured robotic surgery curricula.

Key words: Virtual Reality, Robotic Surgery, Surgical Simulation, Preoperative Planning, Skill Transfer.

Introduction

Robotic-assisted surgery has become an integral component of modern surgical practice and provides enhanced three-dimensional vision, intricate instrument capability, and superior surgeon ergonomics relative to other laparoscopic techniques. Notwithstanding this, robotic-assisted technique also imposes new technical considerations on the surgeon, including indirect instrument control, loss of tactile feedback, and reliance on visuospatial skills. Taken together, these factors contribute to a steep learning curve and raise concerns regarding patient safety during the early use of this technique by novice trainee surgeons.^{1,2}

The classical apprentice model of surgical training faces twin challenges related to reduced operative exposure and ethical concerns surrounding trainee involvement in

surgery, alongside the growing demand for independent assessment of technical competence. Consequently, simulation-based assessment has been recognised as a cornerstone of competency-based surgical education. Virtual reality (VR) simulation provides a risk-free learning environment in which trainees can practice until proficiency is achieved without exposing patients to harm.^{1,2}

A high level of evidence from randomised controlled trials, systematic reviews, and meta-analyses has demonstrated that VR-based robotic simulation training improves technical skill performance and facilitates transfer of skills to the operating room. Furthermore, simulation-derived performance metrics have shown predictive value for operative performance in real-world clinical settings.¹⁻⁴

Beyond training, VR technologies have expanded into preoperative planning and intraoperative navigation.

Patient-specific VR models reconstructed from cross-sectional imaging enable immersive anatomical visualisation and procedural simulation, particularly for anatomically complex procedures such as robotic prostatectomy, nephrectomy, thoracic surgery, and neurosurgery.⁴⁻⁷ In light of the continued expansion of VR applications in robotic surgery, a comprehensive synthesis of the existing evidence is warranted.

Methods

This narrative review follows PRISMA guidance where applicable. A structured literature search was carried out across peer-reviewed journals to identify studies that evaluated VR and augmented reality (AR) technologies in robotic surgery training, planning, and navigation.

The included studies had to involve assessment of VR-based simulation for robotic surgical training, skill transfer to the operating room, or use of VR/AR in preoperative planning or intraoperative navigation. Data were synthesised narratively due to heterogeneity in study designs and outcomes as well as VR platforms. Conference proceedings and technical reports were included only if they provided relevant clinical or educational insights.

Results

VR for robotic surgical training

Several randomised controlled trials have established that VR-based robotic simulation significantly enhances technical performance compared with conventional training alone. Trainees exposed to VR simulation demonstrate reduced error rates, improved economy of motion, and faster completion of tasks in live robotic procedures.^{1,2}

These findings are further supported by systematic reviews and meta-analyses, which also confirm improvements in fundamental robotic skills such as camera control, bimanual dexterity, and depth perception. Collectively, these studies establish strong construct validity for VR simulators and their role within structured training curricula.^{1,2}

Recent developments have focused on enhancing simulator fidelity. Haptic-enhanced VR systems in orthopaedic and trauma-related robotic applications demonstrate improved realism by simulating force feedback during bone manipulation and fracture fixation. Such advances may further bridge the gap between simulation and live surgery.³

Skill transfer and predictive validity

Transferability of skills acquired through VR simulation to the operating room represents a critical determinant of clinical relevance. Meta-analytic evidence confirms that surgeons trained using VR simulation demonstrate superior intraoperative performance compared with those trained using traditional methods alone.^{3,8}

Mastery-based VR training platforms require trainees to meet predefined proficiency benchmarks before progression and have demonstrated improved skill acquisition while reducing inter-trainee variability. Simulator-derived performance metrics have also shown predictive validity for operative competence, further supporting their use within assessment and credentialing frameworks.⁵

Preoperative planning and surgical navigation

VR-based preoperative planning allows immersive, patient-specific visualisation of complex anatomy. In urology, randomised clinical trials have demonstrated improved surgical decision-making and functional outcomes following VR-assisted planning for robotic prostatectomy.⁶ Similarly, VR models developed for robotic partial nephrectomy provide enhanced understanding of tumour location, renal vasculature, and resection strategy.⁹

In thoracic surgery, VR planning systems enhance spatial orientation and appreciation of tumour relationships with adjacent structures, potentially facilitating safer resections. Neurosurgical applications include VR simulation for robotic transsphenoidal tumour resection, enabling procedural rehearsal and evaluation of motion scaling within confined operative corridors.^{10,11}

AR and system integration

Integration of VR and AR into robotic systems has demonstrated technical feasibility in experimental and early clinical settings. Magnetic resonance imaging (MRI)-based VR navigation tools have been developed for robotic-assisted radical prostatectomy, providing enhanced anatomical guidance.¹² Early case series using synchronised VR and AR platforms suggest potential benefits for intraoperative navigation; however, larger studies are required to determine their clinical impact.¹³

Discussion

This review combines the latest evidence concerning the use of VR in robotic surgery. The main themes discussed include surgical training, skill transfer, preoperative planning, and intraoperative navigation. Across different surgical specialities, robotic surgery provides enhanced visualisation, dexterity, and ergonomics. However, it is associated with a steep learning curve due to indirect instrument control and the absence of tactile feedback. Consequently, VR-based technologies have been proposed as a means to overcome these challenges, with increasing evidence demonstrating their educational as well as procedural relevance.¹⁻³

The strongest evidence identified relates to the application of VR simulation in training robotic surgical skills. Robotic surgery requires advanced psychomotor skills that differ from those used in open or conventional laparoscopic surgery, including three-dimensional spatial awareness, bimanual coordination, and precise camera control. Randomised controlled trials and meta-analyses consistently demonstrate that VR-based training significantly improves these fundamental skills, whereas traditional training alone yields comparatively limited benefits.^{1,3} These improvements are clinically relevant, as inadequate technical skills during early robotic experience have been associated with prolonged operative times and increased technical errors.

A key strength of VR simulation lies in its alignment with competency-based surgical education, representing a departure from traditional apprenticeship-based models that rely heavily on case volume. VR simulators provide objective and reproducible performance metrics, including task completion time, instrument path length, and error frequency, enabling structured feedback, benchmarking, and longitudinal assessment of trainee progression.¹ Meta-analytic evidence further demonstrates a correlation between simulator-derived metrics and intraoperative performance, supporting the construct and predictive validity of VR-based assessment tools.³

The transfer of skills acquired through VR simulation to the operating room is central to determining the clinical value of these training modalities. High-level evidence indicates that surgeons trained using VR simulation perform better intraoperatively than those trained exclusively through conventional methods, with greater

efficiency and fewer technical errors.³ These findings counter concerns that simulation-based training may not translate to real-world surgical performance and support the integration of VR into structured robotic surgery curricula.²

Mastery-based VR training platforms further enhance the effectiveness of simulation by requiring trainees to achieve predefined proficiency thresholds before progression. Evidence suggests that such platforms promote more consistent skill acquisition and reduce inter-trainee variability, potentially contributing to safer and more reliable operative performance.⁵

Despite these advantages, limitations in simulator fidelity persist. Robotic surgery is inherently challenging due to the absence of tactile sensation, as surgeons cannot directly feel tissue interaction. Traditional VR systems have struggled to replicate haptic feedback accurately. Recent developments in haptic-enabled VR simulators aim to address this limitation by incorporating force-feedback mechanisms that simulate tissue resistance and bone interaction. Early studies in robot-assisted orthopaedic and trauma surgery suggest improved realism and user engagement; however, robust evidence demonstrating improved intraoperative outcomes remains limited.¹¹

Beyond training, VR has demonstrated growing clinical utility in preoperative planning for robot-assisted surgery. Patient-specific VR models derived from computed tomography or MRI allow surgeons to immerse themselves in complex anatomy within a three-dimensional environment. Randomised clinical trials in urology have shown that VR-assisted planning for robotic prostatectomy improves surgical decision-making and functional outcomes, including continence and erectile function.⁴

These findings suggest that enhanced anatomical understanding may translate into tangible patient benefits. Similarly, VR-based planning for robotic partial nephrectomy improves visualisation of tumour location, renal vasculature, and resection margins, potentially reducing intraoperative uncertainty and ischaemia time.⁶ In robotic thoracic surgery, VR planning tools enhance spatial orientation and comprehension of tumour relationships to vascular and bronchial structures, which is particularly valuable in minimally invasive procedures where tactile cues are absent.⁷

The high precision required in neurosurgery underscores the relevance of VR applications in this field. VR simulation of robotic transsphenoidal brain tumour resection enables procedural rehearsal within confined anatomical spaces and facilitates evaluation of motion scaling, potentially improving surgical accuracy.¹⁰ Review studies further highlight the value of VR and augmented reality in neurosurgical education, spatial orientation, and operative rehearsal.^{9,14}

The integration of VR with AR and navigation systems represents an important emerging direction in robotic surgery. MRI-based VR navigation tools have been developed to enhance anatomical guidance during robotic-assisted radical prostatectomy, improving intraoperative orientation relative to critical structures.⁷ Early clinical experiences with synchronised VR and AR platforms suggest improved alignment between preoperative planning and intraoperative anatomy; however, current evidence remains limited to small case series.¹⁵

Limitations

Several limitations of the existing evidence base regarding virtual reality (VR) in robotic surgery must be acknowledged, despite promising findings. Firstly, considerable heterogeneity exists in terms of VR platforms, training curricula, and outcome measures, thereby hindering direct comparisons across studies. Few studies assess only short-term technical outcomes, while long-term skill retention and patient-centred endpoints

remain largely unexplored. Moreover, the cost and technical infrastructure necessary for VR systems may restrict the adoption of such technology in resource-constrained settings.^{1,2}

Secondly, studies evaluating VR-based robotic training mostly address short-term technical outcomes measured immediately after simulation or early operative exposure. While improvements in task performance, error rates, and efficiency have been consistently reported, data on long-term skill retention and sustained operative competence remain scarce.^{2,5} How VR-acquired skills persist over time, particularly in low-volume robotic practices, remains an open question.

Thirdly, although the evidence supporting VR as a training tool is substantial, data regarding its use in preoperative planning and intraoperative navigation remain limited. Most studies in these domains are observational, single-centre investigations, or small case series, particularly in neurosurgical and thoracic applications.^{7,14,15}

Another challenge that persists while using VR is the difference in simulator quality. It is necessary to evaluate how well surgeons retain their skills over time. Additional research is also required on how VR affects patient outcomes.^{7,13} VR can be expensive and requires a lot of infrastructure.^{1,2} This can act as a barrier in certain clinical scenarios.

Conclusion

VR has evolved from being an adjunctive educational tool to a key component in the training of and planning for robotic surgery.^{1,2,4} Evidence already exists to support its effectiveness; it enhances technical performance, facilitates skill transfer, and improves preoperative planning and navigation. Greater integration of VR into structured, proficiency-based robotic surgery curricula may ensure quality and safety for patients. Further studies are needed to standardise implementation and evaluate the long-term clinical impact of this technology.

Future research should focus on creating VR training protocols.⁷ There is a need to evaluate the long-term effects of virtual reality on patients.^{6,13} There is also a need to combine technologies to improve both surgical training and patient care.^{12,14} Overall, VR has the potential to greatly improve surgery and patient care. This is true when VR is used in a planned and evidence-based manner. By focusing on VR simulation, one can ensure that surgeons are well-prepared. Patients are likely to receive the best care possible with the help of VR.

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References

1. Kawashima K, Nader F, Collins JW, *et al.* Virtual reality simulations in robotic surgery training: a systematic review and meta-analysis. *J Robot Surg.* 2024;19(1):29.
2. Ujiie H, Chiba R, Yamaguchi A, *et al.* Developing a virtual reality simulation system for preoperative planning of robotic-assisted thoracic surgery. *J Clin Med.* 2024;13(2):611.
3. Alruwaili FH, Halim-Banoub DW, Rodgers J, *et al.* Haptic-enhanced virtual reality simulator for robot-assisted femur fracture surgery. In: 21st International Conference on Ubiquitous Robots (UR). 2024 Jun 24;[New York]. IEEE; 39–44.
4. Covaciu F, Crisan N, Vaida C, *et al.* Integration of virtual reality in the control system of an innovative medical robot for single-incision laparoscopic surgery. *Sensors (Basel).* 2023;23(12):5400.
5. Das S, Vyas S. In: 4th International Conference on Information Management & Machine Intelligence. [Internet]. 2022 Dec 23;[Jaipur, India]. 1–8.
6. Shirk JD, Reiter R, Wallen EM, *et al.* Effect of 3-dimensional, virtual reality models for surgical planning of robotic prostatectomy on trifecta outcomes: A randomized clinical trial. *J Urol.* 2022;208(3):618–25.
7. Radi I, Tellez JC, Alterio RE, *et al.* Feasibility, effectiveness and transferability of a novel mastery-based virtual reality robotic training platform for general surgery residents. *Surg Endosc.* 2022;36(10):7279–87.
8. Schmidt MW, Köppinger KF, Fan C, *et al.* Virtual reality simulation in robot-assisted surgery: meta-analysis of skill transfer and predictability of skill. *BJS Open.* 2021;5(2):zraa066.
9. Shirk JD, Kwan L, Saigal C. The use of 3-dimensional, virtual reality models for surgical planning of robotic partial nephrectomy. *Urology.* 2019;125:92–7.
10. Fiani B, De Stefano F, Kondilis A, *et al.* Virtual reality in neurosurgery: “can you see it?”—A review of the current applications and future potential. *World Neurosurg.* 2020;141:291–8.
11. Heredia-Pérez SA, Harada K, Padilla-Castañeda MA, *et al.* Virtual reality simulation of robotic transsphenoidal brain tumor resection: Evaluating dynamic motion scaling in a master-slave system. *Int J Med Robot.* 2019;15(1):e1953.
12. Mehralivand S, Merino MJ, Harmon S, *et al.* A multiparametric magnetic resonance imaging-based virtual reality surgical navigation tool for robotic-assisted radical prostatectomy. *Turk J Urol.* 2019;45(5):357–65.
13. Louis RG, Steinberg GK, Duma C, *et al.* Early experience with virtual and synchronized augmented reality platform for preoperative planning and intraoperative navigation: a case series. *Oper Neurosurg.* 2021;21(4):189–96.
14. Long Y, Cao J, Deguet A, *et al.* Integrating artificial intelligence and augmented reality in robotic surgery: An initial dVRK study using a surgical education scenario. In: International Symposium on Medical Robotics (ISMR) [Internet]. ISMR 2022 Apr 13;[Georgia]. IEEE; 2022. 1–8.
15. Raison N, Harrison P, Abe T, *et al.* Procedural virtual reality simulation training for robotic surgery: A randomised controlled trial. *Surg Endosc.* 2021;35(12):6897–902.

A Paradigm Shift in Respiratory Syncytial Virus Prevention in Infants

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Abstract:

Respiratory syncytial virus (RSV) is the leading cause of lower respiratory tract infections (LRTIs) such as bronchiolitis and pneumonia in infants and young children worldwide, with the highest burden occurring during the first six months of life. Infants are particularly susceptible because of their narrow airways, immature immune responses, developing lungs, and decline in maternally derived antibodies, resulting in a high risk of severe bronchiolitis, hypoxia, respiratory failure, hospitalisation, and mortality. India contributes substantially to the global RSV burden, with a significant proportion of RSV-related deaths occurring in community settings before timely access to healthcare. In addition to acute illness, severe RSV infection in infancy is associated with long-term respiratory sequelae, including recurrent wheezing, asthma, and impaired pulmonary function. As effective antiviral therapies remain limited, prevention has become the cornerstone of RSV control. Recent advances in RSV prevention, including long-acting monoclonal antibodies and maternal immunisation, have transformed the preventive landscape. Nirsevimab, a long-acting monoclonal antibody targeting the prefusion F protein of RSV, provides rapid and sustained protection with a single intramuscular dose and has demonstrated substantial reductions in medically attended RSV-LRTIs and RSV-related hospitalisations in both clinical trials and real-world studies. International health organisations and national paediatric bodies now recognise RSV prevention as a major public health priority. These advances represent a paradigm shift in infant RSV prevention with the potential to significantly reduce RSV-associated morbidity, hospitalisation, mortality, and long-term respiratory complications, particularly in high-burden settings such as India.

Key words: Respiratory Syncytial Virus (RSV), Bronchiolitis, Infant Pneumonia, Nirsevimab, Maternal Immunisation, Monoclonal Antibody, RSV Prevention, Infant Respiratory Infection.

Introduction

Respiratory syncytial virus (RSV) is the leading cause of lower respiratory tract infection (LRTI), bronchiolitis, and pneumonia in infants and young children globally.^{1,2} Despite decades of recognition, RSV continues to impose a substantial and often underestimated burden of disease, particularly during the first year of life, when infants are biologically most vulnerable.^{2,3} The absence of effective antiviral therapy and the early age at which severe disease occurs make prevention the cornerstone of RSV control.^{3,4} The advent of maternal vaccines and

long-acting monoclonal antibodies against RSV marks a turning point in RSV prevention.^{4,5}

Why does RSV Cause Disproportionately Severe Disease in Infants?

Infants are uniquely susceptible to RSV due to anatomical, physiological, and immunological immaturity.^{3,6,7} Infant bronchioles are narrow, and even minimal mucosal oedema can critically impair airflow. A reduction in bronchiolar diameter from 4 mm to 2 mm due to circumferential oedema results in an approximately

75% reduction in airway cross-sectional area in infants, compared with nearly 43% in adults.^{3,6} This explains the rapid progression from mild upper respiratory symptoms to severe bronchiolitis, hypoxia, and respiratory failure.^{3,6}

In parallel, infants have immature innate and adaptive immune responses, developing lungs, and declining transplacentally acquired maternal antibodies.⁵ Very preterm neonates have a further disadvantage as they have immature lungs, altered airway mechanics, and lower levels of maternal antibodies.^{3,7}

RSV bronchiolitis is most common between 30–90 days of age, and chronological age is the single strongest predictor of severe disease.² Approximately 65%–70% of RSV-related hospitalisations and nearly 50% of RSV-associated deaths occur within the first five months of life.^{4,5}

Mortality and Disease Burden: Global and Indian Perspective

Globally, RSV is recognised as the leading respiratory infectious cause of death in infants.^{1,2} Mortality in children under one year accounts for more than 70% of all RSV-related deaths among children under five years of age, highlighting the extreme vulnerability of early infancy.^{4,5} Importantly, most RSV-related deaths occur in the community, before infants can access timely medical care.⁷ In infancy, mortality attributable to RSV is approximately equivalent to the combined mortality from rotavirus and *Streptococcus pneumoniae*.⁵

India carries a disproportionately high share of the global RSV burden.^{2,4} Large prospective surveillance studies from the Indian subcontinent demonstrate that RSV is a major contributor to community-acquired serious infections in young infants.² Approximately 93% of RSV-related deaths in India occur in community settings, with reported case fatality rates of 7%–9% in infants under six months of age, compared with approximately 3% among hospitalised infants.⁴ Indian clinical studies further confirm that previously healthy, full-term infants constitute a substantial proportion of severe RSV cases, with many requiring respiratory support, mechanical ventilation, and prolonged hospitalisation.⁴ Under-reporting is common, so the true burden may be higher than documented.⁴

RSV Transmissibility and Inevitable Exposure

RSV is among the most contagious respiratory viruses, with a mean basic reproduction number (R_0) of approximately 4.5, exceeding that of influenza and Coronavirus disease 2019

(COVID-19).⁴ As a result, nearly 70% of infants are infected within the first year of life, irrespective of socioeconomic or geographic background.^{3,4} RSV therefore represents an almost inevitable early-life exposure, with the greatest risk of severe disease concentrated in the first few months of life.⁴

Clinically, RSV accounts for:

- Up to 4 in 5 cases of infant bronchiolitis^{3,6}
- Approximately 1 in 3 cases of infant pneumonia^{2,6}
- Bacterial coinfection in 26%–43% of cases, amplifying disease severity, antibiotic exposure, and healthcare utilisation^{3,4}

Long-Term Sequelae: Beyond Acute Infection

The impact of RSV extends well beyond the acute episode. Severe RSV infection in infancy is associated with:

- Recurrent wheezing in approximately 40% of affected children⁸
- Up to an eight-fold increased risk of asthma later in childhood⁹
- Evidence of long-term pulmonary impairment and adverse neurodevelopmental outcomes following severe RSV requiring intensive care⁸

These sequelae underline that RSV not only drives the acute hospital burden but may also alter long-term respiratory health trajectories.^{8,9}

Treatment Limitations

Management remains supportive, including oxygen therapy, hydration, and ventilatory support when required. There is no routinely recommended antiviral therapy for RSV in infants. Aerosolised ribavirin approved for use in severely immunocompromised infants remains controversial and is not routinely used due to cost, delivery challenges, high toxicity, and teratogenicity.^{3,4} A newer antiviral, ziresovir, which is still under investigation, has shown promise in reducing viral loads in hospitalised children.⁴

Preventive Strategies Against RSV

Given the early age at which severe RSV disease occurs, its high transmissibility, the predominance of community-based mortality, and the lack of durable immunity following natural infection, prevention remains the most effective strategy for reducing RSV-associated morbidity and mortality.

Palivizumab: Passive immunisation for high-risk infants

Palivizumab is a short-acting monoclonal antibody requiring monthly injections during the RSV season and is indicated for a limited subset of high-risk infants such as those with extreme prematurity, chronic lung disease (CLD), and congenital heart disease (CHD). Its impact has been limited by repeated dosing requirements, cost, and restricted eligibility.^{3,4,5}

India's ill-defined RSV seasonality, typical of many tropical countries, further limits the practicality of seasonal, multi-dose preventive strategies and supports the need for simpler, longer-acting approaches.⁴

Nirsevimab: A new paradigm in RSV prevention

Nirsevimab is a fully human, long-acting immunoglobulin G1 (IgG1) monoclonal antibody targeting the prefusion F protein of RSV. It is a passive immunoprophylactic agent designed to provide immediate and sustained protection during the period of greatest vulnerability.^{10,11}

Key attributes

- Extended half-life through fragment crystallisable (Fc) region modification
- Onset of protection within 24–48 hours

- Single intramuscular dose providing season-long protection
- Weight-banded dosing: 50 mg for infants < 5 kg and 100 mg for infants ≥ 5 kg
- Approved for use from birth, including term and preterm infants

Recommended use of nirsevimab

Based on current evidence and international guidelines:

- First year of life: A single dose of nirsevimab is recommended for all infants to protect against RSV during their first RSV season.^{5,11}
- Second year of life: Nirsevimab is recommended only for infants and young children at high risk of severe RSV disease (e.g., prematurity, CLD, CHD, significant comorbidities). The recommended dosage is 200 mg, administered for high-risk children entering their second RSV season.

Evidence from pivotal clinical trials of nirsevimab is summarised in Table 1.

Study	Population	Study design	Key outcomes
Phase IIb	Preterm infants (29–35 weeks GA)	Randomised, placebo-controlled	Nearly 70% reduction in medically attended RSV-LRTI ¹⁰
MELODY	Healthy late-preterm and term infants	Phase III, randomised, placebo-controlled	Around 75%–76% reduction in medically attended RSV-LRTI; nearly 78% reduction in RSV hospitalisations ¹²
MEDLEY	Preterm infants and infants with CHD/CLD	Safety and PK comparison vs palivizumab	Comparable safety; similar or lower RSV-LRTI rates ¹²
HARMONIE	Infants ≥ 29 weeks GA	Pragmatic, real-world effectiveness study	Nearly 83% reduction in RSV-related hospitalisations ¹¹

Table 1: Clinical trial evidence of nirsevimab.

Abbreviations: CHD: Congenital Heart Disease, CLD: Chronic Lung Disease, GA: Gestational Age, PK: Pharmacokinetic, RSV-LRTI: Respiratory Syncytial Virus-Lower Respiratory Tract Infection.

Across all trials, no serious adverse events were attributed to nirsevimab, including in preterm and high-risk populations. Neutralising antibody levels remained substantially higher than those in the placebo for up to 12 months, supporting sustained protection.^{10,11}

Nirsevimab real-world evidence: Journal of the American Medical Association (JAMA) Pediatrics meta-analysis

Beyond controlled trials, nirsevimab effectiveness has been validated in routine clinical practice. A large post-licensure meta-analysis published in JAMA Pediatrics evaluated real-world data from over 260,000 infants across multiple countries and healthcare systems.¹¹

Key findings included:

- Nearly 83% reduction in RSV-related hospitalisations
- Nearly 62% reduction in all-cause LRTI hospitalisations
- Significant reductions in RSV-related and all-cause emergency department visits

This real-world evidence confirms that benefits observed in clinical trials are replicated in routine practice, with substantial reductions in disease burden and healthcare utilisation.

Policy and guideline alignment

Global and national public health bodies recognise the importance of early RSV prevention:

- The World Health Organization (WHO) recommends the introduction of RSV preventive products such as nirsevimab, with year-round strategies preferred in tropical countries.⁵
- The Centers for Disease Control and Prevention (CDC) recommends nirsevimab for all infants entering their first RSV season, and for high-risk infants entering their second season.⁵
- The National Neonatology Forum (NNF) of India supports RSV prevention (with nirsevimab) in young infants below six months of age and recommends it in high-risk groups — including prematurity with bronchopulmonary dysplasia, CHD, post-tracheostomy, cystic fibrosis, congenital immunodeficiencies and neuromuscular disorders — within the Indian context.⁵

RSV vaccine ABRYSSVO-maternal immunisation

ABRYSSVO is an RSV vaccine recommended for individuals aged 18 years and older. It is bivalent (targeting both major RSV subgroups A and B) and contains stabilised prefusion F proteins from the virus.⁵ A single intramuscular dose administered to pregnant individuals between approximately 32–36 weeks' gestation helps protect infants from RSV-related LRTI disease from birth through about 6 months of age via transplacental antibody transfer. It is also approved for the prevention of RSV in older adults (≥ 60 years) and adults 18–59 years at increased risk of LRTI.⁵

Conclusion

RSV remains the single greatest respiratory infectious threat in the first year of life, driving high hospitalisation rates, substantial community mortality, and long-term respiratory sequelae.^{1,9} In the absence of effective treatment, early prevention is critical. Long-acting immunoprophylaxis with nirsevimab represents a transformational advance, enabling early, single-dose protection during the period of highest vulnerability.^{5,10} Its integration into clinical practice offers the potential to significantly reduce hospitalisations, prevent community deaths, and improve long-term respiratory outcomes — particularly in high-burden settings such as India.⁵

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References

1. Lozano R, Naghavi M, Foreman K, *et al.* Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: A systematic analysis for the Global Burden of Disease Study 2010. *Lancet.* 2012;380:2095–128.
2. PERCH Study Group. Causes of severe pneumonia requiring hospital admission in children without HIV infection from Africa and Asia: The PERCH multi-country case-control study. *Lancet.* 2019;394:757–79.
3. Meissner HC. Viral bronchiolitis in children. *N Engl J Med.* 2016;374:62–72.
4. Simões EAF, Bont L, Manzoni P, *et al.* Past, Present and Future Approaches to the Prevention and Treatment of Respiratory Syncytial Virus Infection in Children. *Infect Dis Ther.* 2018;7(1):87–120.
5. World Health Organization. WHO position paper on immunisation to protect infants against respiratory syncytial virus disease, May 2025. *Wkly Epidemiol Rec.* 2025;100(22):193–218. Available at: <https://www.who.int/publications/i/item/who-wer-10022-193-218>. Accessed on: 12th April 2026.
6. Piedimonte G, Perez MK. Respiratory syncytial virus infection and bronchiolitis. *Pediatr Rev.* 2014;35:519–30.
7. Simon AK, Hollander GA, McMichael A. Evolution of the immune system in humans from infancy to old age. *Proc Biol Sci.* 2015;282:20143085.
8. Riccò M, Corrado S, Palmieri S, *et al.* Respiratory Syncytial Virus: A Systematic Review and Meta-Analysis of Tomographic Findings (2000-2022). *Children (Basel).* 2023;10(7):1169.
9. Sigurs N, Gustafsson PM, Bjarnason R, *et al.* Severe respiratory syncytial virus bronchiolitis in infancy and asthma/allergy at age 13. *Am J Respir Crit Care Med.* 2005;171:137–41.
10. Griffin MP, Yuan Y, Takas T, *et al.* Single-dose nirsevimab for prevention of RSV in preterm infants. *N Engl J Med.* 2020;383:415–25.
11. Drysdale SB, Cathie K, Flamein F, *et al.* Nirsevimab for prevention of hospitalization due to RSV in infants. *N Engl J Med.* 2023;389:2425–35.
12. Hammit LL, Dagan R, Yuan Y, *et al.* Nirsevimab for prevention of RSV in healthy late-preterm and term infants. *N Engl J Med.* 2022;386:837–46.

Role of Interventional Radiology in Hepatocellular Carcinoma: Transarterial Chemoembolisation and Beyond

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Abstract:

Hepatocellular carcinoma (HCC) remains a major global health burden and a leading cause of cancer-related mortality. Interventional radiology (IR) has emerged as a cornerstone in the management of HCC, particularly for patients ineligible for surgical resection or transplantation. Transarterial chemoembolisation (TACE) is the standard of care for intermediate-stage HCC; however, advancements in IR techniques, such as radiofrequency ablation, microwave ablation, and transarterial radioembolisation have broadened therapeutic strategies. This review provides a comprehensive overview of IR-based management of HCC, highlighting TACE and emerging precision-driven interventions, including robotics, three-dimensional (3D) printing, and smart implant technologies.

Key words: Hepatocellular Carcinoma, Interventional Radiology, Transarterial Chemoembolisation (TACE), Radiofrequency Ablation, Microwave Ablation, Radioembolisation, Precision Medicine.

Introduction

Hepatocellular carcinoma (HCC) is the most common primary malignancy of the liver and represents a significant global health challenge, ranking among the leading causes of cancer-related mortality worldwide. Its incidence continues to rise due to the increasing prevalence of chronic liver diseases, particularly cirrhosis, chronic infection with hepatitis B and C viruses, alcohol-related liver disease, and non-alcoholic fatty liver disease. The pathogenesis of HCC is complex and multifactorial, involving chronic inflammation, hepatocellular injury, fibrosis, and progressive genetic and epigenetic alterations that ultimately lead to malignant transformation.¹

Early-stage HCC is often asymptomatic, and despite improvements in surveillance strategies, many patients

are diagnosed at an intermediate or advanced stage. This delayed presentation significantly limits the applicability of curative treatment options such as surgical resection, liver transplantation, and local ablative therapies. Moreover, underlying liver dysfunction and comorbidities further restrict treatment eligibility, making management particularly challenging. In this setting, the need for effective, minimally invasive, and patient-tailored therapeutic approaches becomes increasingly critical.^{2,3}

Interventional radiology (IR) has emerged as a cornerstone in the multidisciplinary management of HCC, bridging the gap between diagnostic imaging and therapeutic intervention. By utilising advanced imaging modalities such as computed tomography (CT), magnetic resonance imaging (MRI), and ultrasound, IR

enables precise localisation and targeted treatment of hepatic lesions. Among these techniques, transarterial chemoembolisation (TACE) has become the standard of care for patients with intermediate-stage disease, particularly those classified under the Barcelona Clinic Liver Cancer staging system. TACE exploits the dual blood supply of the liver by selectively delivering chemotherapeutic agents into the tumour-feeding hepatic arteries, followed by embolisation to induce ischaemic necrosis, thereby maximising tumour control while preserving the surrounding liver parenchyma.^{2,3}

Recent technological advancements are driving a paradigm shift towards precision and personalised medicine in interventional oncology. The incorporation of robotic-assisted systems enhances procedural accuracy and operator control, while three-dimensional (3D)-printed patient-specific models facilitate pre-procedural planning and device customisation. Furthermore, the development of smart implants with embedded biosensors enables real-time monitoring of treatment response and early detection of complications, thereby optimising clinical outcomes. The integration of artificial intelligence (AI) into radiological workflows further augments diagnostic accuracy, treatment planning, and outcome prediction, reinforcing the role of IR as a dynamic and evolving speciality.⁴⁻⁷

Pathophysiology and Imaging Basis

HCC exhibits unique vascular and biological characteristics that form the foundation for both its radiological diagnosis and interventional management. One of the most critical features of HCC is its predominant arterial blood supply, in contrast to normal liver parenchyma, which derives approximately 70%–80% of its blood flow from the portal vein and only 20%–30% from the hepatic artery. This fundamental difference in vascularisation plays a pivotal role in the development, progression, imaging appearance, and treatment of HCC.^{2,3}

Tumour angiogenesis and vascular remodelling

The pathogenesis of HCC involves progressive angiogenesis driven by chronic liver injury and inflammation. During hepatocarcinogenesis, there is a shift from portal venous perfusion to arterial

neoangiogenesis, mediated by pro-angiogenic factors such as vascular endothelial growth factor. As the tumour grows, it develops an abnormal network of unpaired arteries, reduced portal venous supply, and sinusoidal capillarisation. These vascular changes result in:

- Increased arterial perfusion
- Decreased portal venous contribution
- Formation of tortuous, irregular tumour vessels

This altered haemodynamic profile is a hallmark of HCC and serves as the basis for both imaging diagnosis and targeted intra-arterial therapies.^{2,3}

Imaging characteristics of HCC

The vascular behaviour of HCC is reflected in its characteristic appearance on contrast-enhanced imaging modalities, particularly CT and MRI.

Arterial phase hyperenhancement

During the arterial phase, HCC lesions demonstrate intense enhancement due to their rich arterial supply. This feature is highly sensitive for detecting hypervascular tumours.

Portal venous and delayed phase washout

In the portal venous and delayed phases, HCC lesions typically exhibit washout, appearing hypodense or hypointense relative to the surrounding liver parenchyma. This occurs because the tumour lacks normal portal venous perfusion, while the background liver enhances.

Capsule appearance

A peripheral enhancing capsule may be observed in delayed phases, representing a fibrous pseudocapsule surrounding the tumour.

Diffusion and hepatobiliary imaging

On MRI, diffusion-weighted imaging (DWI) shows restricted diffusion in HCC due to high cellularity. Hepatobiliary contrast agents further improve lesion detection by demonstrating reduced uptake in tumour tissue compared to normal hepatocytes.

These imaging features form the cornerstone of non-invasive diagnosis, often eliminating the need for a biopsy.^{2,3}

Physiological Basis for Intra-Arterial Therapies

The preferential arterial supply of HCC provides a unique therapeutic advantage that is exploited in interventional radiology. Procedures such as TACE and transarterial radioembolisation selectively target tumour-feeding arteries while sparing the surrounding normal liver tissue, which continues to receive blood from the portal vein.^{2,3}

Clinical Implications

Understanding the vascular biology of HCC is essential for:

- Accurate radiological diagnosis
- Treatment planning and patient selection
- Predicting response to therapy
- Monitoring post-treatment outcomes

Furthermore, variations in tumour vascularity may influence therapeutic response, with hypervascular tumours generally responding better to intra-arterial therapies.^{2,3}

Transarterial Chemoembolisation

TACE is a cornerstone locoregional therapy in the management of HCC, particularly for patients with intermediate-stage disease who are not candidates for curative treatments such as surgical resection or liver transplantation. It is a minimally invasive, image-guided procedure that combines targeted chemotherapy delivery with arterial embolisation to achieve selective tumour necrosis while preserving the surrounding liver tissue.^{2,3,8}

Principle and mechanism of action

The therapeutic efficacy of TACE is based on the unique vascular supply of HCC, which is predominantly arterial. The procedure involves two synergistic mechanisms:

- **Targeted chemotherapy delivery:** High concentrations of chemotherapeutic agents are directly infused into the tumour-feeding hepatic arteries, maximising local cytotoxic effects while minimising systemic exposure.

- **Arterial embolisation:** Embolic agents are subsequently administered to occlude the arterial blood supply, leading to ischaemia and prolonged retention of the chemotherapeutic drugs within the tumour.

This combined approach results in tumour ischaemia, hypoxia, and enhanced drug-induced cytotoxicity, ultimately leading to tumour necrosis.^{2,3}

Procedural technique

TACE is typically performed under fluoroscopic guidance in an interventional radiology suite using a stepwise approach:^{2,3}

Vascular access

- Percutaneous access is usually obtained via the common femoral artery (or radial access in selected cases).
- A vascular sheath is inserted to facilitate catheter manipulation.

Diagnostic angiography

- A catheter is advanced into the coeliac trunk and common hepatic artery.
- Angiographic imaging is performed to delineate hepatic arterial anatomy and identify tumour-feeding vessels.
- Variants such as replaced or accessory hepatic arteries are carefully assessed.

Superselective catheterisation

- A microcatheter is navigated into the segmental or subsegmental arteries supplying the tumour.
- Superselective delivery improves treatment efficacy and reduces damage to normal liver tissue.

Drug delivery

- Chemotherapeutic agents (e.g., doxorubicin, cisplatin, or epirubicin) are infused directly into the tumour vasculature.
- In conventional TACE, these drugs are often mixed with lipiodol, an oily contrast agent that enhances drug retention within the tumour.

Embolisation

- Embolic materials (e.g., gelatin sponge particles, polyvinyl alcohol particles, or microspheres) are injected to occlude arterial flow.
- This results in vascular stasis and promotes ischaemic necrosis.^{2,3}

Precision and Personalised Interventional Radiology

The field of IR has undergone a significant transformation from a primarily technique-based speciality to a precision-driven and patient-centred discipline. In the management of HCC, this evolution is particularly evident, as treatment strategies are increasingly tailored to individual patient anatomy, tumour characteristics, and underlying liver function. Advances in technology have enabled a more refined and targeted therapeutic approach, thereby improving both efficacy and safety.^{2,3}

One of the most notable developments is the integration of robotic-assisted surgery, which enhances procedural precision and reproducibility. Robotic systems facilitate accurate catheter navigation within the complex hepatic arterial network, allowing for superselective targeting of tumour-feeding vessels. This not only improves therapeutic outcomes but also minimises damage to the surrounding healthy liver parenchyma. Additionally, robotic assistance reduces operator fatigue and radiation exposure, contributing to overall procedural efficiency and safety.^{2,3}

Another major advancement is the application of 3D printing in medicine, which enables the creation of patient-specific anatomical models based on high-resolution imaging data. These models provide a 3D understanding of tumour location and vascular anatomy, allowing for detailed pre-procedural planning and simulation. In complex cases of HCC, 3D printing enhances the accuracy of catheter placement and ablation techniques, thereby reducing intra-procedural uncertainty and improving clinical outcomes.^{2,3}

Furthermore, the emergence of smart implants has introduced the possibility of real-time monitoring in interventional oncology. These implants incorporate biosensors capable of tracking physiological parameters such as temperature, pressure,

and biochemical changes within the tumour microenvironment. Such real-time data can facilitate early detection of complications, assessment of treatment response, and timely clinical decision-making. Collectively, these innovations are redefining IR as a highly personalised and precision-oriented speciality.⁹⁻¹³

Role of Artificial Intelligence

AI is increasingly being integrated into interventional radiology, playing a transformative role in enhancing diagnostic accuracy, procedural planning, and therapeutic outcomes in HCC. AI-driven algorithms, particularly those based on deep learning, have demonstrated significant potential in the automated detection and segmentation of hepatic tumours on imaging modalities such as CT and MRI. This not only improves early diagnosis but also reduces interobserver variability and enhances reproducibility.

In addition to diagnostic applications, AI serves as a powerful tool for treatment planning and decision support. By analysing large datasets that include imaging features, clinical parameters, and patient outcomes, AI models can predict tumour behaviour, assess treatment response, and assist clinicians in selecting the most appropriate therapeutic approach. This is particularly valuable in complex cases where multiple treatment options are available, such as choosing between TACE, ablation, or combination therapies.

Moreover, AI has the potential to provide real-time procedural guidance during interventional procedures. Through techniques such as image fusion and augmented reality, AI can overlay pre-acquired CT or MRI data onto live fluoroscopic images, enabling precise navigation and targeting. Automated vessel tracking and catheter guidance further enhance procedural accuracy while reducing the risk of complications. Additionally, AI-based predictive models can aid in post-procedural monitoring by identifying patients at higher risk of recurrence or adverse outcomes, thereby facilitating personalised follow-up strategies. Despite these advancements, challenges such as data standardisation, regulatory concerns, and integration into clinical workflows remain to be addressed.^{2,3}

Complications

Although IR procedures are minimally invasive and generally well tolerated, they are not without risks, particularly in patients with underlying liver dysfunction. One of the most common complications following procedures such as TACE is post-embolisation syndrome, which is characterised by fever, abdominal pain, nausea, and malaise. This condition results from tumour necrosis and the associated inflammatory response and is typically self-limiting with supportive management.

More serious complications include hepatic decompensation and liver failure, especially in patients with advanced cirrhosis or compromised liver function. These patients may develop worsening ascites, hepatic encephalopathy, or coagulopathy following the procedure. Therefore, careful patient selection and pre-procedural assessment of liver function are essential to minimise these risks. Another significant concern is non-target embolisation, where embolic agents inadvertently occlude vessels supplying non-tumour tissues, potentially leading to complications such as gastrointestinal ischaemia, cholecystitis, or pancreatitis. The use of superselective catheterisation techniques has been instrumental in reducing the incidence of such events.

Infectious complications, including hepatic abscess formation and sepsis, may also occur, particularly in patients with biliary interventions or immunocompromised states. Additionally, vascular complications such as arterial dissection, access site haematoma, and contrast-induced nephropathy can arise during or after the procedure. Despite these potential risks, advancements in imaging guidance, procedural techniques, and supportive care have significantly improved the safety profile of interventional radiology procedures.^{2,3}

Future Perspectives

The future of IR in the management of HCC is poised to be shaped by continuous technological innovation and the integration of multidisciplinary approaches. One of the most promising developments is the emergence of AI-integrated interventional platforms, which combine real-time imaging, automated data analysis, and decision support systems to enhance procedural precision and efficiency. These platforms are expected to enable more accurate targeting of tumours and improve overall treatment outcomes.

Personalised dosimetry represents another advancement, particularly in therapies such as transarterial radioembolisation. By tailoring radiation doses based on tumour characteristics, vascularity, and patient-specific liver function, clinicians can optimise therapeutic efficacy while minimising toxicity. Similarly, nanotechnology-based therapies are gaining attention for their potential to deliver drugs directly to tumour cells with high specificity, thereby reducing systemic side effects and enhancing treatment response.^{2,3}

The integration of multimodal treatment strategies, including interventional procedures, systemic therapies, and immunotherapy, is also expected to play a crucial role in the future management of HCC. These combined approaches aim to achieve synergistic effects and improve long-term survival. Ultimately, the goal of these advancements is to achieve fully personalised medicine, where treatment is tailored not only to the disease but also to the individual patient's biological and clinical profile. As these technologies continue to evolve, interventional radiology is set to become an even more central component of comprehensive cancer care.^{14,15}

Conclusion

IR has emerged as a pivotal component in the multidisciplinary management of HCC, offering minimally invasive, image-guided therapeutic options for patients who are not candidates for curative surgical interventions. Among these, TACE continues to serve as the cornerstone therapy, particularly for intermediate-stage disease, by exploiting the tumour's preferential arterial blood supply to achieve targeted drug delivery and ischaemic necrosis. Over time, the scope of IR has expanded significantly, incorporating advanced techniques such as tumour ablation and transarterial radioembolisation, thereby broadening the therapeutic landscape and improving survival outcomes.

The integration of emerging technologies has further accelerated the transition of IR towards a precision and personalised medicine paradigm. Innovations such as robotic-assisted interventions, 3D-printed patient-specific models, and smart implants with embedded sensors are enhancing procedural accuracy, optimising treatment planning, and enabling real-time monitoring of therapeutic response. In parallel, the incorporation of AI into radiological workflows is transforming diagnostic capabilities, facilitating treatment decision-making, and improving outcome prediction. These advancements collectively contribute to more individualised and effective patient care. Despite these promising developments, challenges remain, including the need for standardised protocols, improved patient selection criteria, and the integration of advanced technologies into routine clinical practice. Future research should focus on large-scale clinical trials, validation of AI-driven tools, and the development of cost-effective solutions to ensure broader accessibility. In conclusion, interventional radiology continues to evolve as a dynamic and indispensable speciality in HCC management, with ongoing innovations poised to further enhance precision, safety, and patient-specific outcomes in the years to come.

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References

1. Llovet JM, Kelley RK, Villanueva A, et al. Hepatocellular carcinoma. *Nat Rev Dis Primers*. 2021;7(1):6.
2. Lammer J, Malagari K, Vogl T, et al. Prospective randomized study of doxorubicin-eluting-bead embolization in the treatment of hepatocellular carcinoma: Results of the PRECISION V study. *Cardiovasc Intervent Radiol*. 2010;33(1):41–52.
3. Salem R, Lewandowski RJ, Mulcahy MF, et al. Radioembolization for hepatocellular carcinoma using yttrium-90 microspheres: A comprehensive report. *J Clin Oncol*. 2010;28(24):1–8.
4. Reig M, Forner A, Rimola J, et al. BCLC strategy for prognosis prediction and treatment recommendation: The 2022 update. *J Hepatol*. 2022;76(3):681–93.
5. Forner A, Reig M, Bruix J. Hepatocellular carcinoma. *Lancet*. 2018;391(10127):1301–14.
6. Burrel M, Reig M, Forner A, et al. Survival of patients with hepatocellular carcinoma treated by transarterial chemoembolization. *Hepatology*. 2012;56(6):227–35.
7. Golfieri R, Bargellini I, Spreafico C, et al. Patients with Barcelona Clinic Liver Cancer stages B and C hepatocellular carcinoma: Time for a subclassification. *Radiology*. 2011;261(1):267–75.
8. Ahmed M, Solbiati L, Brace CL, et al. Image-guided tumour ablation: Standardization of terminology and reporting criteria. *Radiology*. 2014;273(1):241–60.

9. Vogl TJ, Nour-Eldin NEA, Hammerstingl RM, *et al.* Microwave ablation therapy: Clinical utility in treatment of pulmonary metastases. *Eur Radiol.* 2017;27(5):1–10.
10. Kulik L, Heimbach JK. State of the art: Transarterial chemoembolization and radioembolization for hepatocellular carcinoma. *Hepatology.* 2018;67(1):1–12.
11. Kudo M. Artificial intelligence in hepatology: Current status and future perspectives. *Liver Cancer.* 2019;8(6):1–10.
12. Yang JD, Hainaut P, Gores GJ, *et al.* A global view of hepatocellular carcinoma: Trends, risk, prevention and management. *Nat Rev Gastroenterol Hepatol.* 2019;16(10):589–604.
13. European Association for the Study of the Liver. EASL Clinical Practice Guidelines: Management of hepatocellular carcinoma. *J Hepatol.* 2018;69(1):182–236.
14. Bruix J, Sherman M. Management of hepatocellular carcinoma: An update. *Hepatology.* 2011;53(3):1020–22.
15. Sangro B, Sarobe P, Hervás-Stubbs S, *et al.* Advances in immunotherapy for hepatocellular carcinoma. *Nat Rev Gastroenterol Hepatol.* 2021;18(8):525–43.

Arthrodesis or Arthroplasty: Where Do We Stand?

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Abstract:

Arthrodesis and arthroplasty represent two contrasting surgical philosophies in the management of joint pathology, focusing respectively on the elimination and preservation of joint motion. This review aimed to examine the historical evolution, current indications, and comparative roles of these procedures across major joints through a narrative analysis of historical developments, surgical principles, and contemporary clinical trends. Findings indicate that arthroplasty has emerged as the preferred treatment for large joints such as the hip, knee, and shoulder because of its favourable functional outcomes and restoration of mobility. In contrast, arthrodesis continues to play a significant role in the management of the spine, ankle, wrist, and small joints, especially in resource-constrained settings where durability and cost considerations are important. Overall, the selection between arthrodesis and arthroplasty is guided by joint biomechanics, patient-specific factors, and available healthcare resources, highlighting that these procedures function as complementary rather than competing surgical strategies.

Key words: Arthrodesis, Arthroplasty, Joint Fusion, Joint Replacement, Orthopaedics.

Introduction

Surgery to permanently fuse the bones of a joint is called arthrodesis. The word comes from the Greek word “arthron”, meaning “joint”, and “desis”, meaning “binding” or “tying”. A less commonly used etymology to describe the same procedure is artificial ankylosis or syndesis. Arthrodesis is primarily done to relieve pain and correct deformity.

The common sites of arthrodesis are the spine, hand, ankle, and foot. Arthrodesis was once commonly performed for painful hips or knees, but the advent and success of arthroplasty for these joints have rendered arthrodesis a salvage procedure.

Arthroplasty is the term for the removal of a diseased or injured joint and its replacement with an artificial joint. The Greek word “arthros” means “joint,” and “plassein” means “to form” or “to mould”. Arthroplasty is performed when non-surgical treatments have proven futile in treating

osteoarthritis, rheumatoid arthritis, avascular necrosis, or severe joint fractures. The common sites for arthroplasty are the hip, knee, and shoulder.

Historical Aspects

Arthrodesis

In 1878, Eduard Albert in Vienna coined the term arthrodesis when he performed the fusion of both knees and ankles in a 14-year-old child who had severe palsy of the lower extremities.^{1,2} Albert was a Czech surgeon who held the chair of surgery in Vienna.

Arthrodesis of the hip was attempted in 1888 by Heuster and Lampugnani.³ The earlier fusers of the tarsus, after the publication of Albert’s paper, were Cuthbert Hilton Golding-Bird of Guy’s Hospital in London and Alexander Ogston of Aberdeen, who in 1884 described talonavicular fusion in children with severely pronated feet.

In Philadelphia, Gwilym G. Davis popularised subtalar arthrodesis in 1913. It remained a commonly performed procedure for a decade, and seriously competed with Royal Whitman's astragalectomy, done for paralytic equinovarus deformity.⁴ Edwin W. Ryerson, a surgeon in Chicago, coined the term "triple arthrodesis", an operation still performed today.⁴ This is the fusion of three joints: the subtalar, talonavicular, and the calcaneocuboid joints.

Frederick Albee, at the New York Postgraduate Medical School Clinic, perfected spinal arthrodesis using bone grafts from the tibia in children with tuberculosis (TB) of the spine.⁵ Interestingly, he had learnt tree grafting as a youngster working on a farm, he applied the same principles to attain spine fusions. Another American, Russell Hibbs, at the New York Orthopaedic Hospital, performed spinal fusion using the spinous processes of vertebrae.⁶ These were divided at their base and used as autografts to obtain interlaminar fusion. These fusion techniques were used in treating spinal TB.

In 1949, DJ Glissan from New Zealand laid down the four principles specifically for ankle arthrodesis. These are cited as fundamental to performing the procedure in any part of the body. They are the complete removal of all cartilage and fibrous tissue, accurate and close fitting of fusion surfaces, optimal joint positioning, and maintenance of bone apposition undisturbed until fusion is complete.⁷ John Charnley, in 1951, showed that sustained compression in joint fusion operations was the essential biological mechanism for the knee, ankle, and shoulder.⁸ In a remarkable intellectual journey, Charnley moved from fusion surgery, abolishing all movement, to arthroplasty, permitting full movement.

Robert Danis was a Belgian surgeon who used the principles of arthrodesis in fracture treatment. Maurice Muller was impressed with his work and assembled a study group, leading to the Arbeitsgemeinschaft für Osteosynthesefragen (AO) group. They advocated the same principles for arthrodesis as they did for fracture treatment. These are rigid stabilisation, compression, and early mobilisation.⁹ Essentially, they transformed Charnley's principles into a disciplined teaching system. They provided the hardware for arthrodesis, including lag screws, cancellous screws, and compression plates.

Arthroplasty

Though the French surgeon, Jules-Emile Pean, performed the first shoulder replacement on a baker, Jules Pedoux,

in 1893,¹⁰ ancient Greek mythology credits the myth of Pelops' ivory shoulder as the first shoulder replacement.¹¹ Arthroplasty evolved to treat joint destruction, mainly due to TB. Ivory was used to create a prosthesis by Themistocles Gluck, who performed the first ivory knee replacement on 20th May 1890; he followed this up with a total wrist, replacement in another patient three weeks later. Gluck realised that his prosthesis needed sound fixation in bone. He experimented with copper, amalgam, plaster of Paris, and stone putty — a resin mixed with pumice stone or gypsum. He favoured osseointegration, or bone ingrowth into the implant to secure fixation. He predated the work of John Charnley, and even today, cement versus cementless fixation stokes controversy.¹² Infection, however, remained a major obstacle. Marius Smith-Petersen, a pioneer in the early days of hip arthroplasty, worked on mould arthroplasty (he is known for a surgical approach to the hip, spinal osteotomy, and nailing of hip fractures),¹³ using glass and Vitallium cups. Various materials have been used for interpositional arthroplasty, such as fascia lata and pig bladder. In 1940, Austin Moore replaced the proximal end of the femur with a metallic prosthesis shaped in the form of the proximal femur.¹⁴ Eighty-five years later, it is still in use in many parts of the world, including India, for older and less active patients with femoral neck fractures. In the 1960s, Sir John Charnley perfected 'low-friction arthroplasty' for the treatment of end-stage, symptomatic osteoarthritis of the hip. Essentially, the femoral head and femoral neck are excised. The acetabulum is enlarged, and an acetabular cup is inserted. The femoral component is cemented in place. Total hip replacement is effective in alleviating pain, restoring mobility, and is a cost-effective option for hip arthritis. It is arguably the most successful of all surgical inventions.¹⁵ In 1974, John Insall developed the total condylar knee, and modern knee replacements are based on his concepts. He is known as the Father of Knee Replacement.¹⁶ Charles Neer reported a series of eight shoulder hemiarthroplasties, with encouraging results. This developed into the Neer 1 prosthesis, made of Vitallium. He used it to treat fracture-dislocations, avascular necrosis, and osteoarthritis.¹⁷ He emphasised the importance of tuberosity fixation and healing. The Neer 2 prosthesis was a monoblock stem, and by the 1980s, modularity was introduced, with a stem and head of several sizes. Reverse total shoulder arthroplasty, again introduced by Neer, reversed the normal anatomy by placing the socket in the proximal humerus and the prosthetic ball in the glenoid of the scapula. This allows treatment of glenohumeral

arthritis and rotator cuff deficiency. Paul Grammont, a French surgeon, further refined the procedure.

The trends today are towards cementless fixation using porous coatings, allowing bone to grow into the implant, ceramic acetabular components, and highly cross-linked polyethylene to reduce wear. Recent advances include robotic-assisted surgery, computer navigation, and three-dimensional (3D) printing to produce patient-specific implants. These refinements improve the life of the implant.

Fusion is performed mainly in the spine, ankle, wrist, foot, hand, and smaller joints. It is a salvage procedure for failed arthroplasty in the knee and hip joints.

The Paradox of Motion

The goal of surgery is to restore meaningful function. Joints are designed by nature to permit movement; copying nature's stance, prostheses have been designed with considerable ingenuity to permit this. The success of an operation is judged by motion preservation using these implants. Admirably, favourable outcomes have been achieved in the hip and knee joints. Paradoxically enough, the success of arthrodesis in the joints of the spine, ankle, and wrist challenges the assumption that movement is the only sine qua non as the barometer of success. Figure 1 shows the outcomes of arthrodesis and arthroplasty.

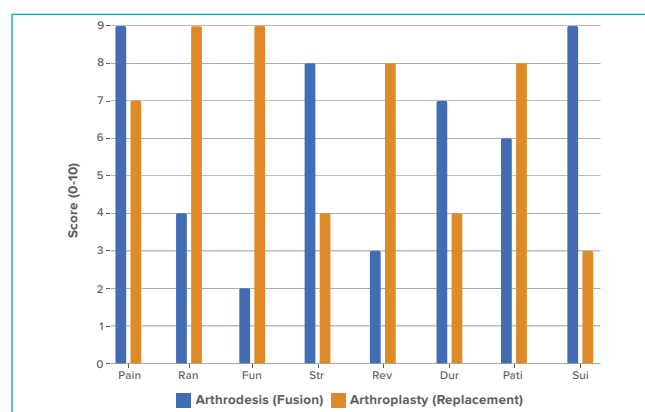


Figure 1: Arthrodesis vs arthroplasty — a comparison of clinical parameters. The Y-axis measures the relative advantage score on a scale of 0–10, where 0 is the worst possible outcome, and 10 is the best possible outcome. A high bar means the best possible outcome. The X-axis measures various parameters. The measured parameters are Pai (pain); Ran (range of motion), or the range of motion preserved/restored in the joint after surgery; Fun (functional mobility), or day-to-day mobility, such as walking and climbing stairs; Str (structural stability), or the mechanical reliability of the construct under load and over time; Rev (revision flexibility), or the ease with which the procedure can be revised if needed; Dur (duration/longevity), or the expected lifespan of the surgical procedure; Pati (patient satisfaction) with the procedure; and Sui (Suitability) for high-demand, young patients.

Arthrodesis, or the renunciation of movement, is the equivalent of surgical austerity — it is a procedure that removes painful motion and thereby confers stability and restores function.

The spine

The spine is a surgical outlier. The indications for spinal fusion are clear: degenerative disc disease, spondylolisthesis, spinal stenosis, fractures, and scoliosis. The problem in the spine is not the absence of motion, but that motion is painful, or is excessive, as in degenerative disc disease. Movement in the affected region of the spine is clearly unhelpful. Pain in degenerative spine disease is frequently attributed not to immobility, but to abnormal or excessive motion. Spinal fusion, therefore, aims to eliminate pathological micromotion, restore the overall alignment, particularly sagittal balance, and protect the neural elements. It is somewhat of a paradox that the fusion of the painful part makes the spine overall more mobile. In carefully selected patients, the results of well-performed surgery are excellent. Figure 2 shows the fusion between L5 and S1 vertebrae in the spine.



Figure 2: L5–S1 fusion of the spine.

Spinal fusion numbers have increased from 40,000 to a million per year, representing an enormous increase.¹⁸ No global registry exists to determine the true incidence of spinal fusion. It is estimated that in the United States, approximately 4,00,000–6,00,000 spines are fused annually. Comparative trends are seen in Europe and Asia as well.

Fusion surgery has its limitations as well. It is not effective in chronic back pain of no identifiable cause.^{19,20} Here, a structured rehabilitation programme is more effective. Correction of vitamin D₃ deficiency, back and abdominal strengthening exercises are useful.

Pain that returns after surgery may be due to a failed fusion, causing instability, or due to adjacent segment

degeneration. This is a common complication where discs above and below a fusion become stressed and degenerate.²¹

Is artificial disc replacement an alternative to fusion? It replaces the damaged disc with a prosthesis to restore mobility and height; it is used in the cervical and lumbar spine.²² It is restricted to candidates who have degeneration at one or two levels, and there should not be arthritis in the facet joints, otherwise persistent pain may remain unrelieved. The recipient's bones should be robust without osteoporosis. This prevents the implant from sinking into the bone. It remains a technically demanding procedure.

Endoscopic spine surgery is an elegant alternative for treating herniated discs or spinal stenosis. When performed correctly, it obviates many of the problems associated with spinal fusion, without causing any soft-tissue damage.

Research is ongoing into biological solutions. Scientists aim to heal the spine using bioactive materials and by using stem cells.

The ankle

The ankle is a terminal load-bearing joint. End-stage arthritis due to trauma or disease is frequently encountered in the outpatient department (OPD). The preferred procedure is ankle arthrodesis. This is because it is widely available, Indian surgeons are familiar with it, and above all, it remains cost-effective.

Total ankle replacement (TAR) is emerging as an alternative to ankle arthrodesis. It maintains movement and relieves pain. Arthrodesis alone removes pain, but at the expense of movement. TAR is a demanding procedure because of the anatomy of the ankle.²³ The ankle joint is a highly constrained load-bearing joint, subject to repetitive load-bearing forces. The tolerances are narrow, in contrast to the hip, which is a ball-and-socket joint and more forgiving. The knee distributes the load over a broader surface. However, ankle arthroplasty has to maintain alignment, withstand loads, preserve motion, and avoid loosening.

The number of dedicated foot and ankle specialists is limited to large tertiary centres. There are sparse TAR case volumes. The estimated ratio of arthrodesis to arthroplasty is 10–20:1, and this may be even higher. In

the United States and Europe, the ratio of arthrodesis to arthroplasty is 1.5–5:1.

One factor may be the high cost of TAR, which is 1.5–4.5 lakh. Fusion is substantially cheaper. Arthroplasty is restricted by implant availability, lack of specialised centres, follow-up requirements, and the lack of revision infrastructure. It is confined to tertiary centres in the metropolitan cities and to surgeons with international training.

In India, ankle arthrodesis predominates. Arthroplasty is not the best choice for younger and more active patients.

The wrist

The wrist is a multiaxial joint. Despite its important role in hand function and grip strength, arthritis of smaller joints, including the wrist, often goes unaddressed. They are considered part of the “other osteoarthritis” category in epidemiology.²⁴ In the general population, wrist arthritis affects 1%–2% of adults. Common causes are osteoarthritis due to wear and tear, rheumatoid arthritis, post-traumatic arthritis, and tubercular arthritis.

Wrist arthrodesis remains the procedure of choice in arthritis. It has predictable outcomes — relief of pain, improved grip strength; the trade-off is complete loss of wrist motion. Patients compensate using forearm pronation–supination and by finger–elbow movements. Most daily activities, such as eating, writing, and lifting light objects, are possible. Heavy manual work is possible because the pain has gone. Fine tasks needing wrist flexion and extension are not possible. Other side effects of arthrodesis may be non-union, hardware irritation, and adjacent joint stress.

Total wrist arthroplasty, in contrast to wrist arthrodesis, is a relatively rare procedure. It accounts for less than 1% of all joint replacements, and its use is limited by implant longevity and the biomechanical complexity of the wrist. The wrist has multiple small joints and intricate motion.

These factors make it difficult to replicate with a prosthesis.

Wrist arthroplasty is valuable in patients with inflammatory arthritis.²⁵ Preservation of motion is desirable. Even so, concerns regarding the longevity, loosening, limited availability of the implant, surgical expertise, and the need for revision in the future are limiting factors.

In the Indian subcontinent, data are sparse, but arthrodesis is the predominant procedure. Arthroplasty remains a rare, niche, and tertiary-centre procedure. The reasons mirror ankle arthroplasty — cost constraints, implant availability, and surgeon familiarity.

The shoulder

The shoulder or the glenohumeral joint is a spheroidal ball and socket joint, where the head of the humerus articulates with the glenoid fossa of the scapula. It has the greatest range of movement of any joint in the human body. Stability is low compared to mobility. It relies heavily on soft tissues for stability — the glenoid labrum, capsule, and the rotator cuff. The shoulder has a built-in advantage — it is not a weight-bearing joint, unlike the hip and knee.

Shoulder arthroplasty is indicated in painful conditions such as osteoarthritis, rheumatoid arthritis, irreparable rotator cuff tears, avascular necrosis of the humeral head, and complex fractures.²⁶ Anatomic shoulder replacement is used when the rotator cuff is intact. It has been largely superseded by reverse shoulder arthroplasty, particularly when the rotator cuff is deficient²⁷ or in glenohumeral arthritis. Hemiarthroplasty has limited indications and may be of value in elderly patients with painful or grossly comminuted humeral head and neck fractures as a salvage operation.

Arthroplasty is not preferred when there is an irreparable nerve injury, such as an upper brachial plexus injury, resulting in a flail shoulder.²⁸ It is an option in failed arthroplasty and chronic infection. The fusion is performed in 30° of flexion, 30° of abduction, and 30° of internal rotation. The aim is to produce a stable, pain-free shoulder; movements are provided by the scapula moving on the thorax. This enables the hand to reach the mouth and the head, perform basic hand hygiene, and use the hand in front of the body.

Shoulder arthroplasty is preferred because it provides effective pain relief and preserves the range of motion — an essential function in a highly mobile, non-weight-bearing joint. Figure 3 shows reverse shoulder arthroplasty performed in the right shoulder.



Figure 3: Reverse shoulder replacement.

Foot, hand, and smaller joints

Arthrodesis remains the procedure of choice, and fusion produces superior outcomes as compared with arthroplasty.

Hip and knee fusion

Replacement arthroplasty is preferred over fusion; the latter is a salvage procedure for failed arthroplasty or infection.

Arthrodesis Overall

Precise figures for fusion surgery overall in the entire human body are not available. However, several points are clear. Spinal fusion or arthrodesis, accounts for the vast majority of fusions done worldwide. Ankle arthrodesis, or tibiotalar fusion, is commonly used to treat ankle arthritis. Subtalar arthrodesis is combined with talonavicular and calcaneocuboid arthrodesis to treat severe foot arthritis, particularly when the cartilage is worn away, and the bones are painfully grinding against each other. Ankle arthroplasty remains an evolving procedure. It works well in older patients with a low-demand lifestyle, and patient selection is crucial. The wrist joint is routinely fused for severe rheumatoid or post-traumatic arthritis. The first metatarsophalangeal joint is fused if painful arthritis develops. Knee fusion is a rare procedure due to the success of knee arthroplasty. It is an option for painful failed arthroplasty.

Conclusion

Arthrodesis and arthroplasty remain complementary surgical strategies rather than competing doctrines. The choice between them depends on the joint involved, the underlying pathology, patient age and functional demands, bone quality, and available resources. Arthroplasty is generally favoured for large, load-bearing joints where motion preservation is essential, while arthrodesis continues to provide durable pain relief and stability in smaller joints and selected salvage situations. With continued advances in implants, fixation methods, navigation, and biologic augmentation, both procedures will continue to play important roles in restoring function and improving quality of life.

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References

1. Zwipp H, Rammelt S, Endres T, *et al*. High union rates and function scores at midterm follow-up with ankle arthrodesis using a four screw technique. *Clin Orthop Relat Res*. 2009;484(4):958–68.
2. Bick EM. Classics of Orthopaedics. Philadelphia: J.B. Lippincott Co., 1976. p. 52–4.
3. Bardakos NV, Villar RN. History and evolution of hip surgery. In: Sekiya JN, Safran MR, editors. *Techniques in Hip Arthroscopy and Joint Preservation Surgery*. Philadelphia: Elsevier; 2011. p. 2–8.
4. Ryerson EW. Arthrodesing operations on the feet. *J Bone Jt Surg*, 1923;5:453–71.
5. Albee FH. Transplantation of a portion of the tibia into the spine for Pott's disease. *JAMA*. 1911;57:855.
6. Hibbs RA. An operation for progressive spinal deformities. *NY Med J*. 1911;93:1013–6.
7. Glissan DJ. The indications for inducing fusion at the ankle joint by operation: with description of two successful techniques. *Aust N Z J Surg*. 1949;19(1):64–71.
8. Charnley J. Compression arthrodesis of the ankle and shoulder. *J Bone Jt Surg Br*. 1951;33-B(2):180–91.
9. Muller ME, Allgower M, Schneider R, *et al*. Manual of internal fixation: Techniques recommended by the AO-ASIF group. 3rd Edition. Berlin: Springer-Verlag; 1991. ISBN: 978-3-540-52523-3.
10. Hawk AJ. The case of Jules Pedoux. *Clin Orthop Relat Res*. 2015;474(2):302–3.
11. Nomikos NN, Yiannakopoulos. The first shoulder replacement in ancient Greek Mythology: the story of Pelops, King of Elis. *Orthop Traumatol Surg Res*. 2019;105(5):801–3.
12. Eyenon-Lewis NJ, Ferry D, Pearse MF. Themistocles Gluck: an unrecognised genius. *BMJ*. 1992;305:1534–6.
13. Hernigou P. Smith-Petersen and the early development of hip arthroplasty. *Int Orthop*. 2014;38(1):193–8.
14. Hawk AJ. Artifacts: Austin Moore's hip. *Clin Orthop Relat Res*. 2023;481(5):870–1.
15. Charnley J. Low-friction arthroplasty of the hip. Theory and practice. Berlin, Heidelberg: Springer-Verlag; 1979.
16. Insall J, Scott WN, Ranawat CS. The total condylar knee prosthesis. A report of two hundred and twenty cases. *J Bone Jt Surg Am*. 1979;61-A:173–80.
17. Neer CS, Brown Jr TH, McLaughlin HL. Fracture of the neck of the humerus with dislocation of the head fragment. *Am J Surg*. 1953;85(3):252–8.
18. Ponkilainen VT, Huttunen TT, Neva MH, *et al*. National trends in lumbar spine decompression and fusion surgery in Finland, 1997-2018. *Acta Orthop*. 2021;92(2):199–203.
19. Fritzell P, Hagg O, Wessberg P, *et al*. Swedish lumbar spine surgery group. Chronic low back pain and fusion: a randomized controlled trial. *Spine*. 2001;26(23):2521–32.
20. Fairbank J, Frost H, Wilson-MacDonald J, *et al*. Randomised controlled trial to compare surgical stabilisation with intensive rehabilitation for chronic low back pain. *BMJ*. 2005;330(7502):1233–6.

21. Harrop JS, Youssef JA, Maltenfort M, *et al.* Lumbar adjacent segment degeneration and disease after arthrodesis. *Spine*. 1976;2008;33(15):1701–7.
22. Rao MJ, Cao SS. Artificial total disc replacement versus fusion for lumbar degenerative disease. *J Orthop Surg Res*. 2014;9:82–90.
23. Haddad SL, Coetzee JC, Estok R, *et al.* Intermediate and long-term outcomes of total ankle arthroplasty and ankle arthrodesis: a systematic review of the literature. *J Bone Joint Surg Am*. 2007;89(9):1899–905.
24. Singh A, Das S, Chopra A, *et al.* Burden of osteoarthritis in India and its states, 1990–2019: findings from the Global Burden of disease study 2019. *Osteoarthritis Cartilage*. 2022;30(8):1070–8.
25. Cavaliere CM, Chung KC. A systematic review of total wrist arthroplasty compared with total wrist arthrodesis for rheumatoid arthritis. *J Hand Surg Am*. 2008;33(10):1740–7.
26. Neer CS. Articular replacement for the humeral head. *J Bone Joint Surg Am*. 1955;37(2):215–28.
27. Walch G, Boileau P. Lateralization and distalization of the center of rotation in reverse shoulder arthroplasty. *J Shoulder Elbow Surg*. 2011;20(3):480–6.
28. Cho AB, Choi HJ, Ferreira CHV, *et al.* Shoulder arthrodesis for traumatic brachial plexus injuries: functional outcomes and complications. *HAND*. 2023;18(1 Suppl):6S–13S.



REVIEW ARTICLES

62 Towards Universal Adult Immunisation:
Review of the 2026 Global and Indian
Schedules – **Aryan Arora, Monica Mahajan**

78 The Neurovascular Conflict Syndromes —
Part I: A Review of Anatomy and
Pathophysiology – **Harjinder S Bhatoe**

Towards Universal Adult Immunisation: Review of the 2026 Global and Indian Schedules

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Abstract:

Adult immunisation is a vital yet underprioritised component of preventive healthcare, particularly in India, where the burden of vaccine-preventable diseases (VPDs) has shifted towards adults. Immunosenescence and rising chronic diseases amplify susceptibility, however, vaccination coverage remains poor due to low awareness and the lack of a national policy. This review consolidates the 2025 adult immunisation recommendations from global (Centers for Disease Control and Prevention [CDC], World Health Organization [WHO]) and Indian (Associations of Physicians of India [API]) guidelines, with an emphasis on vaccine updates, risk-based strategies, and implementation challenges. A narrative review of official guidelines, peer-reviewed literature, and consensus statements published between 2020–2025 was performed, focusing on adult vaccination schedules, contraindications, and special-risk groups such as pregnant women, immunocompromised individuals, and those with chronic diseases. Key vaccines reviewed include influenza, pneumococcal, coronavirus disease 2019 (COVID-19), hepatitis A and hepatitis B, human papillomavirus (HPV), zoster, tetanus–diphtheria–acellular pertussis (Tdap), meningococcal, measles-mumps-rubella (MMR), and varicella vaccines. Recent additions — respiratory syncytial virus (RSV) and monkeypox vaccines — expand protection for older and high-risk adults. Despite robust global frameworks, India faces barriers including limited awareness (4.9%), fragmented delivery systems, and inadequate provider advocacy. Strengthening adult immunisation through unified national policy, integration with chronic disease programmes, and enhanced public education is imperative. Adopting a life-course vaccination approach will improve adult health outcomes and align India with WHO Immunization Agenda 2030.

Key words: Adult Immunisation, Vaccine-Preventable Diseases, Centers for Disease Control and Prevention (CDC) 2025, Associations of Physicians of India (API) Guidelines, Life-Course Vaccination, India.

Introduction

Adult immunisation remains substantially underutilised globally, particularly in low- and middle-income countries like India, despite clear evidence of substantial disease burden and clinical benefit.

Vaccine-preventable diseases are shifting epidemiologically from children to older adults. In India, approximately 95% of deaths from infectious diseases occur in adults, with pneumococcal disease,

influenza, and hepatitis B causing significant morbidity and mortality. Older adults (≥ 60 years) comprise 8.6% of India's population (~ 130 – 140 million); projections indicate an increase to 300–324 million elderly individuals by 2050 (19%–20% of the population). Immunosenescence progressively reduces immune protection in this population.¹

Chronic diseases (diabetes, cardiovascular disease [CVD], chronic obstructive pulmonary disease [COPD], and chronic kidney disease [CKD]) are prevalent in older

Indian adults. These populations experience 3–9-fold higher incidence of pneumococcal disease and an elevated risk of influenza and hepatitis B compared with healthy peers.²

Only 4.9% of Indian adults are aware of all recommended vaccines, while 70.9% are aware of at least one. Awareness of tetanus vaccination is 63.5%, but awareness of hepatitis B, pneumococcal, and influenza vaccines is substantially lower. Awareness of newer vaccines (herpes zoster, human papillomavirus [HPV], and meningococcal vaccines) remains around 10%. Healthcare providers also show inadequate knowledge: 27.6% of postgraduate residents are unaware of adult immunisation schedules, and only 35.6% of adults receive vaccine recommendations from physicians.³

The Centers for Disease Control and Prevention (CDC) and the Advisory Committee on Immunization Practices (ACIP) (2025) recommend age- and risk-stratified vaccination for influenza, pneumococcal disease, coronavirus disease 2019 (COVID-19), herpes zoster, hepatitis A and hepatitis B, HPV infection, pertussis, and meningococcal disease. The World Health Organization (WHO) Immunization Agenda 2030 emphasises life-course vaccination. The Association of Physicians of India (API) (2024) provides India-specific guidelines aligned with international standards but faces implementation gaps. Unlike the well-established paediatric Universal Immunization Programme (UIP), India lacks a unified national adult immunisation schedule despite multiple society guidelines.

This review synthesises evidence on adult immunisation epidemiology, vaccine recommendations across risk groups, efficacy and safety data, and implementation strategies, comparing Indian and international (CDC, WHO, and API) guidelines to optimise adult immunisation coverage in India.

Classification of Vaccines

Table 1 presents the six major vaccine classes used in adult immunisation. Key features of each platform are described below:

1. Inactivated vaccines

These vaccines contain killed pathogens that cannot replicate but can still elicit an immune response. They are safe for immunocompromised and pregnant individuals.

Key point: Often require multiple doses and booster shots to maintain immunity.

2. Live-attenuated vaccines

These vaccines contain weakened forms of the pathogen capable of limited replication, producing a strong and long-lasting immune response.

Key point: Contraindicated in pregnancy and in individuals with severe immunosuppression.

3. Ribonucleic acid (RNA) and deoxyribonucleic acid (DNA) vaccines

These newer-generation vaccines use genetic material to encode antigenic proteins that stimulate immunity.

Key point: Do not contain live virus, can be rapidly developed, and produce both humoral and cellular immunity.

4. Subunit, recombinant, polysaccharide, and conjugate vaccines

These vaccines use specific antigenic components of the pathogen (protein, polysaccharide, or conjugate) to induce immunity without the risk of infection.

Key point: Safe in immunocompromised individuals; often require adjuvants and multiple doses.

5. Toxoid vaccines

These vaccines contain inactivated bacterial toxins (toxoids) that stimulate antitoxin antibody production.

Key point: Immunity wanes over time; booster doses are recommended every 10 years.

6. Viral vector vaccines

These vaccines use harmless carrier viruses (vectors) to deliver genetic material encoding the target antigen.

Key point: Produce robust immune responses; rare risks include vector-related adverse events such as thrombosis.

Inactivated vaccines	Live-attenuated vaccines	mRNA pDNA vaccines	Subunit, recombinant, polysaccharide, and conjugate vaccines	Toxoid vaccines	Viral vector vaccines
Hep A Influenza (Injectable only) Polio (Injectable only) Rabies	Chickenpox Chikungunya Influenza Japanese encephalitis MMR Smallpox Yellow fever	COVID-19	Hib Hep B Pertussis (Tdap) Pneumococcal Meningococcal Shingles (Herpes zoster)	Diphtheria Tetanus	COVID-19

Table 1: Classification of vaccines.⁴

Abbreviations: COVID-19: Coronavirus Disease 2019; Hep A: Hepatitis A; Hep B: Hepatitis B; Hib: *Haemophilus influenzae* Type b; HPV: Human Papillomavirus; MMR: Measles, Mumps, and Rubella; mRNA: Messenger Ribonucleic Acid; pDNA: Plasmid Deoxyribonucleic Acid; Tdap: Tetanus, Diphtheria, and Acellular Pertussis.

Key Principles of Vaccination

- Route of administration:** The route specified must be strictly adhered to. Intramuscular (IM) is standard for most adult vaccines and is administered in the deltoid muscle (45° angle, 22–25-gauge needle). Subcutaneous (SC) administration is used for select vaccines (e.g., varicella), administered at a 45° angle. Deviation from the specified route may compromise efficacy or increase adverse events.⁵
- Dose and dosing:** Vaccine doses are fixed and calibrated for immunological efficacy and clinical protection. For example, hepatitis B vaccination in adults requires 20 µg (versus 10 µg in children); most inactivated vaccines are administered as 0.5 mL. Interrupted schedules do not require restarting; remaining doses should be administered as soon as possible while maintaining minimum intervals.⁵
- Spacing between doses:** For inactivated vaccines, the minimum interval is 4 weeks, with no maximum interval; prolonged delays do not require restarting the series. For live vaccines, if two live vaccines cannot be administered on the same day, they should be separated by ≥ 28 days. Live vaccines can be administered after inactivated vaccines without spacing; inactivated vaccines administered after live vaccines should be separated by ≥ 28 days. For pneumococcal vaccines, the 13-valent pneumococcal conjugate vaccine (PCV13) and the 23-valent pneumococcal polysaccharide vaccine (PPSV23) should be separated by ≥ 1 year in either sequence; intervals of < 1 year may cause hyperresponsiveness.⁵
- Simultaneous co-administration:** Multiple vaccines may be administered during a single visit, supported by extensive safety and efficacy data. Different vaccines should be administered at separate sites using different syringes and needles; vaccines should never be mixed in the same syringe. Up to two injections may be administered in the deltoid region, separated by ≥ 2.5 cm). Administering the most reactogenic vaccine last may minimise injection-site pain.⁵
- Technical requirements:** The "Eight Rights" of immunisation include the right patient, vaccine/diluent, time, dose, route, site, technique, and documentation. Cold chain storage should be maintained at 2–8°C. Sterility should be ensured by using a new sterile needle and syringe for each injection; reuse of multidose vials should be avoided where possible. Individuals should be monitored for at least 15 minutes post-vaccination for adverse events.¹

Overall Vaccination Schedule⁶

Vaccine	19–26 years	27–49 years	50–64 years	≥65 years	
COVID–19	1 or more doses of 2025–2026 vaccine (See Notes)			2 or more doses of 2025–2026 vaccine (See Notes)	
Influenza inactivated (IIV3, ccIIV3) Influenza recombinant (RIV3)	1 dose annually			1 dose annually (HD–IIV3, RIV3, or aIIV3 preferred)	
Influenza inactivated (aIIV3; HD–IIV3) Influenza recombinant (RIV3)	Solid organ transplant (See Notes)				
Influenza live, attenuated (LAIV3)	1 dose annually				
Respiratory syncytial virus (RSV)	Seasonal administration during pregnancy (See Notes)			60–74 years (See Notes)	≥75 years
Tetanus, diphtheria, pertussis (Tdap or Td)	1 dose Tdap each pregnancy; 1 dose Td/Tdap for wound management (See Notes)				
	1 dose Tdap, then Td or Tdap booster every 10 years				
Measles, mumps, rubella (MMR)	1 or 2 doses depending on indication (if born in 1957 or later)			For health care personnel (See Notes)	
Varicella (VAR)	2 doses (if born in 1980 or later)		2 doses		
Zoster recombinant (RZV)	2 doses for immunocompromising conditions (See Notes)		2 doses		
Human papillomavirus (HPV)	2 or 3 doses depending on age at initial vaccination or condition	27–45 years			
Pneumococcal (PCV15, PCV20, PCV21, PPSV23)			See Notes		
			See Notes		
Hepatitis A (HepA)	2, 3, or 4 doses depending on vaccine				
Hepatitis B (HepB)	2, 3, or 4 doses depending on vaccine or condition				
Meningococcal A, C, W, Y (MenACWY)	1 or 2 doses depending on indication (See Notes for booster recommendations)				
Meningococcal B (MenB)	19–23 years	2 or 3 doses depending on vaccine and indication (See Notes for booster recommendations)			
Haemophilus influenzae type b (Hib)	1 or 3 doses depending on indication				
Mpox	2 doses				
Inactivated poliovirus (IPV)	Complete 3-dose series if incompletely vaccinated. Self-report of previous doses acceptable (See Notes)				
	Recommended vaccination for adults who meet age requirement, lack documentation of vaccination, or lack evidence of immunity	Recommended vaccination for adults with an additional risk factor or another indication	Vaccination is based on shared clinical decision-making	No Guidance/ Not Applicable	

Figure 1: Adult Immunization Schedule - 2025 by the Centers for Disease Control and Prevention (CDC).

Abbreviations: allIV3: Adjuvanted Inactivated Influenza Vaccine, Trivalent; cclIV3: Cell Culture–Based Inactivated Influenza Vaccine, Trivalent; COVID-19: Coronavirus Disease 2019; HepA: Hepatitis A; HepB: Hepatitis B; Hib: *Haemophilus influenzae* Type b; HPV: Human Papillomavirus; IIV3: Inactivated influenza vaccine, trivalent; IPV: Inactivated poliovirus vaccine; LAIV3: Live-Attenuated Influenza Vaccine, Trivalent; MenACWY: Meningococcal A, C, W, Y Vaccine; MenB: Meningococcal B Vaccine; MMR: Measles, Mumps, And Rubella; Mpox: Monkeypox; PCV15: 15-Valent Pneumococcal Conjugate Vaccine; PCV20: 20-Valent Pneumococcal Conjugate Vaccine; PCV21: 21-Valent Pneumococcal Conjugate Vaccine; PPSV23: 23-Valent Pneumococcal Polysaccharide Vaccine; RIV3: Recombinant Influenza Vaccine, Trivalent; RSV: Respiratory Syncytial Virus; RZV: Recombinant Zoster Vaccine; Td: Tetanus and Diphtheria Toxoids; Tdap: Tetanus, Diphtheria, and Acellular Pertussis; VAR: Varicella Vaccine.

Individual Vaccines^{4,6,7}

1. Hepatitis A vaccine:

The hepatitis A vaccine is an inactivated whole virus vaccine, administered IM in the upper arm (deltoid region). It is available under brand names such as Havrix, Vaqta, and Twinrix (combined hepatitis A and B). The routine schedule includes a two-dose series: Havrix at 0 and 6 months, or Vaqta at 0 and 12 months, with a minimum interval of 6 months between doses. Twinrix may also be used as a three-dose series (0, 1, and 6 months).

Indications for vaccination include individuals with chronic liver disease (CLD), Human Immunodeficiency Virus (HIV) infection, men who have sex with men (MSM), people who inject drugs, and those in settings with exposure risk. In special situations, vaccination is advised during pregnancy if there is risk for infection or severe disease, and for travellers to high-risk countries, ideally at least 2 weeks before travel, with Twinrix being the preferred option. For rapid protection, an accelerated schedule (0, 1, and 3 weeks, followed by a 12-month booster) may be used. Additionally, close contacts of international adoptees arriving from high-risk regions should receive one dose within 2 weeks before the adoptee's arrival.

The vaccine is contraindicated in individuals with a history of anaphylaxis to a previous dose or vaccine component such as neomycin, and should be deferred in cases of moderate or severe acute illness. Incomplete vaccine series should not be restarted; only the remaining doses should be administered to complete the schedule.

2. Hepatitis B vaccine

The hepatitis B vaccine is a recombinant subunit vaccine containing hepatitis B surface antigen (HBsAg). It is administered IM in the deltoid region, and is available under several brand names including Engerix-B, Heplisav-B, PreHevBrio, Recombivax HB, and Twinrix (combined hepatitis A and B). The routine schedule varies by formulation: for adults aged 19–60 years, the two-dose series (Heplisav-B) is given at 0 and 1 month, while the three-dose series (Engerix-B, PreHevBrio, Recombivax HB, or Twinrix) follows a 0, 1, and 6-month schedule. An accelerated four-dose series (Twinrix: 0, 1, 3 weeks + 12-month booster) may be used when rapid protection is needed. For adults over 60 years, vaccination is indicated when risk factors are present.

Indications include all adults aged 19–60 years and adults over 60 years with conditions such as CLD, HIV infection, MSM, injectable drug use, exposure-prone occupations, and dialysis or end-stage renal disease (ESRD).

In special situations, vaccination is recommended during pregnancy if there is a risk of infection or severe outcomes, although PreHevBrio is not recommended because of limited data. For travellers to high-risk countries, it should be given at least 2 weeks before travel, with Twinrix being preferred, and an accelerated schedule (0, 1, 3 weeks + 12-month booster) may be used. In dialysis patients, Engerix-B (2 mL, dialysis formulation) is given at 0, 1, 2, and 6 months, while Recombivax HB (1 mL = 40 µg) is given at 0, 1, and 6 months. For immunosuppressed individuals, Heplisav-B (0, 1 month) or dialysis formulations of Engerix-B or Recombivax HB are used as per the same schedules.

The vaccine is contraindicated in individuals with a history of anaphylaxis to a previous dose or vaccine component. It should be deferred in cases of moderate or severe acute illness. Incomplete series should not be restarted; remaining doses should be completed as scheduled. Booster doses every 5 years are

recommended for high-risk individuals to maintain protection.

3. Human papillomavirus (HPV) vaccine

The HPV vaccine is a recombinant virus-like particle (VLP) vaccine that provides protection against multiple oncogenic and non-oncogenic HPV types. It is administered IM, and is available as Gardasil 9 (best), as well as bivalent (types 16 and 18), and quadrivalent (types 6, 11, 16, and 18) formulations. Gardasil 9 provides protection against nine HPV types (6, 11, 16, 18, 31, 33, 45, 52, and 58).

The routine schedule includes a two-dose series (0 and 6 months) for individuals aged 9–14 years, and a three-dose series (0, 1, and 6 months) for those aged 15–26 years. The vaccine is indicated for all individuals aged 9 to 26 years of age. In special situations, adults aged 27–45 years who have not completed vaccination may be offered either the two- or three-dose series. The vaccine is contraindicated during pregnancy, and should be deferred until after delivery. In immunosuppressed individuals, including those with HIV infection, a three-dose schedule should always be followed regardless of age or prior doses.

The main contraindication is anaphylaxis to a previous dose or vaccine component. The vaccine should be deferred in moderate or severe acute illness. Importantly, if the series is interrupted, it should not be restarted; the remaining doses should simply be completed according to schedule.

4. Influenza vaccine

Influenza vaccines are available in multiple formulations, including inactivated influenza vaccine (IIV3), adjuvanted inactivated influenza vaccine (A-IIV3; FluAd), high-dose inactivated influenza vaccine (HD-IIV3; Fluzone), cell-culture inactivated influenza vaccine (CC-IIV3; FluCelVax), recombinant influenza vaccine (RIV3; FluBlok), and live-attenuated influenza vaccine (LAIV3; FluMist). All inactivated forms are administered IM, while the live-attenuated vaccine is given intranasally as a spray.

The routine schedule recommends one dose annually for all adults aged 19 years and older. The live-attenuated vaccine (LAV) of influenza should not be used in individuals over 50 years.

Indications include all adults aged over 19 years, with emphasis on pregnant women, older adults, and individuals with chronic diseases.

In special situations, LAV is contraindicated during pregnancy; however, all inactivated forms may be used safely. In solid organ transplant recipients, HD-IIV3 or A-IIV3 formulations are preferred. For close contacts of severely immunosuppressed patients, LAV should be avoided, but other formulations can be used.

Contraindications include a history of anaphylaxis to a previous dose or vaccine component. Additionally, the LAV is contraindicated in pregnancy, immunosuppression, asplenia, individuals with cochlear implants or cerebrospinal fluid (CSF) leaks, age over 50 years, and asthma. Egg allergy is not a contraindication for any influenza vaccine.

Precautions include a history of Guillain–Barré syndrome (GBS) within 6 weeks of a prior influenza vaccine and moderate or severe acute illness. Annual vaccination is essential due to frequent strain variation.

5. Measles, mumps, and rubella (MMR) vaccine

The MMR vaccine is a LAV, and is also available as MMRV (a combination of MMR and varicella). It is administered SC and is available under brand names such as MMR II and Priorix.

The routine schedule consists of a single dose for adults. Travellers and healthcare workers (HCW) should receive a two-dose series at 0- and 1-month intervals. The vaccine is indicated for adults lacking evidence of immunity, including those without documented vaccination or prior infection.

In special situations, pregnancy and immunosuppression are absolute contraindications. However, in HIV-infected persons with a CD4 count $> 15\%$ or > 200 cells/mm³, a two-dose schedule (0 and 1 month) may be given safely. During outbreaks, a booster dose may be administered.

Contraindications include anaphylaxis, immunosuppression, and pregnancy. Precautions include receipt of antibody-containing blood products within the past year (should wait at least 3 months before vaccination), a history of thrombocytopenia or thrombotic thrombocytopenic purpura (TTP), positive tuberculin skin test (TST), or moderate to severe acute illness.

An important additional point is that people born before 1957 are generally considered immune to MMR and

do not require vaccination. If the vaccination series is interrupted, it should not be restarted; the remaining doses should simply be completed.

6. Meningococcal vaccine

The meningococcal vaccine is available in multiple formulations, including MenACWY (brands: Menveo, MenQuadfi), MenB (Bexsero, Trumenba), and MenABCWY (Penbraya). The MenACWY vaccine is a conjugate vaccine (linked to tetanus toxoid), while MenB is a recombinant protein vaccine containing factor H-binding protein (FHbp) antigen, and MenABCWY is a combination of MenACWY–tetanus toxoid (TT) + MenB–FHbp.

The route of administration depends on the formulation: polysaccharide vaccines are given SC, whereas conjugate vaccines are given IM. The routine schedule includes MenACWY at 0 and 2 months, followed by boosters every 5 years, and MenB at 0, 1, and 6 months, with a booster dose at 1 year, and every 3 years thereafter.

Indications include individuals with asplenia, complement deficiencies, those receiving eculizumab or ravulizumab therapy, HIV infection, and travellers to endemic regions. Special situations include first-year college students living in dormitories and military recruits, both of whom should receive a single dose of MenACWY. During pregnancy, MenACWY can be administered if indicated, whereas MenB is contraindicated. Travellers to endemic areas should receive MenACWY with 5-yearly boosters for continued protection.

Contraindications include anaphylaxis to a previous dose or vaccine component; MenACWY is specifically contraindicated in individuals with anaphylaxis to TT. Precautions include moderate or severe acute illness and latex sensitivity.

Additional points include avoiding interchange of vaccine brands and completing, rather than restarting, interrupted vaccination series. Booster intervals are 5 years for MenACWY and 3 years for MenB.

7. Pneumococcal vaccine

The pneumococcal vaccine protects against *Streptococcus pneumoniae* and is available in conjugate and polysaccharide formulations. Conjugate vaccines include pneumococcal conjugate vaccine 13-valent (PCV13; available in India), PCV15 (Vaxneuvance),

PCV20 (Prevenar 20), and PCV21 (Capvaxive). The polysaccharide vaccine is pneumococcal polysaccharide vaccine 23-valent (PPSV23; Pneumovax 23). PCV15, PCV20, and PCV21 contain capsular polysaccharides conjugated to diphtheria toxoid (DT), while PPSV23 consists of pure polysaccharides.

Conjugate vaccines are given IM, whereas polysaccharide vaccines are given SC.

The routine schedule depends on prior vaccination status:

- If no previous pneumococcal vaccination has been received, administer one dose of PCV15, PCV20, PCV21.
- If PCV15 is used, follow with one dose of PPSV23 after 1 year.
- If PCV13 was given previously, administer PCV20 or PCV21 after 1 year.
- If PPSV23 was given earlier, give PCV15, PCV20, or PCV21 after 1 year.
- If PCV13 plus PPSV23 were previously given, then PCV20 or PCV21 should be administered after 5 years.

The minimum interval between any two doses is 2 months. If PCV20 or PCV21 is administered at any point, PPSV23 is not required.

As per API recommendations:

- Adults aged 19–50 years with high-risk conditions should receive PCV13 followed by PPSV23 after 2 months.
- Adults aged over 50 years should receive PCV13 followed by PPSV23 after 1 year.

Indications include all adults aged > 50 years, and 19–50 years with risk factors such as chronic heart, lung, liver, or kidney disease, dialysis, diabetes, smoking, alcohol use, CSF leak, cochlear implant, or immunosuppression.

With regard to special situations, no specific recommendations exist for use during pregnancy.

Contraindications include anaphylaxis to a previous dose or vaccine component, particularly to DT. Precautions are advised in cases of moderate or severe acute illness.

Additionally, if a vaccination series is interrupted, it should not be restarted; the remaining doses should be completed as scheduled.

8. Varicella (chickenpox) vaccine

The varicella vaccine is a LAV administered either SC or IM. It is available under the brand name Varivax.

The routine schedule depends on vaccination history:

- Adults with no previous dose should receive two doses at 0 and 1 month.
- Those who have received one prior dose should receive the second dose after 1 month.

The vaccine is indicated for adults lacking evidence of immunity, including those without prior vaccination, no history of varicella disease, individuals born after 1980 (in the United States of America [USA]), and household contacts of susceptible persons.

In special situations, the vaccine is contraindicated in pregnancy but may be given to healthcare personnel (HCP) as a two-dose series (0 and 1 month). In HIV-infected individuals with CD4 count > 15% or > 200 cells/mm³, two doses are recommended at 0 and 3 months.

Contraindications include anaphylaxis, immunosuppression, and pregnancy. Precautions include:

- Recent receipt of antibody-containing blood products (within the past year), as this may interfere with vaccine response.
- Avoiding antiviral drugs (e.g., acyclovir) for 1 day before and 14 days after vaccination, since antivirals can reduce vaccine efficacy.
- Avoiding aspirin use due to the risk of Reye's syndrome.
- Deferring vaccination during moderate or severe acute illness.

Additional notes include completing, rather than restarting, interrupted vaccination series. When given with another LAV, both may be administered on the same day; if not, they should be spaced at least 4 weeks apart.

9. Zoster (shingles) vaccine

The zoster vaccine is a recombinant zoster vaccine (RZV) containing Varicella-Zoster Virus (VZV) glycoprotein antigen with adjuvant. It is administered IM or SC, and is available under the brand name Shingrix.

The routine schedule includes two doses given at 0 and 2 months (2–6 months), with a minimum interval of 1 month between doses. It is indicated for adults aged ≥ 50 years, as well as for individuals aged ≥ 19 years with immunosuppression or HIV infection.

In special situations, the vaccine should be given regardless of prior history of shingles (herpes zoster). It helps prevent both primary herpes zoster and postherpetic neuralgia in older and immunocompromised adults.

Contraindications include a history of anaphylaxis to a previous dose or vaccine component. Precautions include a current episode of zoster infection, pregnancy, or moderate to severe acute illness at the time of planned vaccination.

Additionally, if the vaccine series is interrupted, it should not be restarted; the remaining doses should be completed as per schedule.

10. Tetanus, diphtheria, and pertussis vaccine (Tdap/Td)

The Tdap/Td vaccine is an inactivated toxoid vaccine containing TT, DT, and acellular pertussis antigen. It is administered IM and is available under the brand names Boostrix (Tdap) and Tenivac (Td).

The routine schedule for adults aged ≥ 19 years includes one dose of Tdap, followed by Td or Tdap every 10 years thereafter.

Indications include all adults over 19 years, pregnant women, wound prophylaxis, and close contacts of infants to prevent pertussis transmission.

In special situations:

- During pregnancy, a single dose of Tdap is recommended between 27–36 weeks of gestation, irrespective of prior vaccination.
- If Td is used during pregnancy instead, it should follow a 0- and 1-month schedule.

- In individuals with unknown vaccination history, the primary series includes doses at 0, 1, and 6 months, followed by Td or Tdap every 10 years.

Contraindications include anaphylaxis to any vaccine component and encephalopathy within one week of a previous Tdap dose (in which case Td should be used instead).

Precautions include a history of GBS within 6 weeks of a prior tetanus vaccine, progressive neurological disease, or moderate to severe acute illness.

Additionally, if a series is interrupted, it should not be restarted; the remaining doses should be completed as scheduled.

11. *Haemophilus influenzae* type b (Hib) vaccine

The Hib vaccine is a polysaccharide antigen conjugated to a protein carrier. It is administered IM and is available under brand names such as ActHIB, Hiberix, and PedvaxHIB.

The routine schedule applies only to adults with specific risk factors. In individuals with anatomical or functional asplenia, a single dose should be administered at least 14 days before elective splenectomy. For haematopoietic stem cell transplant (HSCT) recipients, vaccination should begin 1 year post-transplant, given as three doses at 0-, 1-, and 2-month intervals.

Indications for Hib vaccination in adults include those with asplenia or HSCT recipients.

There are no special situations or additional high-risk indications listed. The vaccine is contraindicated in individuals with a history of anaphylaxis to a previous dose or vaccine component. Precaution should be observed in cases of moderate or severe acute illness at the time of vaccination.

No additional notes beyond these specific indications were listed.

12. Polio vaccine

The polio vaccine is available in two forms — inactivated polio vaccine (IPV) and oral polio vaccine (OPV). The IPV contains inactivated poliovirus types 1, 2, and 3, while OPV is a LAV containing poliovirus types 1 and 3. The IPV is administered IM, whereas the OPV is given orally as 2 drops. The available brand for IPV is IPOL.

The routine schedule depends on vaccination status:

- For unvaccinated adults or those with unknown vaccination history, IPV is given as a 3-dose series at 0, 1, and 6 months.
- For those who were previously vaccinated but have risk factors, a single booster dose is recommended. For OPV, if an individual has received one or two doses of IPV, two doses of OPV may be used to complete protection.

Indications include unvaccinated adults, and adults at risk of exposure, such as travellers to endemic regions, close contacts of polio cases, responders to polio outbreaks, and healthcare workers handling poliovirus specimens.

Contraindications include anaphylaxis to a prior dose or vaccine components such as neomycin, streptomycin, or polymyxin B. Additionally, OPV is contraindicated in pregnancy and in immunosuppressed individuals.

Precautions include moderate or severe acute illness at the time of vaccination.

Additionally, if a vaccination series is interrupted, it should not be restarted; only the remaining doses should be administered.

13. COVID-19 vaccine

The COVID-19 vaccines are categorised into several types based on their formulation and mechanism of action.

A. Whole virus-based vaccines:

- Inactivated vaccine: Covaxin (efficacy ~70%)
- Viral vector-based vaccines using a Modified Replication Defective Chimpanzee Adenovirus Oxford 1 (MRD ChAdOx1) platform: Covishield (efficacy 60%–90%), Sputnik V, Sputnik Light, Johnson & Johnson, and IncoVacc (India's only intranasal COVID-19 vaccine)

B. Protein or subunit vaccines:

These vaccines are based on the spike protein of SARS-CoV-2 and include Novavax, Corbevax, and Covovax.

C. Genetic material-based vaccines:

- Messenger RNA (mRNA) vaccines: Pfizer and Moderna. These vaccines do not cross the nuclear

membrane, are less stable, and require cold chain maintenance (Pfizer: –70°C; Moderna: –25°C to –15°C).

- DNA vaccine: Zydus Cadila (India's only intradermal vaccine), which crosses the nuclear membrane, is more stable, and does not require deep-freezing.

All COVID-19 vaccines are stored at 2–8°C, except mRNA vaccines which require ultra-cold storage.

A comparative summary of Covaxin vs Covishield is presented in Table 2.

Feature	Covaxin	Covishield
Made by	Bharat Biotech	Serum Institute of India
Origin	India	Oxford–AstraZeneca
Adjuvant	TLR 7/8 + Al(OH) ₃	None
Polysorbate	No	Yes
Rare side effects	None	VITT, demyelination



Table 2: Covaxin vs Covishield.

Abbreviations: Al(OH)₃: Aluminium Hydroxide; TLR: Toll-Like Receptor; VITT: Vaccine-Induced Immune Thrombotic Thrombocytopenia.

The routine schedule for adults aged > 19 years is one dose per season, with a minimum interval of 2 months between doses. In India, for adults aged > 18 years, a 0- and 1-month primary series followed by annual booster doses is recommended. Covaxin is approved for use in individuals > 6 years.

Indications include all adults aged ≥ 19 years, regardless of prior infection or vaccination history, especially during outbreaks or epidemics.

With regards to special situations, the vaccine is recommended in all conditions, including chronic illnesses, pregnancy, and immunocompromised states, unless contraindicated.

Contraindications include anaphylaxis to any component of the vaccine, history of myocarditis or pericarditis following an earlier mRNA vaccine, or multisystem inflammatory syndrome.

Precautions include postponing vaccination in cases of moderate or severe acute illness.

Additionally, if a series is interrupted, it should not be restarted; the remaining doses should be completed. Brand interchangeability is allowed.

14. Respiratory syncytial virus (RSV) vaccine

The RSV vaccine is a recombinant F protein-based vaccine developed for the prevention of RSV infection in older adults and pregnant women. It is administered IM and is available under the brand names Abrysvo, Arexvy, and Mresvia.

The routine schedule includes a single dose for adults aged > 75 years, and for pregnant women in the USA during the RSV season (September to January), administered once between 32–37 weeks of gestation.

Indications include adults aged > 75 years and for pregnant women (to prevent severe RSV infection in the newborn). It may also be given to adults aged 60–74 years with risk factors, which include chronic heart, lung, liver, kidney, or neurological disease, diabetes mellitus, immunosuppression, sickle cell disease or thalassaemia, and severe obesity.

Contraindications include anaphylaxis to a previous dose or vaccine component, and egg allergy. Precaution should be observed in individuals with moderate or severe acute illness.

Additional points include that it is a one-time vaccination only; if administered during a previous pregnancy, the infant should instead receive nirsevimab, a monoclonal antibody that blocks the RSV F protein; and that the vaccine is not yet approved in India.

15. Monkeypox (Mpox) vaccine

The Mpox vaccine is a LAV used for both pre-exposure and post-exposure prophylaxis. It is administered SC and is available under the brand name Jynneos.

The routine schedule consists of two doses given one month apart (0 and 1 month). The vaccine should be administered as soon as possible after exposure to maximise protection and prevent disease progression.

Indications include individuals at high risk of sexual exposure, those with occupational exposure to orthopoxviruses (such as laboratory workers or healthcare personnel handling poxvirus specimens), and populations affected during outbreaks.

In special situations, the vaccine is not recommended during pregnancy.

Contraindications include a history of anaphylaxis to a previous dose or vaccine component. Precaution should be observed in individuals with moderate or severe acute illness.

Additionally, if the vaccination schedule is interrupted, it should not be restarted; the remaining doses should be completed according to the prescribed interval.

Additional Vaccines in API Schedule⁴

The additional vaccines recommended by the API 2025 consensus guidelines are presented in Table 3.

Vaccine	Type	Schedule	Indications	Contraindications	Special notes
Anthrax	LAV	Pre-exposure: IM at 0, 1, 6 months → boosters at 6 and 12 months → annual boosters if risk persists. Post-exposure: SC at 0, 2, 4 weeks + antimicrobials	Adults aged 18–65 years at increased exposure risk – lab workers, livestock handlers, or suspected exposure cases	Anaphylaxis to vaccine components	For high-risk occupational or bioterror exposure; maintain annual boosters if risk continues
Chikungunya	LAV	Single IM dose	Adults > 18 years with increased exposure risk – travellers to high-risk areas or during outbreaks	Anaphylaxis, pregnancy, immunosuppressed individuals	Not yet approved for use in India
Cholera	Killed (monovalent/bivalent) or live-attenuated oral vaccine	Monovalent (≥ 2 years): 0, 2, 4 weeks. Bivalent (≥ 1 year): 0, 2 weeks. Live-attenuated (≥ 6 years): single dose	Adults aged 18–65 years at risk – travellers, outbreak settings, or potential exposure	Anaphylaxis to vaccine components	Provides short-term protection; essential for travellers to endemic regions
Japanese encephalitis (JE)	Live-attenuated (SA 14-142) or inactivated vaccine	LAV: single dose. Inactivated: 0, 1 month + booster after 1 year	Travellers staying > 1 month in endemic areas	Anaphylaxis, pregnancy, immunosuppression, vaccination during epidemic season (for LAV)	Should be administered before monsoon season or travel to endemic zones
Yellow fever	LAV (17D strain)	Single IM dose – protection begins after 10 days and lasts lifelong	Travellers to high-risk or endemic countries (certificate required)	Anaphylaxis, pregnancy, immunosuppression, HIV, egg allergy	International certificate mandatory; lifelong immunity after one dose
Typhoid	Inactivated, live-attenuated, Vi polysaccharide, or conjugate vaccine	Inactivated/Vi polysaccharide/conjugate: IM 0.5 mL single dose (boosters every 2–3 years). Live oral vaccine: one capsule every alternate day × 4 dose; booster every 5 years	Travellers, food handlers, and individuals in outbreak-prone regions	Anaphylaxis; LAV contraindicated in pregnancy	Conjugate vaccine preferred for long-term protection; oral form for adults in endemic regions

Table 3: Additional vaccines in Association of Physicians of India (API) schedule.

Abbreviations: HIV: Human Immunodeficiency Virus; IM: Intramuscular; JE: Japanese Encephalitis; LAV: Live-Attenuated Vaccine; mL: Millilitre; SA 14-142: SA 14-142 Live-Attenuated Japanese Encephalitis Virus Strain; SC: Subcutaneous; Vi: Virulence (Capsular) Polysaccharide Antigen of *Salmonella Typhi*.

Summary of Vaccination in Different Conditions^{4,6}

A summary of vaccinations to be given in different conditions as per CDC 2025 and API 2025 guidelines is presented in Table 4.

Condition/Group	Vaccines recommended (✓)	Vaccines to avoid (X)	Special remarks/Notes
Pregnancy	Tdap, Influenza (inactivated), RSV, Hepatitis B (if risk present)	All live vaccines (MMR, Varicella, LAV Influenza), MenB, HPV	Tdap is mandatory between 27–36 weeks in each pregnancy. Avoid all live vaccines. Give Hepatitis B if at risk
Men who have sex with men (MSM)	Tdap, Influenza, COVID-19, MMR, Varicella, Hepatitis A, Hepatitis B	—	High risk of Hepatitis A and B; ensure full immunisation for both
Immunosuppressed (excluding HIV)	Tdap, Influenza (inactivated), COVID-19, Pneumococcal (PCV + PPSV), Zoster (Recombinant), Hib (in HSCT)	All live vaccines (MMR, Varicella, LAV Influenza, JE, Yellow fever)	Avoid live vaccines until immune recovery. Prefer recombinant or inactivated formulations
HIV (CD4 < 15% or < 200 cells/mm ³)	Tdap, Influenza (inactivated), COVID-19, Pneumococcal, Zoster (RZV), Hepatitis A, Hepatitis B, Meningococcal	All live vaccines (MMR, Varicella, LAVs)	Use inactivated and recombinant vaccines only; avoid all live vaccines
HIV (CD4 > 15% or > 200 cells/mm ³)	Tdap, Influenza, COVID-19, Pneumococcal, Zoster, Hepatitis A, Hepatitis B, Meningococcal, MMR, Varicella	—	May receive MMR and Varicella if CD4 count > 200 and clinically stable
Healthcare workers (HCW)	Tdap, Influenza, COVID-19, MMR, Varicella, Hepatitis B, Typhoid (inactivated)	—	Ensure proof of immunity to MMR, Varicella, and Hepatitis B before joining duty
Diabetes/CKD/Haemodialysis	Tdap, Influenza, COVID-19, Pneumococcal, MMR, Varicella, Hepatitis B, HPV, Zoster	—	Use high-dose Hepatitis B vaccine formulations in dialysis. Maintain Pneumococcal boosters
Chronic liver disease/Alcoholism	Tdap, Influenza, COVID-19, Pneumococcal, MMR, Varicella, Hepatitis A, Hepatitis B, HPV, Meningococcal	—	Essential to prevent HAV and HBV superinfection. Administer both Hepatitis vaccines early
Heart/Lung disease	Tdap, Influenza, COVID-19, Pneumococcal, MMR, Varicella, Zoster, HPV, Meningococcal	—	Annual Influenza and Pneumococcal vaccines reduce morbidity and mortality
Asplenia/Complement deficiency/Sickle cell disease	Tdap, Influenza, COVID-19, Pneumococcal, MMR, Varicella, HPV, Hib, Meningococcal	Live-attenuated Influenza vaccine (LAV)	Administer Hib and Meningococcal conjugate vaccines 14 days before elective splenectomy
Cancer (During therapy)	Tdap, Influenza (inactivated), COVID-19, Pneumococcal, Hib	All live vaccines (MMR, Varicella, LAVs)	Defer vaccination during chemotherapy or radiation; give inactivated vaccines before or after therapy

Condition/Group	Vaccines recommended (✓)	Vaccines to avoid (X)	Special remarks/Notes
Recipients of HSCT (after 1 year)	Tdap, Influenza, COVID-19, Pneumococcal, MMR, Varicella, Hepatitis B, HPV, Zoster, Meningococcal, Hib	Live vaccines until immune recovery (< 1 year post-transplant)	Restart primary series post-transplant. Give Hib 3-dose series starting 1 year after HSCT
Recipients of solid organ transplant (SOT)	Tdap, Influenza, COVID-19, Pneumococcal, Hepatitis A, Hepatitis B, HPV, Zoster (RZV), Meningococcal, Hib, Typhoid (inactivated)	Live vaccines (MMR, Varicella, LAV Influenza, JE, Yellow Fever)	Vaccinate before transplant if possible; avoid live vaccines post-SOT due to immunosuppression

Table 4: Summary of vaccination in different conditions.

Abbreviations: CD4: Cluster of Differentiation 4; CKD: Chronic Kidney Disease; COVID-19: Coronavirus Disease 2019; HCW: Healthcare Workers; Hib: *Haemophilus influenzae* Type b; HIV: Human Immunodeficiency Virus; HPV: Human Papillomavirus; HSCT: Haematopoietic Stem Cell Transplantation; JE: Japanese Encephalitis; LAV: Live-Attenuated Vaccine; MenB: Meningococcal Serogroup B; MMR: Measles, Mumps, and Rubella; MSM: Men Who Have Sex with Men; PCV: Pneumococcal Conjugate Vaccine; PPSV: Pneumococcal Polysaccharide Vaccine; RSV: Respiratory Syncytial Virus; RZV: Recombinant Zoster Vaccine; SOT: Solid Organ Transplant; Tdap: Tetanus, Diphtheria, and Acellular Pertussis.

Upcoming Vaccines⁴

The upcoming vaccines that are currently in the developmental pipeline are presented in Table 5.

Disease	Vaccine/Platform	Developer/Institution	Trial phase/Status	Key features/Findings
Dengue ⁸	CYD-TDV (Dengvaxia)	Sanofi Pasteur	Licensed (limited use)	Live-attenuated chimeric YF tetravalent vaccine; low efficacy in seronegative; risk of severe dengue (ADE)
	DENVax + Dengvaxia (Heterologous Prime-Boost)	—	Preclinical/Experimental	Sequential immunisation targeting all 4 serotypes; aims to eliminate ADE; enhanced immune response
	Serum Institute of India Vaccine	Serum Institute of India	Phase I/II (Paediatric)	Early-stage paediatric trials underway
	Panacea Biotec Vaccine	Panacea Biotec + ICMR	Phase III (Approved Jan 2023)	10,335 adults (18–80 yrs) at 20 ICMR sites; trial start expected Aug–Sep 2023
HIV ^{9–14}	mRNA-1644 (eOD-GT8 60mer)	IAVI + Scripps + Moderna	Phase I (IAVI G002, G003)	Germline-targeting design; induces VRC01-class broadly neutralising antibody precursors
	mRNA-1574	Moderna + NIAID	Phase I	Broad mRNA-based HIV coverage under evaluation
	VIR-1388	Vir Biotechnology	Preclinical → Early clinical	T-cell vaccine using CMV vector; HIV prevention focus
	2-vector Arenaviral vaccine	HOOKIPA Pharma	Preclinical	Strong immunogenicity; reduced viral load in models
	HIVACAT T-cell immunogen (HTI)	AELIX Therapeutics	Phase I (Positive)	Robust T-cell response; safe and well tolerated

Disease	Vaccine/Platform	Developer/Institution	Trial phase/Status	Key features/Findings
	CD40.HIVRI.Env	Vaccine Research Institute	Phase I	Novel T-cell immunogen; early human studies ongoing
	HIV-1 Nanoparticle (1cSApNP)	Uvax Bio + NIH	Phase I (2024)	Self-assembling nanoparticle displaying Env trimers
Malaria ^{15–17}	RTS, S/AS01 (Mosquirix)	GSK + PATH + WHO	Approved/Pilot in Africa	First licensed malaria vaccine; used in Ghana, Kenya, Malawi; WHO-endorsed 2019
	R21/Matrix-M	Oxford + Serum Institute of India	Late-stage clinical	Targets PfCSP; promising high efficacy results
	PfSPZ Vaccine	Sanaria Inc.	Late-stage clinical	Attenuated whole sporozoite platform; high immunogenicity
	RTS, S + Seasonal chemoprevention	—	Trial complete	Combination approach more effective than either intervention alone
Tuberculosis ¹⁸	M72/AS01E	GSK + IAVI	Phase IIb → Phase III (2024)	54% efficacy against active TB in latently infected adults; potential first new TB vaccine in 100+ years
Leprosy ¹⁹	<i>Mycobacterium indicus pranii</i> (MiP)	ICMR + NLEP (India)	Implemented nationally	Therapeutic + prophylactic use; reduces bacillary load, improves lesions, shortens MDT duration
Zika virus ²⁰	mRNA/Inactivated platforms	Takeda, Moderna, WRAIR	Preclinical/clinical	Multiple candidates in early development targeting Zika envelope protein
Norovirus	Oral vaccine candidates	Vaxart, Takeda	Phase I–II	Oral/mucosal vaccine platforms; promising immunogenicity
Group B <i>Streptococcus</i> (GBS) ²¹	Polysaccharide/Protein vaccines	Pfizer, GSK, Sanofi	Preclinical → early clinical	Maternal immunisation strategy for neonatal protection
<i>Staphylococcus aureus</i> ²²	Recombinant/Toxoid candidates	Multiple companies	Various clinical stages	Targeting hospital-acquired infections; ongoing clinical evaluations
Bacterial lysates ²³	Immunostimulant therapy	Various	Under evaluation	Derived from lysed bacterial cells; enhances immune defence; studied in COPD and recurrent infections

Table 5: Upcoming vaccines.

Abbreviations: ADE: Antibody-Dependent Enhancement; AS01: Adjuvant System 01; AS01E: Adjuvant System 01E; CMV: Cytomegalovirus; COPD: Chronic Obstructive Pulmonary Disease; CYD-TDV: Chimeric Yellow Fever–Dengue Tetravalent Vaccine; DENVax: Dengue Vaccine; eOD-GT8: Engineered Outer Domain Germline-Targeting 8; Env: Envelope (glycoprotein); GBS: Group B *Streptococcus*; GSK: GlaxoSmithKline; HIV: Human Immunodeficiency Virus; HIVACAT: HIV Antigen Consortium of Catalonia; HTI: HIVACAT T-cell Immunogen; IAVI: International AIDS Vaccine Initiative; ICMR: Indian Council of Medical Research; MDT: Multidrug Therapy; MiP: *Mycobacterium indicus pranii*; mRNA: Messenger Ribonucleic Acid; NIAID: National Institute of Allergy and Infectious Diseases; NIH: National Institutes of Health; NLEP: National Leprosy Eradication Programme; PATH: Program for Appropriate Technology in Health; PfCSP: *Plasmodium falciparum* Circumsporozoite Protein; PfSPZ: *Plasmodium falciparum* Sporozoite; RTS,S: Repeat T-cell Epitope–Sporozoite Protein Vaccine; VRC01: VRC01-class Broadly Neutralising Antibody; WRAIR: Walter Reed Army Institute of Research; WHO: World Health Organization; YF: Yellow Fever.

Conclusion

Adult immunisation represents a crucial yet often neglected pillar of preventive healthcare. As the global population ages and the burden of chronic diseases rises, the need for sustained immune protection across the lifespan has never been more evident. Despite clear recommendations from international authorities such as the CDC, WHO, and API, adult vaccination coverage in India remains alarmingly low. Major barriers include limited public and physician awareness, fragmented healthcare delivery, and the absence of a unified national adult immunisation programmes.

The 2025 Adult Immunization Schedule underscores the importance of vaccines such as influenza, pneumococcal, COVID-19, hepatitis A and B, HPV, zoster, and emerging additions like RSV and monkeypox. These vaccines have proven efficacy in reducing morbidity, hospitalisation, and mortality, particularly among older adults and high-risk groups. To achieve meaningful progress, India must adopt a life-course immunisation strategy, integrating adult vaccination into routine healthcare, chronic disease management, and occupational health programmes. A concerted effort involving policymakers, healthcare professionals, and the public is essential to bridge knowledge gaps, strengthen infrastructure, and ensure equitable vaccine access. Promoting adult immunisation is not merely a public health goal but a moral imperative toward building a healthier, more resilient society.

Aryan Arora, Monica Mahajan. Towards Universal Adult Immunisation: Review of the 2026 Global and Indian Schedules. MMJ. 2026, June. Vol 3 (2).

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References

1. Dash R, Agrawal A, Nagvekar V, *et al.* Towards adult vaccination in India: a narrative literature review. *Hum Vaccines Immunother.* 2020;16(4):991–1001.
2. Lahariya C, Bhardwaj P. Adult vaccination in India: status and the way forward. *Hum Vaccines Immunother.* 2020;16(7):1508–10.
3. Rizvi AA, Singh A. Vaccination coverage among older adults: a population-based study in India. *Bull World Health Organ.* 2022;100(6):375–84.
4. Indian Consensus Guideline on Adult Immunisation. API [Internet]. Available at: <https://apiindia.org>. Accessed on: 10th November 2025.
5. Dhawan AM, Desai A, Gvalani A, *et al.* A comprehensive review of the latest Indian guidelines on adult immunisation. *Int J Community Med Public Health.* 2025;12(2):1159–65.
6. CDC. Vaccines & Immunisations. 2025. Adult Immunisation Schedule by Age (Addendum updated August 7, 2025). Available at: <https://www.cdc.gov/vaccines/hcp/imz-schedules/adult-age.html>. Accessed on: 10th November 2025.
7. Table 1: Summary of WHO Position Papers Recommendations for Routine Immunisation [Internet]. Available at: <https://www.who.int/publications/m/item/table1-summary-of-who-position-papersrecommendations-for-routine-immunisation>. Accessed on: 10th November 2025.
8. Torres-Flores JM, Reyes-Sandoval A, Salazar MI. Dengue Vaccines: An Update. *Biodrugs.* 2022;36(3):325–36.
9. Leggat DJ, Cohen KW, Willis JR, *et al.* Vaccination induces HIV broadly neutralizing antibody precursors in humans. *Science.* 2022;378(6623):eadd6502.
10. National Institute of Allergy and Infectious Diseases (NIAID). A Phase 1, Randomized, Open-label Clinical Trial to Evaluate the Safety and Immunogenicity of BG505 MD39.3, BG505 MD39.3 gp151, and BG505 MD39.3 gp151 CD4KO HIV Trimer mRNA Vaccines in Healthy, HIV-uninfected Adult Participants [Internet]. clinicaltrials.gov; 2025 Sept. Report No.: NCT05217641. Available at: <https://clinicaltrials.gov/study/NCT05217641>. Accessed on: 10th November 2025.
11. International AIDS Vaccine Initiative. A Phase 1 Study to Evaluate the Safety and Immunogenicity of eOD-GT8 60mer mRNA Vaccine (mRNA-1644) in HIV-1 Uninfected Adults in Good General Health [Internet]. clinicaltrials.gov; 2023 Mar.

- Report No.: NCT05414786. Available at: <https://clinicaltrials.gov/study/NCT05414786>. Accessed on: 10th November 2025.
12. Bailón L, Moltó J, Curran A, *et al.* Safety, immunogenicity and effect on viral rebound of HTI vaccines combined with a TLR7 agonist in early-treated HIV-1 infection: a randomized, placebo-controlled phase 2a trial. *Nat Commun.* 2025;16(1):2146.
 13. ANRS, Emerging Infectious Diseases. A Phase I Multicenter Double-blind Placebo Controlled Dose Escalation Trial of an Adjuvanted Anti-CD40 mAb Fused to Env GP140 HIV Clade C ZM-96 (CD40.HIVRI.Env) Vaccine Combined or Not With a DNA-HIV-PT123 HIV-1 Vaccine in Healthy Participants [Internet]. [clinicaltrials.gov](https://clinicaltrials.gov/study/NCT04842682); 2024 Dec. Report No.: NCT04842682. Available at: <https://clinicaltrials.gov/study/NCT04842682>. Accessed on: 10th November 2025.
 14. Zhang YN, Paynter J, Antanasijevic A, *et al.* Single-component multilayered self-assembling protein nanoparticles presenting glycan-trimmed uncleaved prefusion optimized envelope trimers as HIV-1 vaccine candidates. *Nat Commun.* 2023;14(1):1985.
 15. Draper SJ, Angov E, Horii T, *et al.* Recent advances in recombinant protein-based malaria vaccines. *Vaccine.* 2015;33(52):7433–43.
 16. Parums DV. Editorial: Current Status of Two Adjuvanted Malaria Vaccines and the World Health Organization (WHO) Strategy to Eradicate Malaria by 2030. *Med Sci Monit Int Med J Exp Clin Res.* 2023;29:e939357.
 17. RTS,S Clinical Trials Partnership. Efficacy and safety of RTS,S/AS01 malaria vaccine with or without a booster dose in infants and children in Africa: final results of a phase 3, individually randomised, controlled trial. *Lancet.* 2015;386(9988):31–45.
 18. Meeren OVD, Hatherill M, Nduba V, *et al.* Phase 2b Controlled Trial of M72/AS01E Vaccine to Prevent Tuberculosis. *N Engl J Med.* 2018;379(17):1621–34.
 19. Rao PN, Suneetha S. Current Situation of Leprosy in India and its Future Implications. *Indian Dermatol Online J.* 2018;9(2):83–9.
 20. Zika Virus Vaccines. NIAID: National Institute of Allergy and Infectious Diseases [Internet]. 2018. Available at: <https://www.niaid.nih.gov/diseases-conditions/zika-vaccines>. Accessed on: 10th November 2025.
 21. Carreras-Abad C, Ramkhelawon L, Heath PT, *et al.* A Vaccine Against Group B Streptococcus: Recent Advances. *Infect Drug Resist.* 2020;13:1263–72.
 22. Clegg J, Soldaini E, McLoughlin RM, *et al.* Staphylococcus aureus Vaccine Research and Development: The Past, Present and Future, Including Novel Therapeutic Strategies. *Front Immunol.* 2021;12:705360.
 23. Suárez N, Ferrara F, Rial A, *et al.* Bacterial Lysates as Immunotherapies for Respiratory Infections: Methods of Preparation. *Front Bioeng Biotechnol.* 2020;8:545.

The Neurovascular Conflict Syndromes — Part I: A Review of Anatomy and Pathophysiology

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Abstract:

Neurovascular conflict syndromes are hyperactive cranial nerve disorders caused by chronic contact between vascular structures and cranial nerves in the posterior fossa. Since the original description by Walter E Dandy, neurovascular compression has been widely accepted as the underlying mechanism in conditions such as trigeminal neuralgia, hemifacial spasm, and glossopharyngeal neuralgia. This review summarises current knowledge of the anatomical basis and pathophysiological mechanisms of these disorders based on relevant literature. The root entry/exit (Obersteiner–Redlich) zone, where central myelin transitions to peripheral myelin, is particularly vulnerable to pulsatile vascular compression. This leads to focal demyelination and ephaptic transmission, resulting in abnormal cross-talk between nerve fibres and ectopic impulse generation. Mechanisms such as neuroplasticity and kindling further contribute to the hyperexcitability of cranial nerve nuclei, producing characteristic clinical manifestations. Radiological and intraoperative studies support the role of neurovascular compression; however, discrepancies between imaging and clinical findings indicate a multifactorial process involving both peripheral and central mechanisms. Emerging entities, including vagal rhizopathies and the role of venous compression, further expand the spectrum of these syndromes. Despite advances in imaging and microvascular decompression, the precise cellular mechanisms remain incompletely understood. This review highlights the interplay of anatomical susceptibility and neurophysiological changes in the pathogenesis of neurovascular conflict syndromes.

Key words: Neurovascular Conflict, Neurovascular Compression, Trigeminal Neuralgia, Hemifacial Spasm, Glossopharyngeal Neuralgia, Ephaptic Transmission, Demyelination, Cranial Nerves, Posterior Fossa, Obersteiner–Redlich Zone, Microvascular Decompression, Neuroplasticity.

The sensory root is frequently indented, lifted up or bent at an angle by the artery...This I believe is the cause of tic douloureux.
— Walter E Dandy¹

Introduction

The pulsatile impulse generated by the heart in the cardiac cycle propagates the pressure-related events right up to the capillaries. Pulsatile propulsion of blood through blood vessels is responsible for its circulation and transport of oxygen and nutrients.

Venous flow too has a waveform pattern, related partly to thoracic excursions leading to cyclical variations in intrathoracic pressure, thus regulating the venous return. Intracranially, the major trunks of the arteries and veins, and the trunks of major cranial nerves, course through the cerebrospinal fluid-filled subarachnoid space. Since Walter Dandy¹ first described the contact

of a vessel loop with the trigeminal root in patients with trigeminal neuralgia, the theory of neurovascular compression has been widely accepted. It is believed that a close contact between a major artery and a nerve trunk over a prolonged period may cause changes in the nerve trunk, in the form of localised demyelination and initiate the phenomenon of ephaptic transmission (Figure 1).

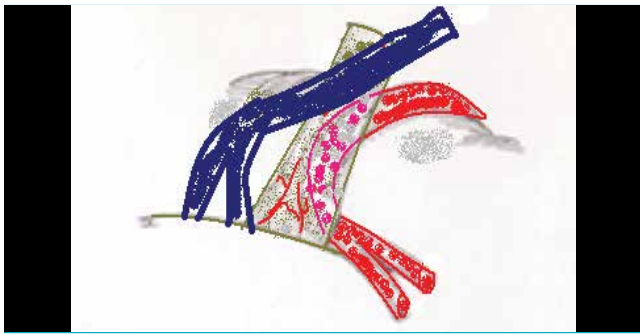


Figure 1: Sketch of trigeminal nerve compression by the superior cerebellar artery/Dandy's vein at the entry zone.

While the theory of neurovascular compression and consequent ephapsis and its clinical consequences is widely accepted, a number of studies, hypotheses, and clinical and radiological observations have attempted to establish this association. This article reviews the data on the observations, likely pathological changes, and the pathophysiological mechanisms. A PubMed database search was performed for articles on pathophysiology and observations, using the key words trigeminal neuralgia, hemifacial spasm (HFS), glossopharyngeal neuralgia, vertigo, ephaptic transmission, neurovascular compression. A total of 60 articles and book chapters were selected based on direct relevance and quality of information provided that enhanced the current understanding of the pathophysiology of neurovascular compression. The articles and book chapters were reviewed, and the pathophysiology of neurovascular compression causing specific syndromes was analysed.

An abnormal volley of impulses to the target musculature or sensory receptors can follow such ephaptic transmission. Subsequently, there can be a rekindling phenomenon at the brainstem nuclei of the nerves concerned, leading to constant electric discharge and impulse transmission. As the cranial nerves enter/exit the brainstem in the posterior fossa, there is a change in the myelin sheath characteristics, central on the brainstem side and peripheral on the distal side. This change occurs close to the entry/exit zone over a variable segment of the nerve, referred to as Obersteiner–Redlich zone. Extraneous contact

with a vessel over this zone or close to the brainstem results in hyperactive, dysfunctional syndromes.

In the case of the trigeminal nerve, the response takes the form of trigeminal neuralgia in the region of distribution of one or more branches. In the case of the facial nerve, there are intermittent tonic-clonic facial movements of one half of the face, commonly known as HFS. Such disorders of ephaptic transmission can also be seen in space-occupying lesions (most of the time, in the posterior fossa) (Figure 2), which probably act by causing or accentuating existing anatomical conflict between an artery and the corresponding nerve. Demyelination, as in multiple sclerosis, can also cause ephaptic transmission, possibly by short-circuiting the impulse volleys. However, a contrarian observation involves the fact that the proximal part of the superior cerebellar artery (SCA), as it passes below and is separated from the posterior cerebral artery (PCA) by the oculomotor nerve. Nearly two-thirds of SCAs have a point of contact with the oculomotor nerve on the inferior surface of the nerve. The SCA passes near and frequently has points of contact with the oculomotor, trochlear, or trigeminal nerves. The oculomotor nerve may occasionally be constricted between the PCA and SCA.² Yet, the only manifestation of oculomotor nerve compression by a vessel or a posterior communicating artery aneurysm is nerve dysfunction in the form of oculomotor nerve palsy, and an optic nerve compressed by an ophthalmic segment aneurysm manifests as optic atrophy. Is the response to a pulsatile impulse different for different cranial nerves?

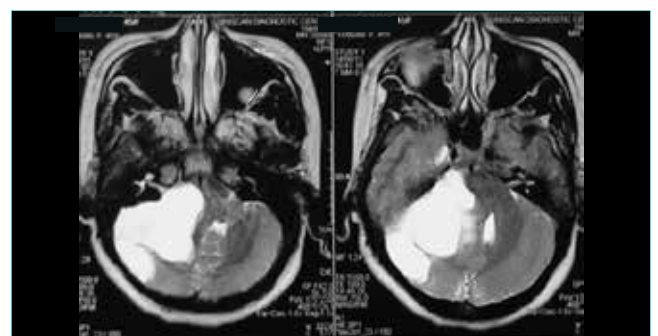


Figure 2: Magnetic resonance imaging (MRI) showing left cerebellopontine angle epidermoid in a patient with hemifacial spasm.

The Transitional Zone

Obersteiner and Redlich³ studied spinal nerves as they entered the spinal cord and described the transition zone (TZ) of myelin depletion. They interpreted this finding as a lack of myelin sheath for about 50 μ m. It is now apparent that this depletion of myelin was due to a preservation artefact, and the myelin sheath of the central portion is thinner⁴ and more susceptible to

injury.⁵ The TZ from central myelin to peripheral myelin still carries the label of Obersteiner–Redlich zone.

There are three types of fibrocollagenous supporting tissue associated with each nerve:

- (a) Endoneurium: A delicate, collagen-rich tissue surrounding each nerve fibre
- (b) Perineurium: A thin sheath with aggregation of funiculi
- (c) Epineurium: The fibroareolar tissue that surrounds the funiculi and forms the nerve trunk.

In the central nervous system (CNS), there is a lack of endoneurium, perineurium, and epineurium, and the axons are ensheathed by oligodendrocytes and follow a parallel course. The transition from a central myelin (from oligodendrocytes) to peripheral myelin (elaborated by Schwann cells) takes place at a variable distance after the nerve exits the brainstem, much like handing over the baton in a relay race. The sensory component of any nerve has a longer segment of central myelin than that in the motor root.⁶ Guclu *et al.*⁷ studied the relationship between the length and volume of the central myelin portion of these nerves and the incidence of corresponding syndromes of the cranial nerves. Central myelin is longer in case of facial nerve,⁷ while it is wider in case of trigeminal nerve. It is very short in glossopharyngeal and vagus nerves, and these two nerves exit the brainstem as multiple rootlets, unlike the facial nerve which exits as a single nerve.

In its course to the brainstem, the cranial nerve splits into thinner rootlets, which further subdivide into smaller rootlets. The TZ occurs within each of these mini-rootlets, and centrally, the nerve bundles enter the brainstem as a mass of compact white matter.⁸ The CNS portion of the mini-rootlet is convex in shape. Thus, the TZ is arched, and there are two compartments within the mini-rootlet: a peripheral zone consisting of axons ensheathed in endoneurium, and a central compact track of white matter. There is a deficiency of central myelin in the area deficient in endoneurium, and myelin in this region is thin as compared to that within the brainstem.⁴ The TZ is also the region where the endoneurial microvasculature exits to anastomose with the extraneural plexus, thus making the TZ relatively poorly vascularised, creating a locus minoris resistae (Achilles heel).⁸

Pathophysiology

The current understanding of neurovascular compression is that a vessel is in close contact with a cranial nerve in the posterior fossa (Figures 3–5). Further, Jannetta⁹ observed that these vessels cross the nerve at a right angle, and a vessel running parallel to the nerve does not cause clinical manifestations.

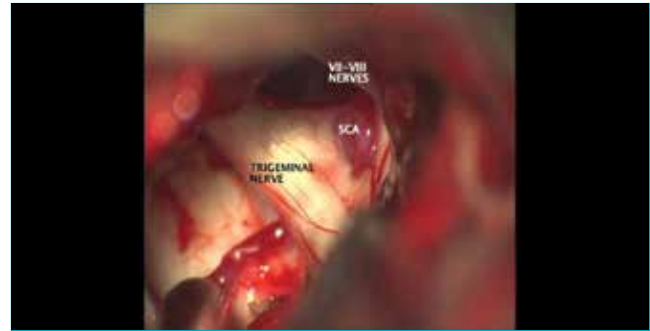


Figure 3: Intraoperative photograph of the trigeminal nerve being compressed by a loop of the superior cerebellar artery (SCA).



Figure 4: Intraoperative photograph of the trigeminal nerve after the loop of the superior cerebellar artery was freed from the brainstem side and axilla of the nerve.

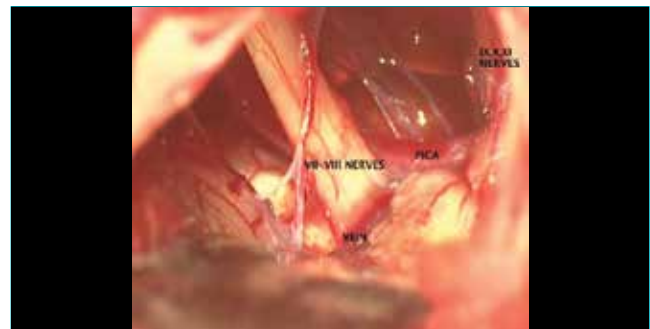


Figure 5: Intraoperative photograph of the cerebellopontine angle showing the facio-vestibulocochlear nerve complex compression by the anterior inferior cerebellar artery (AICA) and a vein at the entry/exit zone.

Mechanical ectopic excitation:

There is probably focal compression and demyelination in the course of adjacent axons, leading to a false synapse (ephapse).¹⁰ Nielsen¹¹ further stated that there is bidirectional cross-transmission between fibres, decreased conduction velocity in “pre-ephaptic” motor fibres, focal slowing of conduction over the suspected site of compression, as suggested by increased latency of the R1 component of the blink reflex. There is also lateral spread of orthodromic impulses, leading to increased amplitude of the blink

reflex and occurrence of synkinetic responses in other facial muscles, as well as autoexcitation related to the passage of a single anti- or orthodromic impulse, with lateral spread of current often resulting in a “cascade effect” that causes clinically evident tonic-clonic spasms. Ectopic excitation induced by hyperventilation, presumably due to a reduction in the concentration of extracellular calcium caused by respiratory alkalosis, can precipitate tonic-clonic events. All these observations fulfil the predictions made by the hypothesis that HFS is caused by abnormal conduction of impulses through the peripheral portion of the facial nerve. Rasminsky¹² summarised these four events as:

- (i) Mechanically induced or ectopic excitation
- (ii) Reflection of impulses: orthodromic and/or antidromic conduction
- (iii) Ephaptic excitation or “cross-talk” between axons
- (iv) After discharge or autoexcitation

It is possible that a demyelinated axon stimulates a myelinated one, instead of two demyelinated axons transmitting impulses.¹³ Due to resistance (resulting from vascular compression) offered by the demyelinated axon, the impulse is directed and transmitted to an adjacent myelinated axon, stimulating muscles innervated by different axons. This phenomenon also explains synkinesis.

Neuroplasticity:

Neuroplasticity, or reorganisation of the system, explains some of the features of neurovascular compression. Extrapolating the observations from limb or digital amputees, it is observed that the topographic representation of it is altered after amputation. The deprived area of the somatosensory cortex then becomes responsive to adjacent skin areas. Chronic stimulation of the facial, trigeminal, cochleovestibular, and glossopharyngeal nerves results in reorganisation of nuclei of these nerves, and abnormal discharges, perceived as pain in the trigeminal distribution, and facial spasm in the facial nerve motor distribution.¹⁴

Kindling:

The kindling theory states that a vascular loop compresses the nerve, causing demyelination and creating a focus of ectopic excitation.^{15,16} Chronic stimulation causes reorganisation in the facial nerve nucleus in patients with HFS.¹⁷ Another explanation proposed is aberrant regeneration in the facial nerves distal to the point of compression, in such a manner that some of the axons are misdirected to other targets.¹⁸ In the trigeminal nerve, compression causes demyelination of inhibitory fibres. Tactile stimulation of the gum or alveolus causes increased activity of the trigeminal nucleus, increased discharge through the fibres, some of which may be demyelinated due to compression, and there is amplification of the

impulse. The nuclear activity increases, and increased discharges are perceived as intense, intermittent, lancinating pain, with a background dull ache over the same region.

Each of the three neurovascular complexes in the posterior fossa includes one of the three cerebellar arteries, the brainstem, cerebellar peduncles, cerebellar surfaces, fissures between the brainstem and cerebellum, and one of the three groups of cranial nerves. There may be a combination of two concurrent neurovascular conflicts, causing tic convulsif (trigeminal neuralgia with HFS).^{19,20} The offending vessel in such cases is a tortuous vertebral artery, dissection of which should begin caudally and laterally. Tumours are also known to cause tic doloureux or tic convulsif, probably by causing vessels to lie against the TZ.²⁰⁻²² Rarely, supratentorial tumours can present with trigeminal neuralgia, presumably due to caudad displacement of the tentorium, causing abnormal neurovascular contact

(Figure 6). Such contact might be reversed when the tumour is excised, and anatomy returns to normal.

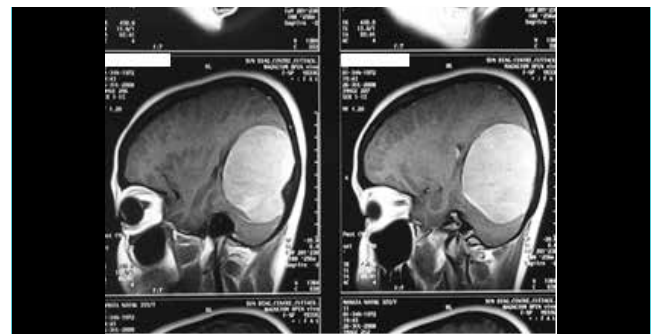


Figure 6: Sagittal T1-weighted contrast magnetic resonance imaging (MRI) of the brain showing a large tentorial meningioma (growing into the supratentorial compartment). The patient presented as ipsilateral trigeminal neuralgia as the sole symptom.

Histopathological Changes

Devor *et al.*²³ described structural and morphological changes seen in the trigeminal nerve as:

- (a) Distortion
- (b) Deviation
- (c) Groove formation
- (d) Nerve atrophy
- (e) Axonal loss and demyelination
- (f) Myelin abnormalities (dysmyelination)
- (g) Presence of excess collagen
- (h) Nerve atrophy²⁴

The microscopic findings of compressed segments of the trigeminal, facial, and glossopharyngeal nerves are remarkably similar, despite the variations in the site of biopsy and nerves involved. Beaver *et al.*²⁵

studied trigeminal nerve specimens from trigeminal nerve sections made for trigeminal neuralgia and demonstrated hypermyelination and demyelination. Demyelination at the point of contact was also reported in nerve specimens, obtained during microvascular decompression for HFS, on electron microscopy by Ruby and Jannetta.²⁶ The exact portion of the nerve compressed was biopsied, and the authors proposed that naked, demyelinated axons came into contact and effected ephaptic transmission. Hypertrophied myelin and Schwann cells were intermixed with axons. Brihaye *et al.*²⁷ reported similar findings of demyelination in patients with glossopharyngeal neuralgia, who had compression due to an atheromatous vertebral artery. Ishii *et al.*²⁸ found demyelination and hypermyelination of the glossopharyngeal nerve in pharyngeal and cervical segments extracranially. In the case of the vestibulocochlear nerve, however, there has been no demonstrable demyelination. On the contrary, there is endoneurial fibrosis,²⁹ which is a plausible explanation for deafferentation.

According to another plausible theory proposed by Calvin *et al.*,³⁰ the mechanism of trigeminal neuralgia involves a slightly injured nerve due to constant pulsations of a vessel adhered to the nerve. Amplification of neural activity and cross-transmission at the site of contact also results from a lack of input of A-fibres to the caudal trigeminal nucleus, a mechanism which could result in disinhibition of pain circuits and thereby result in the pain. Fromm and colleagues^{31,32} provided an explanation for trigeminal neuralgia with segmental inhibition, since the painful condition responds to baclofen, a drug that enhances segmental inhibition. Moreover, carbamazepine inhibits trigeminal neuralgia by acting centrally and is effective in HFS, indicating that it does not act at the site of vascular compression.

A combination of peripheral and central nervous system changes is involved in the aetiology of trigeminal neuralgia. There is an apparent disconnect between nociception and cortical perception of pain. There is reduced tactile and temperature sensation, indicating damage to small unmyelinated and large myelinated fibres, and abnormal temporal summation of pain, suggesting hyperexcitability.³³ With loss of inhibitory fibres, tactile stimuli on the face or gums cause increased activity in the trigeminal nucleus, resulting in increased discharge across the nerve to the effector organs. There is further amplification of impulses at the site of demyelination and reflection of these impulses back to the trigeminal nucleus. Summation of these impulses and the response of the nucleus results in severe episodic, lancinating pain over the distribution of the nerve. In the facial skin, there is abnormal neuronal activity, a higher rate of firing of axons of small-calibre fibres. Centrally, there is nociceptive modification of signal processing, N-methyl-D-aspartate (NMDA) activation with central hyperexcitability.³⁴

Gardner³⁵ postulated that HFS occurs due to a reverberating circuit set up between afferent and efferent fibres at a point of facial nerve compression. He also advocated sectioning of the nervus intermedius in cases of failed facial nerve decompression. The underlying cause of compression is invariably an ectatic or aberrant blood vessel that compresses the facial nerve at its exit from the brainstem.³⁶ The root entry/exit zone has some distinct features: the nerve fibres are ensheathed by the arachnoid membrane only, without the epineurium, and there are no connective tissue septa traversing the individual fascicles. This region is also the TZ between central (oligodendroglia) and peripheral (Schwann cells) myelination.³⁷ All these features result in increased vulnerability and therefore susceptibility to stimuli such as compression, leading to lateral excitation of facial axons by ephaptic transmission³⁸ and hyperexcitability of facial motor neurons.³⁹ The site of compression plays an important role in the pathogenesis of HFS.⁵ The cessation of antidromic stimulation when the conflicting nerve and vessel are separated has been demonstrated by electromyography (EMG) monitoring, which returns to pathological activity if the vessel is replaced.⁴⁰ Nielsen¹¹ proposed abnormal conduction of impulses through the peripheral portion of the nerve with ectopic excitation and ephaptic transmission due to focal demyelination. Nielsen¹¹ also observed electrophysiologically increased resistance in the para-axonal space, which is a prerequisite for ectopic/ephaptic excitation. Microvascular decompression decreases such resistance and facilitates remyelination, thus explaining the delayed benefits of microvascular decompression in HFS, and the severity of compression has no statistically significant difference on the outcome after microvascular decompression.⁴¹

Not all cases of HFS have neurovascular contact. Aoki and Nagao⁴² described a case involving a 5-year history of HFS, in whom neurosurgical exploration was negative for any vascular contact or conflict. The authors merely dissected around the nerve complex, and symptoms were relieved after surgery. Conversely, Sunderland⁴³ reported neurovascular contact between a redundant loop of the anterior inferior cerebellar artery (AICA) and the facial nerve in more than 60% of his autopsy cases, thus proving that the incidence of neurovascular conflict is higher than the reported incidence of HFS in the general population.

Ridder *et al.*⁴⁴ reviewed neurovascular conflict of the vestibulocochlear nerve in patients with tinnitus. They hypothesised, based on electrophysiological studies by auditory brainstem responses, that neurovascular conflict must occur in the intracranial portion of the nerve. Tinnitus may not be the result of demyelination, but rather due to desynchronisation of auditory impulses. The more synchronised the nerves fire, the higher the amplitude of the evoked potentials. Contact of a blood vessel with a nerve may alter neural conduction (decreased conduction velocity in some fibres or inactivate some

fibres), decreasing the temporal coherence of the firing in the central segment of the auditory nerve, decreasing the amplitude of peak II, and clinically this may result in frequency-specific tinnitus.⁴⁵ The desynchronised signal transmission within the auditory nerve from a vascular conflict may lead to reorganisation of auditory nuclei in the auditory brainstem and auditory cortex by way of neuronal plasticity.^{46,47} Clinically, patients suffer recurrent vertigo, disequilibrium, ataxia, and unilateral high-frequency sensorineural hearing loss, and spontaneous nystagmus on electronystagmography.⁴⁸ According to the explanation offered by Schwaber and Whetsell,⁴⁹ the onset follows an episode of vestibular neuronitis and adherence of the vessel to the vestibulocochlear nerve. There is demyelination of the nerve at the point of contact and deafferentation, leading to reorganisation of vestibular nuclei and discharges from these nuclei. It is likely that there are corresponding changes in the cortex, as well as in the interaction between the vestibulospinal system, ocular motility, visual pathways, and the reticular system. Motion and visual cues can precipitate or accentuate the symptoms due to abnormal discharges.

Degrees of nerve contact:

Anderson *et al.*⁵⁰ and Cheng *et al.*⁵¹ described a variable degree of nerve and vessel contact in patients with neuralgia, ranging from no contact to severe deformation with or without nerve atrophy.

Patients with severe deformation tend to have a higher incidence of atrophy, which can be diagnosed preoperatively,⁵¹ and the zone of atrophy consistently correlates with focal demyelination.

Brainstem Surface Conflicts

Can a contact between an ectatic and aberrant artery and brainstem trigger features of neurovascular conflict (Figure 7A–C)? Such neurovascular conflicts have been reported to cause ipsilateral sensorimotor symptoms, hypertension, intractable hiccups, and painful HFS with spasm of masticatory and ocular motor muscles.⁵² Ipsilateral tongue wasting has also been observed (Figure 8). The hypothesis explaining multiple cranial nerve involvement is neurovascular conflict between a vascular loop or an ectatic vessel and neighbouring brainstem nuclei. The reversal of clinical manifestations after microvascular decompression supports this hypothesis.⁵² Intrinsic brainstem lesions like diffuse glioma can also be associated with HFS (Figure 9).

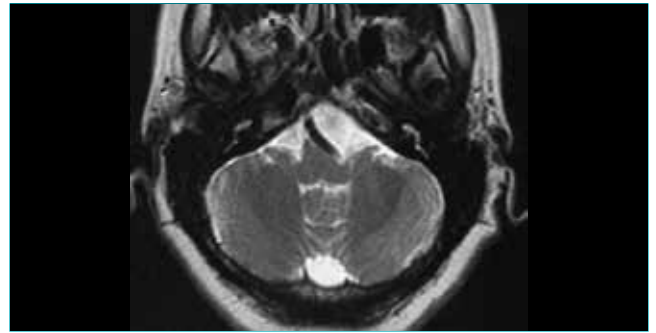


Figure 7A: Axial T2-weighted magnetic resonance imaging (MRI) showing an ectatic vertebral/basilar artery causing indentation on the brainstem.



Figure 7B: Coronal T2-weighted magnetic resonance imaging (MRI) showing an ectatic vertebral/basilar artery causing indentation on the brainstem.

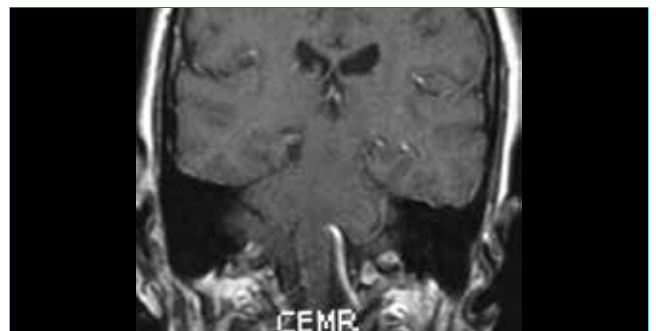


Figure 7C: Coronal T2-weighted magnetic resonance imaging (MRI) showing an ectatic vertebral/basilar artery in the patient with ipsilateral tongue wasting.



Figure 8: Ipsilateral tongue wasting in a patient.

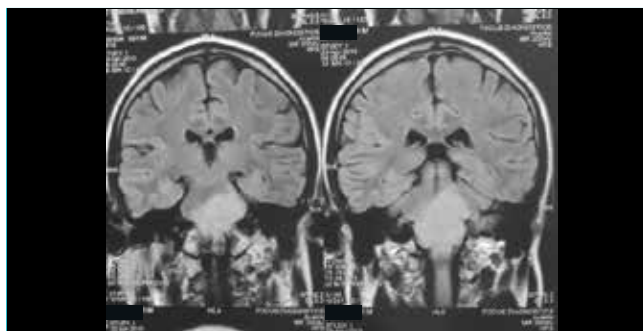


Figure 9: Magnetic resonance imaging (MRI) (T1-weighted contrast) with diffuse glioma of the brainstem in a patient who presented with hemifacial spasm.

Venous Neurovascular Conflicts

Veins also play a part in neurovascular conflicts, which may be purely venous or in combination with an arterial conflict. Far from being rare, there are reports of neurovascular conflicts due to pure venous compression (Figures 10 and 11), and a significant number of these have localised arachnoiditis.⁵³ Characterisation of venous compression is difficult, and many such cases may have atypical facial pain, with a background of continuous pain and paroxysmal fits. The incidence range is wide, varying from 6.1% to 68%, with an average of 25.3%.⁵³ In another study, Dumot and Sindou⁵⁴ reported their experience with 326 consecutive patients who underwent microvascular decompression from 2005 to 2013. Of these, 124 (38%) had a venous conflict, alone in 29 (8.9%) or an association with an artery in 95 (29.1%). There may be associated pathology like focal arachnoiditis and angulation of the nerve over the petrous apex.



Figure 10: Magnetic resonance imaging (MRI) (T2-weighted axial) showing venous conflict with the trigeminal nerve.



Figure 11A: Intraoperative photograph showing venous compression on the left trigeminal nerve.

Abbreviations: SCA: Superior Cerebellar Artery; SPV: Superior Petrosal Vein.



Figure 11B: Intraoperative photograph showing indentation on the trigeminal nerve due to venous compression.

Preoperative diagnosis of neurovascular conflict is essentially clinical, based on the characteristic pain profile of trigeminal nerve root compression and appearances in hemifacial clonic contractions. Diagnosis of involvement of other cranial nerves rests on intractable tinnitus and vertigo (vestibulocochlear nerve) and intermittent lancinating pain in the tonsillar fossa (glossopharyngeal neuralgia). Almost all cases of glossopharyngeal neuralgia are idiopathic,⁵⁵ although some cases have been described due to a calcified stylohyoid ligament,⁵⁶ nasopharyngeal and cerebellopontine angle tumours,⁵⁷ or compression by an artery.^{27,58} These symptoms have to be evaluated by an otologist. Rarely, there may be conflict between the vertebral artery and the brainstem, or the hypoglossal nerve (Figures 7 and 8). Trigeminal neuralgia (after exclusion of atypical mimics of the same) is graded by severity, according to the Barrows Neurological Institute Grading into five grades (Table 1).

Score	Pain description
I	No pain, no medications
I	Occasional pain, no medications required
III	Some pain, adequately controlled with medications
IV	Some pain, not adequately controlled with medications
V	Severe pain or no pain relief

Table 1: Barrow Neurological Institute Pain Institute Score.

HELPS and VANCOUVER

Honey *et al.* (2025) described episodic vagal rhizopathies manifesting as hemilaryngopharyngeal spasm (HELPS) and chronic non-productive cough due to vagus-associated neurogenic cough occurring due to unilateral vascular encroachment of its root (VANCOUVER) secondary to compression of vagal rootlets (that supply the laryngeal musculature) by posterior inferior cerebellar artery (PICA) in the posterior fossa. These symptoms may be accompanied by glossopharyngeal neuralgia. There are symptom-free periods between such episodes. Patients present with a feeling of choking and incessant coughing and may have to be intubated or tracheostomised. These patients may present to the emergency room (ER) and be misdiagnosed as having gastroesophageal reflux or may be labelled as psychogenic. Magnetic resonance imaging (MRI) of the posterior fossa shows a neurovascular conflict between the ipsilateral PICA and the vagus nerve.⁵⁹ Microvascular decompression of the vagal nerve is curative in these patients.

Neuroimaging and Operative Correlation

Detection of neurovascular conflict:

T2-weighted MRI study of the posterior fossa, along with T1-weighted contrast administration, is generally sufficient to demonstrate the neurovascular conflict (Figures 11–15). Leal *et al.*⁶⁰ carried out three-dimensional (3D) time-of-flight magnetic resonance angiography (3D TOF MRA), and 3D T1-gadolinium enhanced MRI to observe the vessels related to nerve in 100 patients with trigeminal neuralgia. Image analysis of these 100 patients showed that 88 had vessels in relation to the nerve, and 12 did not. All 88 patients had neurovascular conflict observed at surgery, with no false positives. Of the 12 patients who did not have vessels related to nerves, nine did not have neurovascular conflict at the time of surgery, concluding that there were three false negatives. Thus, the sensitivity of MRI was 96.7%, and the specificity of 100%, when correlated to surgical findings. Ronak Jani *et al.*⁶¹ studied the images and operative findings around the trigeminal nerve in 27 patients undergoing surgery for HFS. In these patients with no symptoms of neuralgia, they found that 23 patients had intraoperative evidence of neurovascular compression of the trigeminal nerve, 18 out of whom had MRI evidence of an aberrant artery in the root exit zone of the trigeminal. Further, they observed that the remaining five patients, who did not have MRI evidence of neurovascular conflict for the trigeminal nerve, had intraoperative neurovascular conflict.

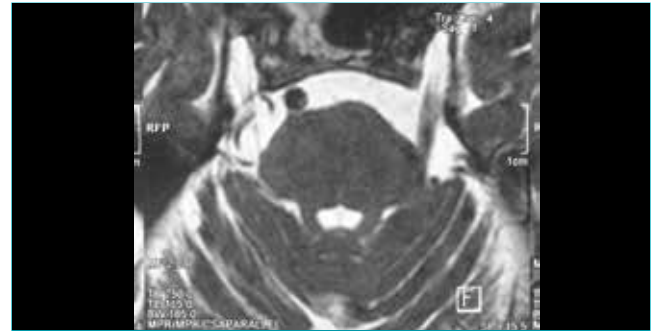


Figure 12: Magnetic resonance imaging (MRI) (T2-weighted axial) showing neurovascular conflict on the right side with the trigeminal nerve.

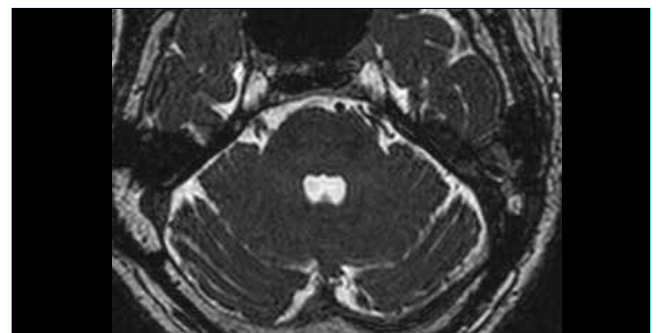


Figure 13: Magnetic resonance imaging (MRI) (T2-weighted axial) showing neurovascular conflict on the left side involving the trigeminal nerve.

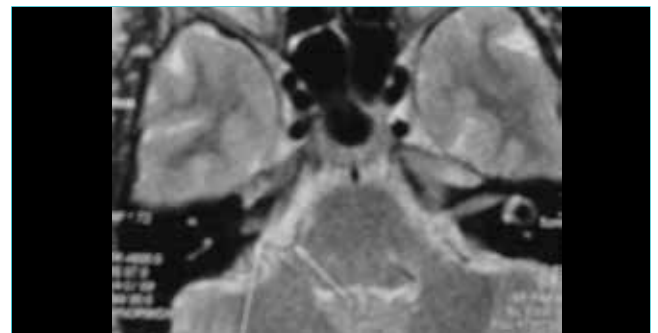


Figure 14: Magnetic resonance imaging (MRI) (T2-weighted) showing neurovascular conflict on the right side involving the facial nerve.

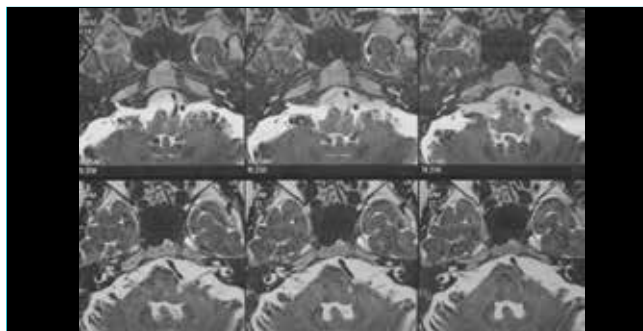


Figure 15: Magnetic resonance imaging (MRI) (T2-weighted axial) showing neurovascular conflict at VII–VIII entry/exit zone.

Prediction of culpability of the vessel in neurovascular conflict:

In their study, the vessel was correctly predicted to be compressing the nerve in 91 out of 100 patients, with accurate prediction of the SCA, AICA artery and basilar artery, while prediction was moderate in venous compression.

Prediction of the site of compression on the surface of the nerve:

Image analysis correctly identifies the surface of the circumference of the nerve as the site of compression, while predicting the severity of compression.

Conclusion

After nearly five centuries of clinical description and more than a century of surgical management, the pathogenesis of neurovascular compression syndromes is by no means completely settled. While imaging studies confirm neurovascular conflict in the majority of patients, the exact cellular and biochemical changes are unknown. Studies about the TZ and neuronal plasticity in response to ephapsis hold promise for unfolding the mystery of the changes that lead to clinical manifestations. Cochleovestibular manifestations and compression of the medulla by ectatic vessels also fall in the realm of the unknown. Recently described vagus nerve compression (HELPS and VANCOUVER syndromes) adds to the spectrum of neurovascular conflict lesions in the posterior fossa. Microvascular decompression, with its consistent and often long-lasting, permanent relief of symptoms, provides fair evidence of the culpability of TZ neurovascular conflict.

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References

1. Dandy WE. Concerning the cause of trigeminal neuralgia. *Am J Surg*. 1934;24:447–55.
2. Sunderland S. Neurovascular relations and anomalies at the base of the brain. *J Neurol Neurosurg Psychiatr*. 1948;2:243–57.
3. Kulkarni A. Complex Neurovascular Syndromes: Is the Compressing Vessel Alone the Culprit?. *J Neurosci Rural Pract*. 2022;13(2):283–9.
4. Sunderland S. Cranial nerve injury. Structural and pathophysiological considerations and a classification of nerve injury. In: Samii M, Jannetta P (Eds). *The Cranial Nerves*. New York: Springer Verlag; 1981: p. 16–23.
5. Jannetta PJ. Neurovascular compression in cranial nerve and systemic disease. *Ann Surg*. 1980;192:518–25.
6. Tarlov IM. Structure of nerve root 1. Nature of the junction between the central and peripheral nervous system. *Arch Neurol Psychiatr*. 1937;37:555–83.
7. Guclu B, Sindou M, Meyronet D, et al. Cranial nerve vascular syndromes of the trigeminal, facial and vagoglossopharyngeal nerves: comparative anatomical study of the central myelin portion and transitional zone; correlation with incidences of corresponding hyperactive dysfunctional syndromes. *Acta Neurochir*. 2011;153:2365–75.
8. Berthold CH, Carlstedt T, Corneliussen O. Anatomy of the nerve root at the central-peripheral transitional region. In: Dyck PJ, Thomas PK, Lambert EH, Bunge R (Eds). *Peripheral Neuropathy*. Philadelphia: WB Saunders; 1984. p. 156–70.

9. Jannetta PJ. Microvascular decompression for hemifacial spasm. In: May M (Ed). *The Facial Nerve*. New York: Thieme Stratton; 1985. p. 499–508.
10. Nielsen VK. Pathophysiology of hemifacial spasm. I. Ephaptic transmission and ectopic excitation. *Neurology*. 1984;34:418–22.
11. Nielsen VK. Electrophysiology of hemifacial spasm. In: May M (Ed). *The Facial Nerve*. New York: Thieme; 1986. p. 487.
12. Rasminsky M. Ectopic impulse generation in pathologic nerve fibers. In: Dyck PJ et al. (Eds). *Peripheral Neuropathy*. Philadelphia: WB Saunders; 1984. p. 911–8.
13. Rasminsky M. Ephaptic transmission between single nerve fibers in the spinal roots of “dystrophic” mice. *J Physiol*. 1980;305:151–69.
14. Schwaber Mitchell K. Vascular compression syndromes. In: Jackler Robert K, Brackmann Derald E (Eds). *Neurotology*. St Louis: Mosby; 1994. p. 881–904.
15. Møller AR, Sen CN. Recordings from the facial nucleus in the rat. Signs of abnormal facial muscle response. *Exp brain Res*. 1990;81(1):18–24.
16. Møller AR, Jannetta PJ. Physiological abnormalities in hemifacial spasm studied during microvascular decompression operations. *Exp Neurol*. 1986;93:584–600.
17. Møller AR, Jannetta PJ. On the origin of synkinesis in hemifacial spasm: Results of intracranial recordings. *J Neurosurg*. 1984;61:569–75.
18. Digre KB, Corbett JJ. Hemifacial spasm: Differential diagnosis, mechanism and treatment. *Neurology*. 1988;49:151–5.
19. Zhong J, Zhu J, Li ST, et al. Microvascular decompression in patients with coexistent hemifacial spasm and trigeminal neuralgia. *Neurosurgery*. 2011;68:916–20.
20. Desai K, Nadkarni T, Bhayani R, et al. Cerebellopontine angle epidermoid tumor presenting with “tic convulsif” and tinnitus: case report. *Neurol Med Chir*. 2002;42(4):162–5.
21. Wakabayashi T, Tamaki N, Saroh H, et al. Epidermoid tumor presenting as painful tic convulsif. *Surg Neurol*. 1983;19(3):244–6.
22. Ogansawara H, Oki S, Kohno H, et al. Tentorial meningioma and painful tic convulsif: case report. *J Neurosurg*. 1995;82(5):895–7.
23. Devor M, Govrin-Lippmann R, Rappaport ZH. Mechanism of trigeminal neuralgia : an ulyrastructural analysis of trigeminal root specimens obtained during microvascular decompression surgery. *J Neurosurg*. 2002;96:932–43.
24. Leal PRL, Barbier C, Hennier M, et al. Atrophic changes in the trigeminal nerves of patients with trigeminal neuralgia due to neurovascular compression and their association with severity of compression and clinical outcomes. *J Neurosurg*. 2014;120:1484–95.
25. Beaver DL, Moses HL, Ganote CE. Electron microscopy of the trigeminal ganglion. III. Trigeminal neuralgia. *Arch Path*. 1965;79:571–82.
26. Ruby JR, Jannetta PJ. Hemifacial spasm. Ultrastructural changes in the facial nerve induced by neurovascular compression. *Surg Neurol*. 1975;4:369–70.
27. Brihaye J, Périer O, Smulders J, et al. Glossopharyngeal neuralgia caused by compression of the nerve by an atheromatous vertebral artery. *J Neurosurg*. 1956;13:299–301.
28. Ishii T. Glossopharyngeal neuralgia: surgical treatment and electron microscopic findings. *Laryngoscope*. 1976;86:577–83.
29. Belal A, Ylikoski J. Pathologic significance of Meniere’s symptom complex: a histopathologic and electron microscopic study. *Am J Otol*. 1980;1(4):275–84.
30. Calvin WH, Loeser JD, Howe JF. A neurophysiological theory for the pain mechanism of tic douloureux. *Pain*. 1977;3:147–54.
31. Fromm GH. Pathophysiology of trigeminal neuralgia. In: Fromm GH, Sessle BJ (Eds). *Trigeminal Neuralgia*. Boston: Butterworth-Heinemann; 1991.
32. Fromm GH, Chattha AS, Terrence CF, et al. Role of inhibitory mechanism in trigeminal neuralgia. *Neurology*. 1981;31:683–7.
33. Levine DA, Argoff CE, Pilitsis J Trigeminal neuropathic pain and anesthesia dolorosa. In: Kim Burchiell (Ed). *Surgical management of pain*. New York: Thieme; 2015. p. 180–90.
34. Attal N. Neuropathic pain: mechanisms, therapeutic approach, and interpretation of clinical trials. *Continuum (Minneap Minn)*. 2012;18(1):161–75.
35. Gardner WJ. Cross talk – the paradoxical transmission of a nerve impulse. *Arch Neurol*. 1966;14:149–56.
36. Girard N, Poncet M, Caces F, et al. Three-dimensional MRI of hemifacial spasm with surgical correlation. *Neuroradiology*. 1997;39:46–51.
37. Nielsen VK. Electrophysiology of the facial nerve in hemifacial spasm: ectopic/ephaptic excitation. *Muscle Nerve*. 1985;8:545–55.
38. Sanders DB. Ephaptic transmission in hemifacial spasm: a single fiber EMG study. *Muscle Nerve*. 1989;12:690–4.
39. Martinelli P, Giuliani S, Ippoliti M. Hemifacial spasm due to peripheral injury of facial nerve: a nuclear syndrome? *Mov Disord*. 1992;7:181–4.
40. Samii M, Günther T, Iaconetta G, et al. Microvascular decompression to treat hemifacial spasm: Long

- term results for a consecutive series of 143 patients. *Neurosurgery*. 2002;50:712–9.
41. Kim JP, Chung JC, Chang WS, Chang Won Seok, et al. Outcomes of surgical treatment for hemifacial spasm associated with the vertebral artery: severity of compression, indentation and color change. *Acta Neurochir*. 2012;154:501–8.
42. Aoki N, Nagao T. Resolution of hemifacial spasm after posterior fossa exploration without vascular compression. *Neurosurgery*. 1986;18:478–9.
43. Sunderland S. Neurovascular relations and anomalies at the base of the brain. *J Neurol Neurosurg Psychiatry*. 1948;11:243–57.
44. De Ridder D, Vanneste S, Adriaensens I, Adriaensens I, et al. Vascular compression of the cochlear nerve and tinnitus. A pathophysiological investigation. *Acta Neurochir*. 2012;154:807–13.
45. De Ridder D, Heijneman K, Haarman B, et al. Tinnitus in vascular conflict of the eighth cranial nerve: A surgical pathophysiological approach. *Prog Brain Res*. 2007;166:401–11.
46. Szmyd B, Sołek J, Błaszczak M, et al. The Underlying Pathogenesis of Neurovascular Compression Syndromes: A Systematic Review. *Front Mol Neurosci*. 2022;15:923089.
47. Muhlneckel W, Elbert T, Taub E, et al. Reorganization of auditory cortex in tinnitus. *Proc Natl Acad Sci USA*. 1998;95:10340–3.
48. Schwaber MK, Hall JW. Cochleovestibular nerve compression syndrome: I. Clinical features and audiovestibular test findings. *Laryngoscope*. 1992;102(9):1020–9.
49. Schwaber MK, Whetsell WO. Cochleovestibular nerve compression syndrome: II. Histopathology and theory of pathophysiology. *Laryngoscope*. 1992;102(9):1030–6.
50. Anderson VC, Berryhill PC, Sandquist MA, et al. High resolution three-dimensional magnetic resonance imaging in the evaluation of neurovascular compression in patients with trigeminal neuralgia. A double-blind pilot study. *Neurosurgery*. 2006;58:666–73.
51. Cheng J, Meng J, Liu W, et al. Nerve atrophy in trigeminal neuralgia due to neurovascular compression and its association with surgical outcomes after microvascular decompression. *Acta Neurochir (Wien)*. 2017;159:1699–05.
52. Idriceanu TM, Sindou M. Painful spasms in facial, masticatory, and motor ocular muscles reversed after microvascular decompression of a neurovascular conflict at the brainstem. *Acta Neurochir*. 2017;159:1701–11.
53. Dumot C, Brinzeu A, Berthiller J, et al. Trigeminal neuralgia due to venous neurovascular conflicts: outcome after microvascular decompression in a series of 55 consecutive patients. *Acta Neurochir*. 2017;159:237–47.
54. Dumot C, Sindou M. Trigeminal neuralgia due to neurovascular conflicts from venous origin: an anatomical-surgical study (consecutive series of 124 operated cases). *Acta Neurochir*. 2015;157:455–66.
55. Onofrio Burton M. Glossopharyngeal neuralgia. In: Wilkins RH, Rengachary SS (Eds). *Neurosurgery Vol III*. New York: McGraw-Hill; 1996:3969–72.
56. Graf CJ. Glossopharyngeal neuralgia and ossification of stylohyoid ligament. *J Neurosurg*. 1958;16:448–53.
57. Dandy W. The Brain. In: Lewis D (Ed). *Practice of Surgery*. Hagerstown MD: WF Prior; 1932. p. 201–2.
58. Laha RK, Jannetta PJ. Glossopharyngeal neuralgia. *J Neurosurg*. 1977;47:316–20.
59. Leal PR, Hermier M, Froment JC, et al. Preoperative demonstration of the neurovascular compression characteristics with special emphasis on the degree of compression, using high-resolution magnetic resonance imaging: a prospective study, with comparison to surgical findings, in 100 consecutive patients who underwent microvascular decompression for trigeminal neuralgia. *Acta Neurochir*. 2010;152:817–25.
60. Jani RH, Hughes MA, Gold MS, Gold Michael S, et al. Trigeminal nerve compression without trigeminal neuralgia: Intraoperative vs Imaging evidence. *Neurosurgery*. 2019;84:60–5.
61. Honey CR. The vagal rhizopathies. *Front Neurol*. 2025;15:1513160.



CASE STUDIES

-
- 90** A Rare Case of Gastric Volvulus with Paraesophageal Hernia – **Vikas Panwar, Vedant Rai, Rittik Chakravorty**
-
- 94** Scrub Typhus Causing Encephalitis, Myositis, and Polyneuropathy: A Case Report – **Nitin Dambhare, Nikhil Dongre, Pavan Kale**
-
- 98** Bifid Renal Pelvis in a Single Kidney: A Different Approach to Managing Renal Calculi in a Partially Duplex Collecting System – A Case Report – **Sanjay S. Nabar, Sachin V. Pahade, Vrushabh B. Petkar**
-
- 101** Safe Application of Robotic Colorectal Surgery in an Elderly High-Risk Patient: A Case Report – **Abhinav Deshpande, Kawadu Jawade, Kapilnath, Nimish Ganvir**
-
- 105** Iron Infusion-Induced Kounis Syndrome Presenting as Inferior ST-Segment Elevation Myocardial Infarction with Normal Coronaries: A Case Report – **Shashi Bhushan, Pallavi Sehgal, Dheeraj Bhaskaran Nair**
-
- 108** Delayed Presentation of Post-Traumatic Hepatic Artery Pseudoaneurysm Following Blunt Abdominal Injury – **Nishit Mashru, Aaditya Yadav, Chintala Sai Venkata Chiranjeevi, Dheeraj Bhaskaran Nair**
-
- 112** The Rash That Followed the Remedy: Phenytoin-Induced Drug Reaction with Eosinophilia and Systemic Symptoms Syndrome – **Nitin Wadaskar, Sumit Hajare, Nikhil Dongre, Vivek Rathore**
-
- 116** Bilateral Vertical Sacral Fracture, a Highly Unstable Pelvic Injury in a Case of Accidental Fall from Height – **Krittika Bhatia, Niranjani V, Paresh Bang, Manoj Pahukar**
-
- 121** Peroral Endoscopic Myotomy Followed by Antireflux Mucosectomy for Gastroesophageal Reflux in Identical Twins with Allgrove Syndrome – **Gaurav Patil, Ankit Dalal, Amol Vadgaokar**
-
- 124** Severe Acute-on-Chronic Hypercapnic Respiratory Failure in Long-Standing Bronchiectasis: A Case Report – **Azhar Khan, Sanjay Kriplani, Manoj Pethe**
-
- 127** Integrating Chrono-Nutrition with Oral Semaglutide Therapy in the Management of Extreme Obesity: A Case Report – **Purva Singh, Swati Waghdhare, Chahat Arora, Vinita Jha**
-
- 131** An Unusual Spontaneous Porto-Systemic Shunt Between the Left Portal Vein and Pericardial Venous System in Decompensated Chronic Liver Disease: Radiological and Intraoperative Correlation – **Soumyadip Sain, Karisangal Ramaswamy Vasudevan, Piyush Kumar Sinha, Rohit Saini, Manmohan Singh Rajput, Saurabh Kumar**
-
- 135** Management of Conversion of Atrioventricular Block to Complete Heart Block During One-Lung Ventilation in Thoracic Surgery: A Case Report – **Priya Singla, Abhilasha Mishra, Sachidanand Jee Bharti**
-
- 139** Uncommon Presentation of Cervical Abscess Causing Melioidosis due to Burkholderia pseudomallei Infection in a Patient with Uncontrolled Diabetes Mellitus: A Case Report – **Nitin Rathod, Andrea Janice Fonseca, Snehal Sadanandan, Priyal Shah**
-
- 143** Reconstruction of Synchronous Bilateral Buccal Mucosa Defects with a Single Free Anterolateral Thigh Flap with Intraoral Anastomosis – **Bharat Saxena, Raj Lakshmi Pandey, Devendra Chaukar**
-
- 147** A Case Report of Metallosis-Related Aseptic Loosening of a Primary Total Knee Arthroplasty Implant Managed with Revision Total Knee Arthroplasty – **Debasish Sarkar, Pradeep Bhosale**
-
- 151** Elastofibroma Dorsi in a Patient with Right Breast Carcinoma: A Potential Diagnostic Pitfall – **Manish Chetwani, Zainul Abedeen, Niraj Kanchankar**
-
- 154** Total Skin Electron Therapy : Basic Technical Aspects for Radiation Therapists – **Priyanka Kumari, Manish Mangal, Anusheel Munshi, Akash Goyal**
-

A Rare Case of Gastric Volvulus with Paraesophageal Hernia

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Abstract:

Acute gastric volvulus and strangulated paraesophageal hernias (PEHs) have similar clinical histories, with individuals presenting with severe epigastric abdominal pain and lower chest pain. Development of gastric ischaemia and necrosis will present with abdominal pain and signs of peritonitis. PEHs represent 5%–15% of hiatal hernias, where part or all of the stomach protrudes through the oesophageal hiatus alongside the oesophagus, classified into types II–IV based on extent. Predominantly affecting older adults over 60 years of age, risk factors include obesity, advanced age, and increased intra-abdominal pressure from coughing or straining. Many remain asymptomatic and are discovered incidentally on imaging. But symptomatic cases manifest with postprandial chest or epigastric pain, dysphagia, early satiety, regurgitation, heartburn, nausea, or shortness of breath due to compression. Complications pose significant risks such as gastric volvulus, incarceration, strangulation, bleeding ulcers, or perforation, potentially leading to acute emergencies.

Key words: Abdominal Pain, Paraesophageal Hernia, Gastric Volvulus, Nissen's Fundoplication, Cruroplasty.

Introduction

Gastric volvulus is an uncommon but potentially life-threatening condition characterised by abnormal rotation of the stomach, leading to luminal obstruction and possible vascular compromise.¹ Although it can occur as a primary event due to congenital or acquired laxity of the gastric ligaments, secondary gastric volvulus is more frequently associated with underlying structural abnormalities, particularly diaphragmatic defects such as paraesophageal hernia. Among the spectrum of hiatal hernias, paraesophageal hernias (classified as type II–IV) are distinguished by herniation of the gastric fundus alongside a normally positioned gastro-oesophageal junction or by progressive migration of additional abdominal viscera into the thoracic cavity. This anatomical distortion predisposes the stomach to abnormal mobility and

torsion, creating a favourable environment for the development of gastric volvulus.

The pathophysiology of gastric volvulus in the setting of paraesophageal hernia involves displacement of the stomach into the mediastinum, elongation and attenuation of supporting ligaments, and disruption of normal anatomic fixation. Two principal types of volvuli have been described — Organoaxial, in which rotation occurs along the stomach's longitudinal axis connecting the gastroesophageal junction and pylorus; and Mesenteroaxial, in which rotation occurs along the transverse axis.² Organoaxial volvulus is more commonly associated with paraesophageal hernias and carries a higher risk of strangulation, ischaemia, and perforation. Clinically, presentation may range from intermittent, nonspecific upper gastrointestinal (GI) symptoms to acute surgical

emergencies. Chronic or intermittent volvulus may present with dysphagia, postprandial fullness, anaemia from mucosal ulceration, or respiratory symptoms due to mediastinal compression. Given the potential for rapid progression to gastric ischaemia and necrosis, timely diagnosis is critical.³

Advances in imaging, particularly contrast-enhanced computed tomography and upper GI contrast studies, have significantly improved diagnostic accuracy by delineating the abnormal orientation of the stomach and identifying associated complications. Management strategies depend on the acuity of presentation and patient stability but typically involve urgent surgical intervention in acute cases, with reduction of the volvulus, assessment of gastric viability, and definitive repair of the paraoesophageal hernia to prevent recurrence.

This study presents a case of gastric volvulus occurring in the context of paraoesophageal hernia, highlighting the clinical presentation, radiologic findings, surgical management, and relevant literature. Through this case, we aimed to underscore the importance of early recognition and definitive treatment of this rare yet serious complication of paraoesophageal hernia.

Case Report

A 72-year-old gentleman presented to the emergency department with complaints of abdominal pain for seven days associated with vomiting and obstipation. On primary survey, the patient had a pulse rate of 88 beats per minute (bpm), a respiratory rate of 18 breaths per minute, and SpO₂ of 92% on room air. On abdominal examination, the abdomen was distended with epigastric tenderness on palpation.

After resuscitation, the patient underwent basic radiological investigation, which showed “obscured dome of diaphragm and costophrenic angle” on the right side. An oral positive contrast-enhanced whole abdomen with pelvis scan was done (Figure 1), which revealed a “Large hiatus hernia with gastric volvulus and distention of the stomach with collapse of the rest of the bowel. Minimal fluid and fat stranding are seen surrounding the herniated stomach with almost entire distended stomach in the chest.”



Figure 1: Gastric volvulus mimicking coffee bean appearance with the entire stomach in the right thorax, compressing the right lung.

With the above evidence of hiatus hernia with gastric volvulus, the patient was planned for an emergency surgery.

During the procedure, we found the entire stomach and the contents of the hernia sac along with the greater omentum. After a careful and meticulous adhesiolysis, the content was reduced into the abdomen, along with the excision of the sac (Figure 2). Intraoperatively, an upper GI endoscopy was performed. Once the content was reduced, crural repair was done with non-absorbable Ethibond suture (Figure 3), and a composite mesh was placed over the crura in an onlay fashion, secured with Prolene stitches. The lower part of the oesophagus was mobilised, and a 360-degree Nissen's fundoplication was done in a tension-free manner (Figures 4 and 5). After fixing the stomach in anatomical position, an anterior wall gastropexy was done.



Figure 2: Reducing the content (stomach) from the sac.

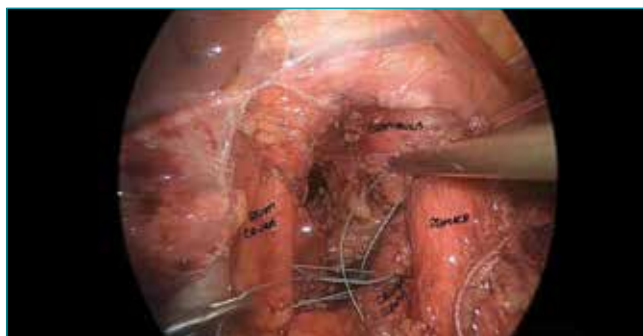


Figure 3: Repairing the crura (Cruroplasty).



Figure 4: Performing Shoe sign manoeuvre for fundoplication, mesh is placed in situ.

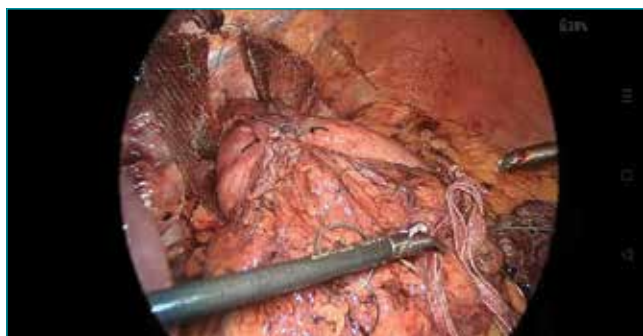


Figure 5: Nissen's fundoplication (360-degree wrap).

Follow-up

Postoperatively, the patient was managed symptomatically, along with total parenteral nutrition, incentive spirometry and chest physiotherapy. Scheduled antiemetics were administered to prevent postoperative nausea and vomiting.

Follow-up radiology scans show no abnormality (Figure 6).

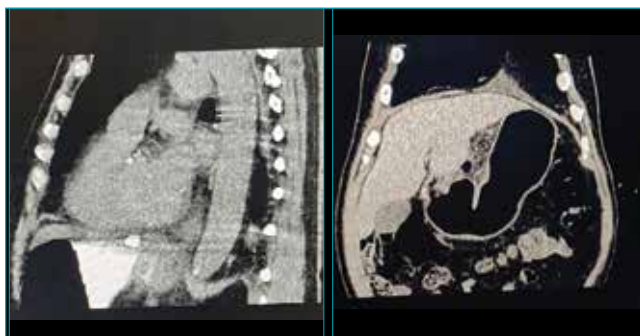


Figure 6: Postoperative oral contrast scan showing stomach below the diaphragm and contrast in wrap.

Discussion

Paraesophageal hernias are relatively rare and typically occur in elderly patients. The various presenting symptoms are non-specific and often occur in combination. These include symptoms of gastro-oesophageal reflux disease (GERD) in 26%–70% of cases, microcytic anaemia in 17%–47%, and respiratory symptoms in 9%–59%.⁴ Acute complications such as gastric volvulus with incarceration or strangulation are rare (estimated incidence of 1.2% per patient per year). Before the advent of minimally invasive techniques, open surgeries via transabdominal and transthoracic entry were the indicated management of primary hiatal hernia (PHH). Since its introduction in 1992, laparoscopic PHH repair (LPHHR) has emerged as the forefront of PHH treatment.⁵ As most of the paraesophageal hernias are associated with GERD symptoms, fundoplication is warranted.⁶ The concept of radial tension, caused by a very wide hiatus, and axial tension, caused by an apparent short oesophagus, are widely accepted among authors as the main incriminating factors in the process of recurrence after surgical repair.⁷ Radial tension can be managed with cruroplasty, and axial tension can be reduced by mobilising the distal part of the oesophagus. Advancements in mesh technology, including the advent of biologic and biosynthetic meshes, have contributed to a safer profile with fewer complications, better biocompatibility, and improved tissue integration.⁸ Studies showed that anterior gastropexy will decrease the chances of recurrences.⁹

Conclusion

Gastric volvulus associated with paraoesophageal hernia is a rare but serious condition that demands prompt recognition and intervention to prevent life-threatening complications. This case underscores the importance of considering this diagnosis in elderly patients presenting with non-specific upper GI symptoms.

Early imaging and timely surgical management, including reduction of the volvulus and definitive hernia repair with fundoplication and gastropexy, are key to achieving favourable outcomes and minimising recurrence.

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References

1. Rashid F, Thangarajah T, Mulvey D, *et al.* A review article on gastric volvulus: a challenge to diagnosis and management. *Int J Surg.* 2010;8(1):18–24.
2. Chau B, Dufel S. Gastric volvulus. *Emerg Med J.* 2007;24:446–7.
3. Shivanand G, Seema S, Srivastava DN, *et al.* Gastric volvulus: acute and chronic presentation. *Clin Imaging.* 2003;27(4):265–8.
4. Collet D, Luc G, Chiche L. Management of large paraesophageal hiatal hernias. *J Visc Surg.* 2013;150(6):395–402.
5. Cuschieri A, Shimi S, Nathanson LK. Laparoscopic reduction, crural repair, and fundoplication of large hiatal hernia. *Am J Surg.* 1992;163(4):425–30.
6. Solomon D, Bekhor E, Kashtan H. Paraesophageal hernia: to fundoplicate or not? *Ann Transl Med.* 2021;9(10):902.
7. Bradley DD, Louie BE, Farivar AS, *et al.* Assessment and reduction of diaphragmatic tension during hiatal hernia repair. *Surg Endosc.* 2015;29(4):796–804.
8. Lopez SZK, Gómez SG, Arenas SG, *et al.* Impact of mesh use in paraesophageal hernia repair: a review of short- and long-term outcomes. *Int Surg J.* 2025;12(7):1230–3.
9. Ponsky J, Rosen M, Fanning A, *et al.* Anterior gastropexy may reduce the recurrence rate after laparoscopic paraesophageal hernia repair. *Surg Endosc.* 2003;17(7):1036–41.

Scrub Typhus Causing Encephalitis, Myositis, and Polyneuropathy: A Case Report

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Abstract:

Scrub typhus, caused by the obligate intracellular bacterium *Orientia tsutsugamushi* and transmitted via bites from infected larval trombiculid mites (chiggers), remains a significant zoonotic threat in the Asia-Pacific "tsutsugamushi triangle" and beyond, with emerging cases reported globally. Initial manifestations often mimic undifferentiated febrile illnesses, including fever, headache, myalgia, eschar formation, and lymphadenopathy, complicating early diagnosis. The disease can rapidly progress to severe complications in 20%–30% of untreated cases, driven by endothelial damage, vasculitis, and cytokine-mediated multiple organ dysfunction. Common complications include hepatic dysfunction (77%), pneumonitis or acute respiratory distress syndrome (ARDS; 7%–54%), acute kidney injury (4%–10%), myocarditis, encephalitis, disseminated intravascular coagulation (DIC), shock, with mortality rates ranging from 3.8% overall to 24% in intensive care settings with multiple organ failure. Early empirical therapy with doxycycline is critical to mitigate progression.

Key words: Scrub Typhus, Scrub Typhus Complication, Myositis, Polyneuropathy.

Introduction

Scrub typhus, caused by *Orientia tsutsugamushi*, continues to impose a substantial public health burden across the Asia-Pacific region.^{1,2} In India, systematic reviews highlight its increasing prevalence, particularly in southern and northern regions, where it accounts for substantial morbidity beyond its classic eschar and fever presentation.² In Southern India, a study described the diverse clinical profile of scrub typhus and highlighted an encouraging trend of improving mortality rates with timely diagnosis and treatment.³ However, experience from a tertiary care centre in Northern India has shown that scrub typhus infection is not a benign disease and can lead to serious

complications.⁴ Neurological involvement in scrub typhus, though relatively uncommon, includes a broadening spectrum of central and peripheral nervous system manifestations.⁵ Severe systemic infections such as scrub typhus can additionally precipitate critical illness polyneuropathy, and myopathy.^{6,7} Rare neurological and neuropsychiatric presentations of scrub typhus have been documented in a case series of 10 patients from eastern India.⁷ Muscle involvement is also well recognised; a dedicated study reported clinical and electrophysiological evidence of myositis in approximately 39% of scrub typhus patients, often with histopathological features of inflammatory myopathy and vasculitis.^{4,7,8} We report a case of scrub typhus manifesting as encephalitis, myositis, and

polyneuropathy, emphasising early recognition and targeted therapy to improve outcomes.

Case Report

A 40-year-old male resident of Baitul, Madhya Pradesh, came to the emergency department with fever, chills and headache for 8 days, along with pedal oedema for the past 3 days. The patient had previously been admitted to another hospital for fever associated with thrombocytopenia.

Outside report showed platelet count 60,000/ μ L, serum glutamic-oxaloacetic transaminase (SGOT) of 110 U/L, and C-reactive protein (CRP) of 91 mg/L. On examination, the patient was febrile, tachypnoeic, irritable, and drowsy in nature. A black-coloured eschar was present on the right thigh (Figure 1). The patient's temperature was 38.1°C, blood pressure was 90/60 mmHg, and pulse rate was 108/min. On systemic examination, the cardiovascular system and per abdomen findings were normal. Respiratory system (RS) examination revealed bilateral crepitations, while central nervous system (CNS) examination showed drowsiness and irritability, with a Glasgow Coma Scale (GCS) score of E4V4M5 (E = Eye response, V = Verbal response, M = Motor response). The patient was admitted to the Intensive Care Unit (ICU). As the patient was tachypnoeic with severe hypoxia, he was intubated and placed on mechanical ventilation. He was sedated and started on inotropic support for hypotension.



Figure 1: Eschar on right thigh.

Routine investigations revealed CRP of 96 mg/L. Complete blood count (CBC) showed haemoglobin (Hb) of 17.6 g/dL, platelet count of 23,000/ μ L, and total leucocyte count (TLC) of 12,000/ μ L. Liver function tests (LFTs) showed SGOT/aspartate aminotransferase (AST) of 169 U/L, serum glutamic-pyruvic transaminase (SGPT)/alanine aminotransferase (ALT) of 106 U/L, total bilirubin of 5.48 mg/dL, and albumin of 2.1 g/dL. Renal function tests (RFTs) revealed sodium (Na^+) of 142 mEq/L, potassium (K^+) of 4.5 mEq/L, and creatinine of 1.7 mg/dL (Table 1). Chest X-ray showed bilateral lower lobe opacities (Figure 2). Scrub typhus immunoglobulin M (IgM) was positive. Two-dimensional echocardiography (2D echo) showed an ejection fraction (EF) of 55% with mild pericardial effusion.

Investigations	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9
CRP (mg/L)	96	144	108	54	23	69	113	76	46
Haemoglobin (g/dL)	16	13	11	10.3	9.9	9.6	10.2	11.6	-
Platelets (/ μ L)	36K	86K	85K	73K	78K	98K	149K	184K	-
TLC (/ μ L)	19K	28K	15K	16K	12K	18K	17K	7K	-
Albumin (g/dL)	2.1	-	2.1	-	2.9	2.7	2.3	-	-
Bilirubin (mg/dL)	5.48	-	3.68	-	3.89	3.68	2.95	-	-
SGOT/SGPT (U/L)	169/106	-	260/105	-	112/102	54/104	57/121	-	-
Creatinine (mg/dL)	1.78	1.63	1.36	1.25	1.23	0.76	0.53	-	-
Urea (mg/dL)	108	113	94	81	79	54	50	-	-
PT/INR (Seconds)	-	10.8/1.0	-	-	14.6/1.4	-	-	-	-

Table 1: Baseline laboratory investigations of the patient.

Abbreviations: CRP: C-Reactive Protein; INR: International Normalised Ratio; PT: Prothrombin Time; SGOT: Serum Glutamic-Oxaloacetic Transaminase; SGPT: Serum Glutamic-Pyruvic Transaminase; TLC: Total Leucocyte Count.



Figure 2: Chest X-ray showed bilateral lower lobe opacities.

Computed tomography (CT) of the thorax showed mild-to-moderate pleural effusion and severe ground-glass opacities throughout the bilateral lung parenchyma, with features suggestive of pulmonary oedema. The patient was treated for septic shock with multiple organ dysfunction syndrome and encephalopathy. Intravenous doxycycline and azithromycin were started along with diuretics. Neurology opinion was taken in view of seizures. CT of the brain showed minimal subarachnoid haemorrhage (SAH) along the bilateral frontal and right temporal lobe sulci. Electroencephalography (EEG) showed generalised slowing of rhythm suggestive of encephalopathy. The GCS score dropped to E2VTM2. A single donor platelet transfusion was administered for thrombocytopenia. Tracheostomy was performed and the patient gradually responded to the given line of treatment. Magnetic resonance imaging (MRI) of the brain showed post-ictal changes along with resolving SAH. Endotracheal (ET) culture showed *Klebsiella pneumoniae* and *Pseudomonas*, sensitive to tigecycline; hence, antibiotics were escalated according to sensitivity pattern, and the patient was shifted to the ward. In view of motor weakness, nerve conduction studies (NCS) were performed, which showed bilateral symmetrical sensorimotor axonal polyneuropathy in both upper and lower limbs. Creatine phosphokinase-MB (CPK-MB) was 1117 U/L. Daily physiotherapy and chest physiotherapy were continued. In view of myositis, steroid pulse therapy was administered for 3 days, following which the patient responded. Tracheostomy was closed on the 18th day of the illness. Lab parameters gradually improved, acute kidney injury (AKI) resolved, respiratory infection subsided, and the patient was discharged home.

At follow-up after 5 days, the patient showed improvement in motor function; however, speech dysfunction and behavioural abnormality persisted. Follow-up investigations showed CBC with Hb 12.1 g/dL, TLC of 5230 / μ L, and platelet count of 396,000/ μ L. LFT revealed albumin of 2.3 g/dL, total bilirubin of 1.03 mg/dL, SGOT of 39 U/L, and SGPT of 54 U/L. CRP was 6.9 mg/L, and creatinine was 0.69 mg/dL.

At 2 months of follow-up, motor recovery was good. The patient was able to walk without support, move all four limbs, and take oral feeds; however, behavioural abnormalities, abusive language, aggression and irritability persisted.

At 3 months of follow-up, behavioural abnormalities, abusive language, aggression, and irritability showed improvement.

Discussion

In the present case, the patient developed encephalitis as a prominent complication of scrub typhus, which aligns with documented reports of CNS invasion by the organism, leading to diffuse or focal inflammatory changes. Acute manifestations such as altered mental status and seizures are commonly reported, whereas myositis and polyneuropathy with scrub typhus are rarely described.⁹ The long-term sequelae, particularly cognitive decline, represent an underappreciated aspect of the disease.

Emerging evidence indicates that scrub typhus-associated encephalitis can result in persistent neurological impairment in a subset of survivors. Follow-up studies in paediatric cohorts with scrub typhus meningoencephalitis have shown that while the majority (approximately 89%–90%) achieve full recovery within one year, 10%–11% experience residual sequelae, including minor to severe impairments such as epilepsy, focal neurological deficits, behavioural issues, intellectual disability, speech difficulties, and motor disabilities.⁸ Although data in adults are more limited, myositis and polyneuropathy (complex neurological signs including peripheral nerve involvement) were reported among rare neurological manifestations, though exact prevalence figures for neuropathy alone were not provided.⁷ Muscle involvement (clinical/myopathic changes) appears to be more common than peripheral neuropathy, with one research report

suggesting that muscle involvement may be present in up to ~40% of scrub typhus patients when assessed objectively by electromyography (EMG) and biopsy findings.⁵

Cognitive decline following scrub typhus encephalitis may stem from direct neuronal injury, hypoxic-ischaemic damage secondary to multiple organ failure (e.g., respiratory or cardiovascular compromise), or immune-mediated processes persisting beyond bacterial clearance. In encephalitis survivors broadly, memory impairment is one of the most disabling long-term effects, often requiring neuropsychological assessment and targeted rehabilitation.

Early diagnosis and prompt initiation of appropriate antimicrobial therapy (doxycycline or azithromycin)

remain critical, as delays contribute to severe CNS involvement and poorer outcomes. In cases with encephalitis, adjunctive supportive care, including management of raised intracranial pressure, seizures, and multiple organ support, is essential.

Declarations

Patient consent

Written informed consent was obtained from the patient for publication of this case report and accompanying clinical details.

Conflicts of interest

The authors declare no conflicts of interest.

Conclusion

Scrub typhus remains an important but treatable cause of meningoencephalitis. Although most patients recover fully with timely doxycycline-based therapy, a minority experience minor to severe sequelae, emphasising the value of early recognition, specific treatment, and structured long-term follow-up.

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References

1. Bonell A, Lubell Y, Newton PN, *et al*. Estimating the burden of scrub typhus: A systematic review. *PLoS Negl Trop Dis*. 2017;11(9):e0005838.
2. Devasagayam E, Dayanand D, Kundu D, *et al*. The burden of scrub typhus in India: A systematic review. *PLoS Negl Trop Dis*. 2021;15(7):e0009619.
3. Varghese GM, Trowbridge P, Janardhanan J, *et al*. Clinical profile and improving mortality trend of scrub typhus in South India. *Int J Infect Dis*. 2014;23:39–43.
4. Jain D, Nand N, Giri K, *et al*. Scrub typhus infection, not a benign disease: an experience from a tertiary care center in Northern India. *Med Pharm Rep*. 2019;92(1):36–42.
5. Kalita J, Misra UK, Mani VE, *et al*. A study of muscle involvement in scrub typhus. *J Neurol Sci*. 2015;348 (1-2):226–30.
6. Visser, L.H. Critical illness polyneuropathy and myopathy: clinical features, risk factors and prognosis. *European Journal of Neurology*. 2006;13:1203–21.
7. Ghosh R, Mandal A, León-Ruiz M, *et al*. Rare neurological and neuropsychiatric manifestations of scrub typhus: a case series of 10 cases. *Neurologia (Engl Ed)*. 2024;39(9):766–80.
8. Jim WT, Chiu NC, Chan WT, *et al*. Clinical manifestations, laboratory findings and complications of pediatric scrub typhus in eastern Taiwan. *Pediatric Neonatal*. 2009;50(3):96–101.
9. Sayen JJ, Pond HS. Scrub typhus in Assam and Burma; a clinical study of 616 cases. *Medicine (Baltimore)*. 1946;25:155–214.

Bifid Renal Pelvis in a Single Kidney: A Different Approach to Managing Renal Calculi in a Partially Duplex Collecting System — A Case Report

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Abstract:

Bifid renal collecting system is one of the most common congenital abnormalities. Management of renal calculi in patients with such an abnormality is complex. We hereby describe a patient with a partially duplex collecting system presenting with a renal calculus in each moiety. The patient underwent multipuncture tubeless percutaneous nephrolithotomy (PCNL) by taking punctures to access the stone in each moiety, followed by antegrade double-J stent insertion.

Key words: Bifid, Multipuncture, Percutaneous Nephrolithotomy (PCNL).

Introduction

Since the turn of the century, the management of patients with urolithiasis has evolved dramatically, with multiple treatment options. These include endourological treatments as well as percutaneous procedures. The choice of treatment depends upon technical considerations as well as patient choice. Congenital renal tract abnormalities may further complicate this decision. Duplex collecting systems are among the most common congenital renal abnormalities, with an incidence of 0.8%.¹ This abnormality arises during the fourth week of gestation, when the ureteric bud, the precursor to the ureter, duplicates or splits.² The duplex system may be complete, wherein two collecting systems drain via two independent ureters into the bladder or elsewhere, or partial, in which the two ureters fuse prior to their entry into the bladder. Though patients with duplex kidneys are more likely to be affected by vesicoureteric reflux and pelvic-ureteric junction (PUJ) obstruction, they often remain asymptomatic, with the abnormality being diagnosed incidentally due to other presentations such as urolithiasis. Retrograde intrarenal

surgery, percutaneous nephrolithotomy (PCNL), and other modalities can be options for tackling renal calculi in duplicated systems.^{3,4} We report the management of symptomatic urolithiasis in a partial duplex renal system with multipuncture access percutaneously, i.e. multipuncture PCNL.

Case Report

A 41-year-old male with a history of right urolithiasis treated with ureterorenoscopic lithotripsy (URSL) five years previously, presented with new onset intermittent right flank pain without signs of sepsis. On clinical examination, he was exquisitely tender at the right renal angle. Blood tests revealed no abnormality in renal function. The patient underwent a computed tomography (CT) urogram as the first-line imaging modality, which showed a 12 × 9 × 15 mm right renal calculus with 1560 HU in the PUJ and an inferior pole calyceal non-obstructive calculus of size 8 × 5 × 6 mm with attenuation value of 1390 HU, along with a partially duplicated renal system with both calyceal systems uniting at the PUJ to form a single ureter (Figures 1 and 2).



Figure 1: Reconstructed computed tomography (CT) cuts showing right-sided pelvic-ureteric junction (PUJ) calculus.



Figure 2: Intraoperative right-sided retrograde pyelogram suggestive of a partially duplex collecting system joining at the pelvic-ureteric junction (PUJ).

A second superior access to the superior moiety was required as a fragment of the PUJ calculus entered into it during lithotripsy. Hence, two separate accesses were gained by taking puncture into each moiety and subjecting each stone to lithotripsy separately (Figure 3). An antegrade double-J (DJ) stent was left in the lower moiety, as it had greater dilatation and was expected to have difficulty in drainage compared to the superior, straighter moiety. No nephrostomy tube was left, thus concluding multipuncture tubeless percutaneous nephrolithotomy (PCNL). The patient recovered well following this procedure and was discharged on the second day without complications after the Foley catheter removal. Three weeks later, the DJ stent was removed after confirming no residual radio-opaque calculi in a follow-up CT kidney, ureter, and bladder (KUB) plain.



Figure 3: Schematic markings over retrograde pyelogram to show the multipuncture accesses taken. Green marker: Inferior calyceal/moiety access; Red marker: Superior calyceal/moiety access.

Discussion

Non-contrast CT KUB is considered to be the gold standard imaging modality for calculi. Where a duplex collecting system is affected by renal stones, a CT intravenous urogram (IVU) should be performed, specifically to delineate the correct altered anatomy.^{5,6} This more readily identifies duplex ureters and may visualise the level of ureteric fusion, further aiding endourological management. This also ensures that the operator is not misled by an apparently normal ureteroscopy (URS), which may have occurred in this case had we not known to seek an additional ureteric orifice. Endourological management of ureteric and renal calculi, including shockwave lithotripsy, URSL and PCNL, is now well established. However, new methods for applying these technologies in the management of complex renal calculi are emerging. We describe a case where selective puncture of a particular renal moiety was performed with percutaneous nephrostomy and antegrade stent insertion. This technique may prove useful where attempts to identify a calculus in a duplex system with URS alone have failed. This case also highlights the importance of the relationship between urology and radiology in the planning and management of such complex cases.

Declarations

Informed consent: Verbal informed consent was obtained from the patient.

Conflict of interests: The author(s) declare(s) that there is no conflict of interest.

Conclusion

Management of renal calculi in partially duplex collecting systems presents unique anatomical and technical challenges. This case demonstrates that multipuncture tubeless PCNL is a safe and effective approach for achieving complete stone clearance in such complex scenarios. Preoperative imaging to delineate anatomy and careful intraoperative planning are essential for successful outcomes. This technique may serve as a valuable alternative when conventional endourological approaches are insufficient.

Sanjay S. Nabar, Sachin V. Pahade, Vrushabh B. Petkar. Bifid Renal Pelvis in a Single Kidney: A Different Approach to Managing Renal Calculi in a Partially Duplex Collecting System — A Case Report. MMJ. 2026, June. Vol 3 (2).

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References

1. Malek RS, Kelalis PP, Stickler GB, *et al.* Observations on ureteral ectopy in children. *J Urol.* 1972;107(2):308–13.
2. Rehman S, Ahmed D. Embryology, Kidney, Bladder, and Ureter. [Updated 2023 Aug 8]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026 Jan-. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK547747/>. Accessed on: 10th March 2026.
3. Bist A, Upadhyaya M, Giri D, *et al.* Recurrent renal calculi in a bilateral partial duplex collecting system: a rare case managed with suction RIRS. *Ann Med Surg (Lond).* 2025;87(9):6206–10.
4. Elhadi M, Bonomaully M, Sheikh MI, *et al.* Two pelvises, one stone: A different approach for management of calculi in a duplex renal collecting system. *Afr J Urol.* 2018;24(1):34–6.
5. Gong H, Gao L, Dai XJ, *et al.* Prolonged CT Urography in duplex kidney. *BMC Urol.* 2016;16(1).
6. Gunawardena S, Ranasinghe WK, McCahy P. Beware the stone in the duplex: use of CT IVP in detecting calculi in duplex ureteric system. *J Clin Urol.* 2016;9(2):128–30.

Safe Application of Robotic Colorectal Surgery in an Elderly High-Risk Patient: A Case Report

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Abstract:

Colorectal cancer in elderly patients poses significant management challenges due to age-related physiological decline and associated comorbidities. We report the case of an 85-year-old female who presented with sub-acute intestinal obstruction and was diagnosed with carcinoma of the colon. Her medical history was significant for hypertension, atrial fibrillation, and two prior cerebrovascular accidents with residual bulbar palsy, placing her at high perioperative risk. Considering the potential morbidity of open surgery, a robotic-assisted colorectal resection was performed. The procedure was completed without complications, and the patient demonstrated accelerated postoperative recovery with early mobilisation on Day 1, initiation of oral intake on postoperative Day 2, and discharge on postoperative Day 3. This case highlights the feasibility and potential benefits of robotic surgery in carefully selected elderly patients with significant comorbidities.

Key words: Robotic Surgery, Colorectal Cancer, Elderly Patient, Minimally Invasive Surgery, Case Report.

Introduction

Colorectal cancer (CRC) is predominantly a disease of the elderly, with a significant proportion of cases occurring in patients above 70 years of age. With increasing life expectancy, the number of elderly patients requiring surgical management for CRC is steadily rising. However, advancing age is often associated with reduced physiological reserve, frailty, and multiple comorbidities, which increase the risk of postoperative morbidity and mortality.¹

Traditionally, elderly patients have been considered high-risk candidates for major abdominal surgery, particularly open colorectal resections, which are associated with increased postoperative pain, pulmonary complications, prolonged ileus, and extended hospital stay. However, emerging evidence suggests that chronological age alone should not be

the sole determinant of surgical candidacy, and that outcomes are more closely related to physiological status and comorbidity burden.²

Minimally invasive approaches, including laparoscopic colorectal surgery, have demonstrated improved short-term outcomes compared to open surgery, with reduced postoperative pain, earlier recovery, and shorter hospitalisation, while maintaining oncological equivalence. More recently, robotic-assisted surgery has further refined minimally invasive techniques by offering enhanced three-dimensional visualisation, improved ergonomics, tremor filtration, and greater instrument articulation, which may be particularly advantageous in technically challenging cases and high-risk patients.

Despite these advances, data on the use of robotic colorectal surgery in very elderly patients

with significant cardiovascular and neurological comorbidities remain limited. We present a case of successful robotic-assisted colorectal resection in an elderly high-risk patient, highlighting its feasibility and potential benefits in this challenging population.

Case Report

An 84-year-old female presented with complaints of abdominal pain, distension, intermittent vomiting, and reduced oral intake for one week. Clinical examination and initial investigations were suggestive of sub-acute intestinal obstruction. Contrast-enhanced computed tomography (CT) of the abdomen revealed a colonic mass consistent with carcinoma of the colon. There was no evidence of distant metastasis.

The patient had significant comorbidities, including long-standing hypertension, atrial fibrillation on medical management, and two prior cerebrovascular accidents, resulting in residual bulbar palsy. Given her age and comorbid status, she was considered a high-risk surgical candidate. After a multidisciplinary team discussion involving oncology, anaesthesiology, and critical care teams, the decision was made to proceed with robotic-assisted colorectal resection to minimise surgical stress and facilitate early postoperative recovery.

Robotic-assisted rectal resection using the da Vinci Xi system is typically performed with a standardised port placement strategy to optimise access to the pelvis and facilitate multi-quadrant surgery. The patient is positioned in modified lithotomy with steep Trendelenburg and slight right tilt. A four-arm technique is commonly employed. The camera port is placed just above or at the level of the umbilicus, slightly to the right of midline. Three additional robotic ports are positioned in a linear or gently curving configuration along a line extending from the right lower quadrant to the left upper quadrant, maintaining an inter-port distance of approximately 6–8 cm to avoid arm collision. A 12 mm assistant port is placed between the camera port and right-sided working port (Figure 1). This configuration allows optimal reach for medial-to-lateral mobilisation, vascular control, splenic flexure mobilisation, and precise pelvic dissection, thereby maximising the advantages of the Xi platform in rectal cancer surgery.

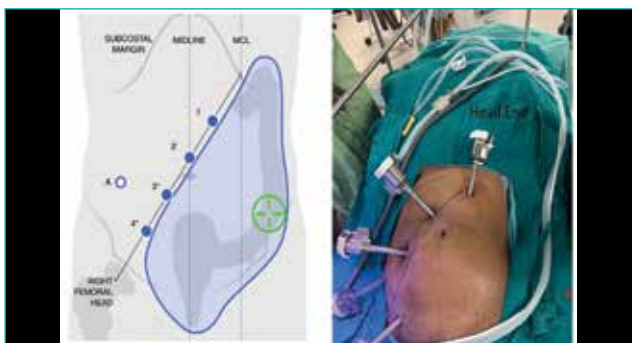


Figure 1: Conventional port positioning for the Da Vinci Xi System.

The procedure was completed successfully without intraoperative complications. Adequate oncological resection was achieved with acceptable operative time and minimal blood loss. Postoperatively, the patient was electively monitored in the Intensive Care Unit (ICU) for 24 hours. She remained haemodynamically stable and was mobilised out of bed on postoperative Day 1. Postoperative wound appeared clean, well-approximated, and healing satisfactorily with no signs of infection or dehiscence (Figure 2). Oral intake was initiated on postoperative Day 2, which she tolerated well. The postoperative course was uneventful, and she was discharged in stable condition on postoperative Day 3 (Figure 3).



Figure 2: Postoperative wound at the time of discharge.



Figure 3: Clinical status of the patient at discharge following robotic colorectal resection.

Discussion

The management of CRC in elderly patients requires careful consideration of both oncological outcomes and perioperative risk. Advanced age is frequently associated with frailty, sarcopenia, and multiple comorbidities, all of which contribute to increased postoperative complications.^{3,4} However, several studies have demonstrated that chronological age alone is a poor predictor of surgical outcomes and that appropriately selected elderly patients can safely undergo curative resection.^{5,6}

Large randomised controlled trials such as the Conventional versus Laparoscopic-Assisted Surgery in Colorectal Cancer (CLASICC), COlorectal cancer Laparoscopic or Open Resection (COLOR), and Clinical Outcomes of Surgical Therapy (COST) trials have established the safety and oncological equivalence of laparoscopic colorectal surgery compared to open surgery.⁷⁻⁹ These studies have consistently shown reduced postoperative pain, shorter hospital stay, and faster recovery in the minimally invasive group, benefits that are particularly relevant in elderly populations.⁷⁻⁹

Robotic-assisted colorectal surgery represents a further evolution of minimally invasive techniques. The RObotic versus LAParoscopic Resection for Rectal cancer (ROLARR) trial demonstrated comparable oncological outcomes between robotic and laparoscopic approaches, with potential advantages in terms of conversion rates in selected patient groups.¹⁰ Additionally, multiple meta-analyses have suggested that robotic surgery may offer improved precision, reduced blood loss, and better preservation of autonomic nerves, although these benefits must be balanced against increased operative time and cost.¹¹

In elderly and high-risk patients, minimising surgical stress is crucial. Robotic surgery, with its enhanced dexterity and visualisation, may facilitate meticulous dissection and reduce tissue trauma, thereby contributing to improved postoperative recovery.¹¹ In the present case, despite significant cardiovascular and neurological comorbidities, the patient underwent successful robotic-assisted resection with minimal complications and rapid recovery, including early mobilisation and discharge.

This case adds to the growing body of evidence supporting the feasibility of robotic colorectal surgery in elderly patients and reinforces the concept that surgical decision-making should be individualised, taking into account functional status rather than age alone.¹¹

Learning Points

- Advanced age alone is not a contraindication to CRC surgery.
- Robotic-assisted surgery may reduce perioperative morbidity in high-risk elderly patients.
- Careful multidisciplinary planning is essential for optimal outcomes.

Declarations

Patient consent: Written informed consent was obtained from the patient for publication of this case report and accompanying clinical details.

Conflicts of interest: The authors declare no conflicts of interest.

Conclusion

Robotic-assisted colorectal resection is feasible and safe in selected elderly patients with significant comorbidities. With careful patient selection and multidisciplinary perioperative management, favourable surgical and functional outcomes can be achieved. Advanced age should not be the sole determinant in deciding surgical eligibility.

Abhinav Deshpande, Kawadu Jawade, Kapilnath, Nimish Ganvir. Safe Application of Robotic Colorectal Surgery in an Elderly High-Risk Patient: A Case Report. MMJ. 2026, June. Vol 3 (2).

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References

1. Teo NZ, Ngu JCY. Robotic surgery in elderly patients with colorectal cancer: Review of the current literature. *World J Gastrointest Surg.* 2023;15(6):1040–7.
2. Crucitti A, Di Flumeri G, Mazzari A. Robotic Colorectal Cancer in the Elderly. In: Ceccarelli, G, Coratti A, editors. *Robotic Surgery of Colon and Rectum.* Cham: Springer; 2024. p. 171–8.
3. Mosquera C, Spaniolas K, Fitzgerald TL. Impact of frailty on approach to colonic resection: Laparoscopy vs open surgery. *World J Gastroenterol.* 2016;22(43):9544–53.
4. Itatani Y, Kawada K, Sakai Y. Treatment of Elderly Patients with Colorectal Cancer. *Biomed Res Int.* 2018;2018:2176056.
5. Roscio F, Bertoglio C, De Luca A, et al. Outcomes of laparoscopic surgery for colorectal cancer in elderly patients. *JSLs.* 2011;15(3):315–21.
6. Franklyn J, Poole A, Lindsey I. Colon cancer survival in the elderly without curative surgery. *Ann R Coll Surg Engl.* 2024;106(7):592–5.
7. Guillou PJ, Quirke P, Thorpe H, et al. Short-term endpoints of conventional versus laparoscopic-assisted surgery in patients with colorectal cancer (MRC CLASICC trial): multicentre, randomised controlled trial. *Lancet.* 2005;365(9472):1718–26.
8. Clinical Outcomes of Surgical Therapy Study Group, Nelson H, Sargent DJ, et al. A comparison of laparoscopically assisted and open colectomy for colon cancer. *N Engl J Med.* 2004;350(20):2050–9.
9. van der Pas MH, Haglind E, Cuesta MA, et al. Laparoscopic versus open surgery for rectal cancer (COLOR II): short-term outcomes of a randomised, phase 3 trial. *Lancet Oncol.* 2013;14(3):210–8.
10. Jayne D, Pigazzi A, Marshall H, et al. Effect of Robotic-Assisted vs Conventional Laparoscopic Surgery on Risk of Conversion to Open Laparotomy Among Patients Undergoing Resection for Rectal Cancer: The ROLARR Randomized Clinical Trial. *JAMA.* 2017;318(16):1569–80.
11. Lund CM, Vistisen KK, Dehlendorff C, et al. The effect of geriatric intervention in frail elderly patients receiving chemotherapy for colorectal cancer: a randomized trial (GERICO). *BMC Cancer.* 2017;17(1):448.

Iron Infusion-Induced Kounis Syndrome Presenting as Inferior STEMI with Normal Coronaries: A Case Report

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Abstract:

Kounis syndrome is an acute coronary syndrome triggered by allergic or anaphylactic reactions, and its recognition is important because treatments for anaphylaxis and myocardial ischaemia may conflict. We report the case of a 38-year-old woman with no prior cardiovascular disease who developed chest pain, palpitations, dizziness, and hypotension within minutes of receiving intravenous iron (Orofer). She was initially managed for anaphylaxis with intramuscular adrenaline, corticosteroids, and antihistamines, and subsequently required noradrenaline infusion because of persistent shock. Electrocardiography (ECG) demonstrated inferior ST-segment elevation myocardial infarction (STEMI), prompting acute coronary syndrome management, while echocardiography revealed regional wall motion abnormalities. Coronary angiography showed unobstructed coronary arteries, and cardiac magnetic resonance imaging excluded myocarditis while demonstrating diffuse hypokinesia consistent with stress cardiomyopathy. Considering the close temporal association with anaphylaxis, transient ischaemic ECG changes, and normal coronary arteries, a diagnosis of Type I Kounis syndrome was established. This case highlights that intravenous iron can precipitate Kounis syndrome presenting as STEMI, and awareness of this entity is essential to facilitate early diagnosis, avoid unnecessary interventions, and guide individualised management.

Key words: Kounis Syndrome, Anaphylaxis, Intravenous Iron, Coronary Vasospasm, Acute Coronary Syndrome.

Introduction

Kounis syndrome, first described by Kounis and Zavras, represents the concurrence of acute coronary syndromes (ACS) with hypersensitivity reactions mediated by mast cell activation and release of inflammatory mediators such as histamine, leukotrienes, and platelet-activating factor.¹⁻³ These mediators can induce coronary vasospasm, endothelial dysfunction, and platelet aggregation, leading to myocardial ischaemia or infarction (Figure 1).

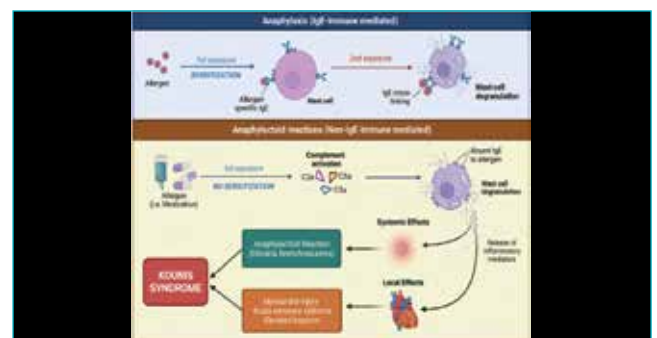


Figure 1: Pathophysiology of Kounis syndrome.
Abbreviation: IgE: Immunoglobulin E.

Three variants of Kounis syndrome have been described: Type I, occurring in patients with normal coronary arteries due to vasospasm; Type II, involving plaque rupture or erosion in patients with pre-existing atherosclerosis; and Type III, associated with stent thrombosis.^{1,2} A wide range of triggers have been implicated, including drugs, foods, insect stings, and environmental exposures, with medications being the most commonly reported cause.⁴

Intravenous iron preparations, though generally safe, have been associated with rare but potentially severe hypersensitivity reactions, including anaphylaxis.⁵ Cardiovascular manifestations during such reactions may be under-recognised and can mimic acute myocardial infarction, posing diagnostic and therapeutic challenges.

We report a case of intravenous iron-induced anaphylaxis complicated by transient inferior ST-segment elevation myocardial infarction (STEMI) with normal coronary arteries, consistent with Type I Kounis syndrome.

Case Report

A 38-year-old woman with iron-deficiency anaemia and no prior cardiovascular history received intravenous iron sucrose (Orofer). Within minutes, she developed acute retrosternal chest pain, palpitations, dizziness, and profound hypotension. Clinical examination revealed features of anaphylaxis with circulatory collapse.

Immediate treatment included intramuscular adrenaline, intravenous corticosteroids, and antihistamines. Persistent hypotension required initiation of noradrenaline infusion.

Electrocardiography (ECG) demonstrated ST-segment elevation in leads II, III, and aVF, with reciprocal changes (Figure 2), suggestive of inferior STEMI. ACS therapy was initiated.

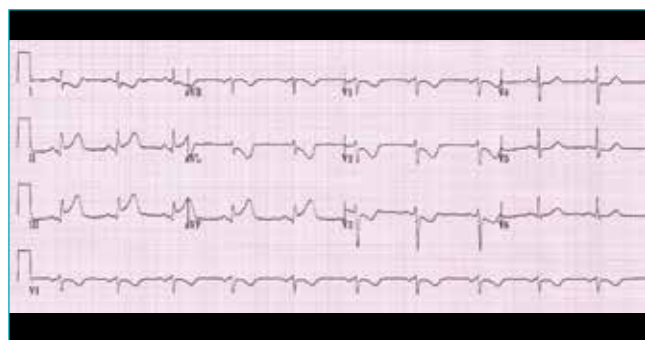


Figure 2: Electrocardiogram showing ST-segment elevation in inferior leads (II, III, aVF).

Transthoracic echocardiography revealed regional wall motion abnormalities in the inferior wall, with an ejection fraction of 42%–45%.

Emergency coronary angiography showed smooth, unobstructed coronary arteries (Figure 3A–C).

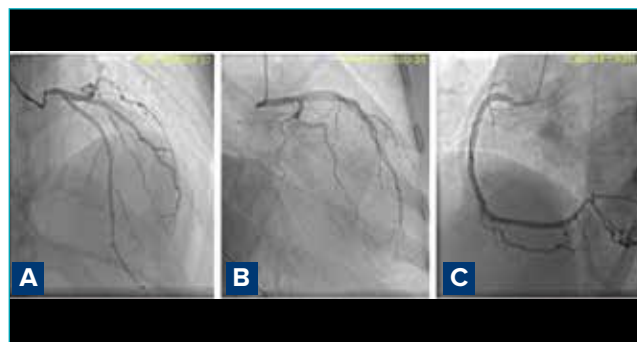


Figure 3A–C: Coronary angiography showing unobstructed coronary arteries.

Cardiac magnetic resonance imaging (MRI) demonstrated diffuse left ventricular hypokinesia without late gadolinium enhancement, thereby excluding myocarditis and supporting a diagnosis of stress cardiomyopathy (Figure 4).

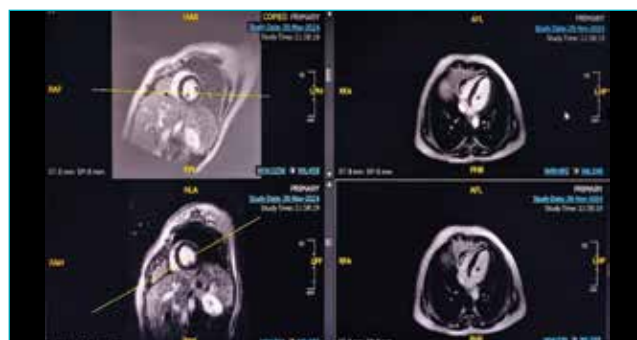


Figure 4: Cardiac magnetic resonance imaging (MRI) showing diffuse hypokinesia without late gadolinium enhancement.

Based on the temporal relationship with anaphylaxis, transient ischaemic ECG changes, and normal coronaries, a diagnosis of Type I Kounis syndrome was established.

Discussion

This case highlights allergic myocardial ischaemia precipitated by drug-induced anaphylaxis. Mast-cell degranulation releases vasoactive mediators that cause coronary vasoconstriction and myocardial ischaemia, even in the absence of coronary artery disease.^{1–3}

Intravenous iron is a recognised but uncommon cause of severe hypersensitivity reactions.⁵ The occurrence

of concurrent myocardial ischaemia suggests Kounis syndrome, particularly the Type I variant in patients without underlying coronary disease.

Management is complex, as treatment of anaphylaxis and myocardial ischaemia may conflict. Adrenaline remains the cornerstone of anaphylaxis management but may exacerbate ischaemia. Morphine and beta-blockers are generally avoided due to their potential to worsen vasospasm or hypotension.^{2,3} Careful haemodynamic monitoring and individualised therapy are essential.

Early recognition is critical, as this condition can mimic ACS and lead to unnecessary invasive interventions. Clinicians

should maintain a high index of suspicion when cardiac symptoms occur in the setting of allergic reactions.

Declarations

Patient consent

Written informed consent was obtained from the patient for publication of this case report and accompanying clinical details. All identifying information has been anonymised.

Case Report (CARE) guidelines

This case report is prepared in accordance with the CARE guidelines for reporting of clinical cases.

Conclusion

Intravenous iron-induced anaphylaxis can precipitate Kounis syndrome, presenting as apparent STEMI with normal coronary arteries. Awareness of this entity is essential for prompt diagnosis and appropriate management.

Shashi Bhushan, Pallavi Sehgal, Dheeraj Bhaskaran Nair. Iron Infusion-Induced Kounis Syndrome Presenting as Inferior ST- Segment Elevation Myocardial Infarction with Normal Coronaries: A Case Report. *MMJ*. 2026, June. Vol 3 (2).

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References

1. Kounis NG. Kounis syndrome (allergic angina and allergic myocardial infarction): A natural paradigm? *Int J Cardiol*. 2006;110(1):7–14.
2. Abdelghany M, Subedi R, Shah S, *et al*. Kounis syndrome: A review article on epidemiology, diagnostic findings, management and complications of allergic acute coronary syndrome. *Int J Cardiol*. 2017;232:1–4.
3. Biteker M. Current understanding of Kounis syndrome. *Expert Rev Clin Immunol*. 2010;6(5):777–88.
4. Renda F, Landoni G, Trotta F, *et al*. Kounis syndrome: An analysis of spontaneous reports from international pharmacovigilance databases. *Int J Cardiol*. 2016;203:217–20.
5. Wang C, Wong S, Graham DJ. Risk of Anaphylaxis With Intravenous Iron Products. *JAMA*. 2016;315(20):2232–3.

Delayed Presentation of Post-Traumatic Hepatic Artery Pseudoaneurysm Following Blunt Abdominal Injury

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Abstract:

Hepatic artery pseudoaneurysm (HAP) is an uncommon but potentially fatal vascular complication of blunt abdominal trauma. It results from disruption of the arterial wall following traumatic injury and may present in a delayed manner, making diagnosis challenging in emergency settings. Delayed presentation is associated with a significant risk of rupture, haemorrhage, and haemodynamic deterioration. Early recognition with appropriate imaging and timely intervention are therefore essential to reduce morbidity and mortality. We report a case of a middle-aged male with a known history of hypertension and chronic kidney disease and was receiving Ayurvedic management, who presented to the emergency department (ED) weeks after a skid-related fall from a two-wheeler. The patient complained of right-sided chest pain, left upper abdominal pain, shortness of breath, and generalised weakness. Initial evaluation revealed severe anaemia, hyperkalaemia, acute kidney injury, and features characteristic of rhabdomyolysis. Contrast-enhanced computed tomography (CECT) polytrauma imaging demonstrated a Grade III liver laceration with active intraparenchymal bleeding and HAP, along with moderate haemoperitoneum, right-sided haemothorax, and multiple rib fractures. The patient underwent successful selective catheterisation and glue embolisation of the right HAP. Supportive management included transfusion of three units of leucodepleted packed red blood cells and one session of haemodialysis, resulting in clinical and biochemical improvement. This case was reported due to the rarity of delayed post-traumatic HAP and the diagnostic challenge associated with its presentation. It highlights the importance of maintaining a high index of suspicion and emphasises the role of multidisciplinary management in a tertiary care setting in achieving favourable outcomes.

Key words: Hepatic Artery Pseudoaneurysm, Blunt Abdominal Trauma, Delayed Presentation, Endovascular Embolisation, Polytrauma.

Introduction

Hepatic artery pseudoaneurysm (HAP) is a rare but potentially life-threatening vascular complication resulting from disruption of the hepatic arterial wall. Unlike true aneurysms, pseudoaneurysms do not involve all three layers of the vessel wall and are instead contained by the surrounding soft tissue or adventitia. HAPs account for a small proportion

of visceral artery pseudoaneurysms but carry a significantly high risk of rupture, with mortality rates reported to be as high as 20%–40% in untreated cases.^{1,2}

The most common aetiologies of HAP include blunt or penetrating abdominal trauma, hepatobiliary interventions, surgery, pancreatitis, and iatrogenic vascular injury.³ Among these, traumatic HAP following

blunt abdominal trauma remains relatively uncommon and may present days to weeks after the initial injury. Delayed presentation occurs due to the gradual expansion of the injured arterial segment before clinical manifestation, making diagnosis particularly challenging in emergency settings. Patients may present with non-specific symptoms such as abdominal pain, anaemia, jaundice, gastrointestinal bleeding, or haemodynamic instability secondary to rupture. In some cases, the condition may remain clinically silent until a catastrophic haemorrhage occurs.

Contrast-enhanced computed tomography (CECT) angiography has emerged as the imaging modality of choice for diagnosis, allowing rapid identification of associated solid organ injury and vascular abnormalities. Endovascular intervention, including coil or glue embolisation, is currently considered the preferred treatment modality due to its minimally invasive nature, high technical success rate, and lower morbidity compared with open surgical repair.^{3,4}

We report a rare case of delayed post-traumatic HAP in a patient presenting weeks after blunt abdominal trauma with associated liver laceration, haemoperitoneum, severe anaemia, and metabolic derangements. This case is reported because of its delayed presentation, associated diagnostic challenge, and the successful multidisciplinary management in a tertiary care emergency setting.

Case Report

On arrival to the emergency department (ED), the patient was conscious and oriented to time, place, and person with a Glasgow Coma Scale (GCS) score of E4V5M6 (E = Eye response, V = Verbal response, M = Motor response), although he appeared acutely ill. He had a blood pressure (BP) of 170/100 mmHg, heart rate (HR) of 105 beats per minute, respiratory rate (RR) of 24 breaths/min, and oxygen saturation of 90%, while receiving oxygen at 3L/min via nasal prongs. Respiratory system examination revealed bilaterally reduced air entry. Cardiovascular examination demonstrated normal heart sounds (S1 and S2). Abdominal examination revealed a soft but distended abdomen with generalised tenderness, while central nervous system examination was unremarkable.

A CECT polytrauma scan demonstrated a Grade III liver laceration with active intraparenchymal bleeding and features suggestive of a HAP, associated with moderate haemoperitoneum (Figure 1). Additional findings included right-sided haemothorax with multiple right-sided rib fractures (Figure 2).

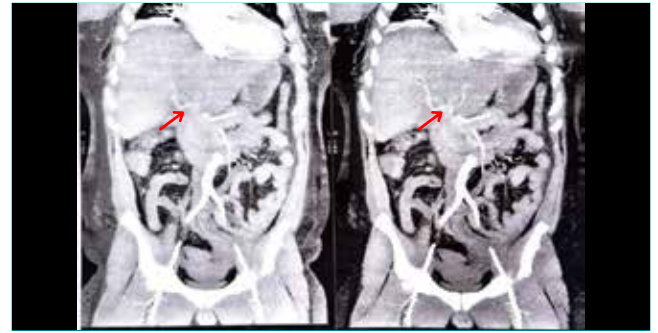


Figure 1: Contrast-enhanced computed tomography (CECT) abdomen demonstrating Grade III liver laceration with hepatic artery pseudoaneurysm (red arrow) and active intraparenchymal contrast extravasation.

Initial laboratory investigations revealed severe anaemia with a haemoglobin level of 5.5 g/dL. Renal function tests were markedly deranged, with serum creatinine elevated to 16.9 mg/dL. Significant electrolyte abnormalities were noted, including hyponatraemia with serum sodium of 126.9 mEq/L and severe hyperkalaemia with serum potassium of 7.4 mEq/L. The overall clinical and biochemical profile was suggestive of advanced chronic kidney disease with superimposed acute kidney injury, associated hyperkalaemia, and rhabdomyolysis in the setting of trauma.

Management

The patient underwent selective catheterisation of the right hepatic artery with 30% glue embolisation, successfully excluding the pseudoaneurysm. Post-embolisation, the patient received three units of leucodepleted packed red blood cells, resulting in an improvement in haemoglobin to 10 g/dL. Due to a persistent electrolyte imbalance, one session of haemodialysis was performed, after which serum potassium decreased to 5.8 mEq/L and serum creatinine decreased from 16.9 mg/dL to 13 mg/dL. The patient was managed in the Intensive Care Unit (ICU) with close monitoring and supportive care. He remained haemodynamically stable and was breathing comfortably on room air throughout the hospital course.



Figure 2: Ultrasonography (USG) of the whole abdomen — Focused assessment with sonography in trauma (FAST) revealed mild free fluid in the pelvis, bilateral paracolic gutters and perihepatic space with internal echoes suggestive of haemoperitoneum. Right-sided pleural effusion with minimal left-sided pleural effusion and features demonstrating post-traumatic liver contusion were also noted.

Discussion

Post-traumatic HAP is a rare but serious complication of blunt abdominal trauma. Delayed presentation may lead to life-threatening haemorrhage if not recognised early. CECT imaging plays a pivotal role in diagnosis, while endovascular embolisation has emerged as the treatment of choice due to its high technical success rate and minimally invasive nature. Management is further

complicated in patients with underlying chronic kidney disease, often necessitating renal replacement therapy.^{4,5}

Patient Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images.

Conclusion

Delayed presentation of HAP following blunt abdominal trauma requires a high index of suspicion. Successful management depends on early imaging, prompt endovascular intervention, and a multidisciplinary approach in a tertiary care setting. Timely referral to an appropriate tertiary care centre plays a crucial role in achieving favourable outcomes.

Nishit Mashru, Aaditya Yadav, Chintala Sai Venkata Chiranjeevi, Dheeraj Bhaskaran Nair. Delayed Presentation of Post-Traumatic Hepatic Artery Pseudoaneurysm Following Blunt Abdominal Injury.

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References

1. Abbas MA, Fowl RJ, Stone WM, *et al.* Hepatic artery aneurysm: factors that predict complications. *J Vasc Surg.* 2003;38:41–5.
2. Stanley JC, Wakefield TW, Graham LM, *et al.* Clinical importance and management of splanchnic artery aneurysms. *J Vasc Surg.* 1986;3:836–40.
3. Belli AM, Markose G, Morgan R. Interventional radiology in the management of hepatic artery pseudo aneurysms. *Cardiovasc Intervent Radiol.* 2012;35:789–98.
4. Gaba RC, Couture PM, Lakhoo J, *et al.* Endovascular management of visceral artery pseudoaneurysms. *J Vasc Interv Radiol.* 2013;24:1386–92.
5. Sarin S, Kumar A, Choudhury A. Management of visceral artery pseudo aneurysms: a single-center experience. *Indian J Radiol Imaging.* 2015;25:303–8.

The Rash That Followed the Remedy: Phenytoin-Induced Drug Reaction with Eosinophilia and Systemic Symptoms Syndrome

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Abstract:

Drug Reaction with Eosinophilia and Systemic Symptoms (DRESS) syndrome is a rare, severe, and potentially fatal delayed hypersensitivity reaction to drugs, most commonly anticonvulsants such as phenytoin. It typically manifests 2–8 weeks after drug exposure, with fever, rash, lymphadenopathy, haematological abnormalities including eosinophilia, and multi-organ involvement, particularly hepatic dysfunction. We report the case of a 22-year-old male who developed DRESS syndrome following phenytoin therapy for seizures, presenting with high-grade fever, generalised maculopapular rash, lymphadenopathy, leucocytosis, and severe liver involvement. Early recognition, prompt withdrawal of the offending drug, and initiation of systemic corticosteroids resulted in gradual clinical and biochemical improvement. This case highlights the importance of early suspicion of DRESS syndrome in patients presenting with fever and rash after initiation of high-risk drugs, emphasising timely diagnosis and management to reduce morbidity and mortality.

Key words: Drug Reaction with Eosinophilia and Systemic Symptoms Syndrome, Phenytoin, Drug Hypersensitivity, Anticonvulsants, Eosinophilia, Liver Involvement, Adverse Drug Reaction, Corticosteroids.

Introduction

Drug Reaction with Eosinophilia and Systemic Symptoms (DRESS) syndrome is a severe idiosyncratic drug reaction characterised by delayed onset and multi-system involvement.¹ Anticonvulsants such as phenytoin, carbamazepine, and lamotrigine are among the most commonly implicated drugs.² The clinical presentation often mimics infections, autoimmune diseases, or malignancy, leading to diagnostic delay.³ Mortality is reported up to 10%, mainly due to hepatic failure.³ Early diagnosis and prompt withdrawal of

the offending drug are essential to reduce morbidity and mortality. The pathogenesis is complex and not fully understood, involving a combination of drug-specific immune responses, detoxification defects, and viral reactivation.^{4,5} Management primarily involves immediate discontinuation of the causative drug and supportive care, with systemic corticosteroids often used in moderate to severe cases. In refractory or life-threatening cases, additional immunosuppressive therapies such as intravenous immunoglobulin or cyclosporine may be considered.⁶

Case Report

A 22-year-old male presented with complaints of high-grade fever, shivering, and generalised redness of the skin for 12–15 days. He had a history of seizure episode 25 days prior, for which he was started on phenytoin. Approximately 14 days later, he experienced another seizure episode and continued the same medication. Subsequently, he developed a persistent fever not responding to oral antipyretics, along with a diffuse erythematous rash.

The patient sought treatment at an outside facility without improvement and was referred to our hospital for further evaluation.

On admission, he was febrile with a pulse rate of 112/min, blood pressure of 130/70 mmHg, respiratory rate of 32/min, and oxygen saturation of 94% on room air. Respiratory system examination revealed bilateral crepitation. Cardiovascular examination was normal. The abdomen was soft. Central nervous system examination showed the patient to be conscious and oriented. Generalised erythematous rash and bilateral axillary lymphadenopathy were noted (Figure 1A–D) — findings consistent with DRESS syndrome manifestations.⁸



Figure 1: A. Rashes on the trunk; B. Rashes on the abdomen.

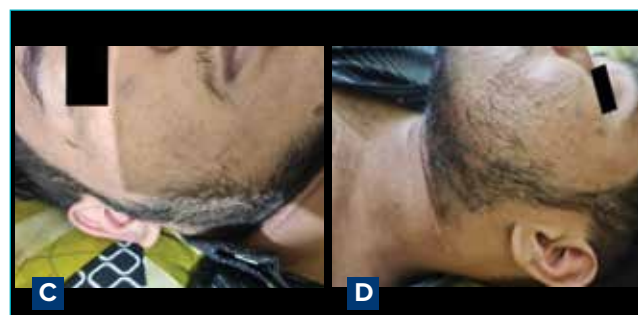


Figure 1C and D: Rashes over the face.

He was started on antibiotics, antipyretics, and supportive care. Laboratory investigations revealed haemoglobin of 10.9 g/dL, total leucocyte count of 13,640/mm³, platelet count of 1.65 lakh/mm³, and elevated C-reactive protein (38.4 mg/L) (Table 1). Liver function tests were markedly deranged with serum glutamic oxaloacetic transaminase (SGOT) 353 U/L, serum glutamate pyruvate transaminase (SGPT) 385 U/L, alkaline phosphatase 264 U/L, and rising bilirubin levels. Hepatic involvement is the most common and serious systemic manifestation of DRESS syndrome.⁷ Renal function was normal. Procalcitonin was 0.36 ng/mL. Phenytoin level was 11 µg/mL, ruling out toxicity, as therapeutic drug levels do not exclude DRESS.³

Investigations	31/08/2025	02/09/2025	04/09/2025	06/09/2025	08/09/2025	10/09/2025
Haemoglobin	10.9	9.6	10.5	-	10.9	10.9
TLC	13640	16060	14460	-	21980	21700
Platelet count	165000	176000	189000	-	235000	294000
CRP	38.40	-	-	-	44.80	13.10
Bilirubin	0.40	1.23	1.53	-	3.55	1.18
SGOT	353	553	345	225	721	102
SGPT	385	553	762	664	1575.8	853
Creatinine	1.00	1.28	-	-	-	-

Table 1: Showing serial blood investigations during the course of hospital stay.

Abbreviations: CRP: C-Reactive Protein; SGOT: Serum Glutamic Oxaloacetic Transaminase; SGPT: Serum Glutamic Pyruvate Transaminase; TLC: Total Leucocyte Count.

Infectious workup, including *Leptospira* immunoglobulin G (IgG) and immunoglobulin M (IgM) was negative. High-resolution computed tomography (HRCT) of the thorax showed subtle centrilobular nodules with mild ground-glass opacities and peribronchial thickening suggestive of infective bronchiolitis. Ultrasound of the abdomen revealed mild hepatosplenomegaly, oedematous gallbladder wall thickening, and mild bilateral pleural effusion.

Autoimmune workup showed antinuclear antibody (ANA) positivity (1:80) with negative anti-cyclic citrullinated peptide (anti-CCP). Despite treatment, the patient continued to have fever, tachycardia, worsening rash, leucocytosis, and progressively rising liver enzymes. Positron emission tomography (PET) scan revealed axillary and supraclavicular lymphadenopathy. To rule out malignancy, a supraclavicular lymph node biopsy was performed, which showed reactive lymphadenitis. GeneXpert for *Mycobacterium tuberculosis* was negative. Serum immunoglobulin E (IgE) levels were normal, which does not exclude the diagnosis.⁷

After exclusion of infectious, autoimmune, and malignant causes, a diagnosis of DRESS syndrome secondary to phenytoin was made based on clinical features and RegiSCAR criteria.⁸ Phenytoin was immediately discontinued, and the patient was started on systemic corticosteroids along with an alternative anti-epileptic

drug, as recommended in moderate to severe disease with organ involvement.⁹

Over the next few days, fever intensity and frequency reduced, skin rash gradually subsided, and heart rate normalised. Although liver enzymes and leucocyte count initially continued to rise, they later showed a declining trend with continued steroid therapy. The patient improved clinically and was discharged with close follow-up.

Discussion

DRESS syndrome is a severe delayed hypersensitivity reaction that typically presents weeks after drug exposure.¹ Phenytoin is a well-recognised trigger.² The hallmark features include fever, rash, lymphadenopathy, haematological abnormalities, and internal organ involvement, with the liver being the most commonly affected organ.⁴

Diagnosis is clinical and by exclusion, often supported by RegiSCAR criteria.⁸ Therapeutic drug levels do not exclude DRESS, as seen in our case.³ Normal serum IgE levels also do not rule out the diagnosis.⁷ Early withdrawal of the offending drug remains the cornerstone of management.^{9,10} Systemic corticosteroids are recommended for moderate to severe diseases with organ involvement, particularly hepatic dysfunction.^{9,10}

Conclusion

DRESS syndrome should be considered in any patient presenting with fever and rash weeks after initiation of high-risk drugs such as anticonvulsants.¹ Early recognition, prompt discontinuation of the offending agent, and timely initiation of corticosteroids can be lifesaving and prevent irreversible organ damage.³

Learning points

- DRESS syndrome has a delayed onset and can mimic infections or malignancy
- Normal drug levels do not exclude DRESS
- Liver involvement is common and may be severe
- Early drug withdrawal and corticosteroid therapy improve outcome

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References

1. Bocquet H, Bagot M, Roujeau JC. Drug-induced pseudolymphoma and drug hypersensitivity syndrome (Drug Rash with Eosinophilia and Systemic Symptoms: DRESS). *Semin Cutan Med Surg.* 1996;15(4):250–7.
2. Kardaun SH, Sidoroff A, Valeyrie-Allanore L, *et al.* Variability in the clinical pattern of cutaneous side-effects of drugs with systemic symptoms: does a DRESS syndrome really exist?. *Br J Dermatol.* 2007;156(3):609–11.
3. Kardaun SH, Sekula P, Valeyrie-Allanore L, *et al.* Drug reaction with eosinophilia and systemic symptoms (DRESS): an original multisystem adverse drug reaction. Results from the prospective RegiSCAR study. *Br J Dermatol.* 2013;169(5):1071–80.
4. Cacoub P, Musette P, Descamps V, *et al.* The DRESS syndrome: a literature review. *Am J Med.* 2011;124(7):588–97.
5. Husain Z, Reddy BY, Schwartz RA. DRESS syndrome: Part I. Clinical perspectives. *JAAD Int.* 2013;68(5):693-e1.
6. Husain Z, Reddy BY, Schwartz RA. DRESS syndrome: Part II. Management and therapeutics. *JAAD Int.* 2013;68(5):709-e1.
7. De A, Rajagopalan M, Sarda A, *et al.* Drug Reaction with Eosinophilia and Systemic Symptoms: An Update and Review of Recent Literature. *Indian J Dermatol.* 2018;63(1):30–40.
8. Criado PR, Criado RF, Avancini JD, *et al.* Drug reaction with eosinophilia and systemic symptoms (DRESS)/drug-induced hypersensitivity syndrome (DIHS): a review of current concepts. *An Bras Dermatol.* 2012;87(3):435–49.
9. Shiohara T, Kano Y. Drug reaction with eosinophilia and systemic symptoms (DRESS): incidence, pathogenesis and management. *Expert Opin Drug Saf.* 2017;16(2):139–47.
10. Knowles SR, Shear NH. Recognition and management of severe cutaneous drug reactions. *Dermatol Clin.* 2007;25(2):245–53.

Bilateral Vertical Sacral Fracture, a Highly Unstable Pelvic Injury in a Case of Accidental Fall from Height

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Abstract:

This report describes a rare and life-threatening presentation of bilateral vertical sacral fractures in a 54-year-old hypertensive female following a high-energy fall from a second-floor balcony. Such fractures are uncommon and inherently unstable, often associated with pelvic ring disruption, neurovascular compromise, and haemodynamic instability. The patient presented to the emergency department (ED) in a drowsy state with a Glasgow Coma Scale (GCS) score of 12, hypotension, tachycardia, and bilateral lower limb weakness, indicative of polytrauma involving the neurological and musculoskeletal systems. Initial management followed a systematic trauma approach, including prompt resuscitation with intravenous (IV) fluids, administration of tranexamic acid, continuous monitoring, and early application of a pelvic binder based on clinical suspicion of an unstable pelvic fracture. Adjunct investigations, including an electrocardiogram, arterial blood gas analysis, cross-matching, and bedside extended Focused Assessment with Sonography in Trauma (e-FAST), aided in ruling out immediate life-threatening conditions. Comprehensive imaging with computed tomography (CT) polytrauma protocol and X-rays revealed an acute subdural haematoma, bilateral vertical sacral fractures with pelvic ring disruption, retroperitoneal haemorrhage, and a right calcaneal fracture. The patient underwent multidisciplinary management involving emergency medicine, anaesthesia, critical care, spine surgery, and orthopaedics. Surgical interventions included L4–S2 lumbopelvic fixation, L5–S1 laminectomy for an S1 nerve root laceration, and calcaneal fixation via the sinus tarsi approach. Perioperative management included invasive haemodynamic monitoring and neuromonitoring. Postoperatively, the patient received intensive critical care support followed by structured rehabilitation, ultimately achieving recovery without residual neurological deficits. This case underscores the rarity and diagnostic challenges of bilateral vertical sacral fractures, which account for less than 1% of sacral injuries and are frequently overlooked in the presence of multiple traumatic insults. It highlights the critical role of early imaging, adherence to structured trauma protocols, and coordinated multidisciplinary care in improving outcomes in high-energy polytrauma patients.

Key words: Bilateral Vertical Sacral Fracture, High-Energy Trauma, Computed Tomography (CT) Polytrauma, Multidisciplinary Care.

Introduction

Pelvic fractures are severe injuries commonly associated with high-energy trauma and are a significant cause of morbidity and mortality worldwide. These injuries frequently result from mechanisms such as road traffic accidents, crush injuries, and falls from height, with axial loading forces playing a key role in fracture patterns.¹

Among pelvic fractures, sacral fractures occur in approximately 30%–45% of cases and are often indicative of substantial force transmission through the axial skeleton.² Sacral fractures are broadly classified based on morphology and neurological involvement. Vertical sacral fractures are more frequently encountered than transverse patterns and are typically associated with vertical shear injuries of the pelvic ring.³

However, bilateral vertical sacral fractures without a transverse component are exceedingly rare, accounting for approximately 1% of all sacral fractures.³ These fractures often disrupt the integrity of the pelvic ring, leading to mechanical instability and a high risk of associated neurovascular compromise. The clinical significance of such injuries lies in their frequent association with polytrauma, including injuries to the spine, abdomen, and head. Early identification is often challenging due to overlapping injuries and altered sensorium in trauma patients. Delayed or missed diagnosis can result in catastrophic outcomes, including exsanguination, permanent neurological deficits, and prolonged disability.^{4,5}

We present a rare case of bilateral vertical sacral fractures in a middle-aged female following an accidental fall from height, complicated by haemodynamic instability and bilateral lower limb neurological deficits. This case highlights the importance of early recognition, prompt imaging using computed tomography (CT) polytrauma protocols, and a multidisciplinary approach to managing such complex injuries.

Case Report

A 54-year-old female, a known case of hypertension, was brought to the emergency department (ED) via private ambulance with an alleged history of an

accidental fall from a second-floor balcony. On arrival, the patient was drowsy but arousable, with altered sensorium. Her Glasgow Coma Scale (GCS) score was E3 V4 M5 (E = Eye response, V = Verbal response, M = Motor response). She was haemodynamically unstable with blood pressure (BP) of 90/60 mmHg, heart rate (HR) of 120 beats per minute, respiratory rate (RR) of 18/min, and oxygen saturation (SpO₂) of 98% on room air. The primary complaint was the inability to move both lower limbs. Clinical examination revealed features of unstable polytrauma, including a head injury, bilateral hip tenderness, right ankle deformity, and bilateral lower limb paresis.

Emergency department management

The patient was immediately connected to continuous monitoring. Two large-bore intravenous (IV) cannulas were secured, and resuscitation was initiated with IV fluids and medications. A structured primary survey (Airway, Breathing, Circulation, Disability, Exposure – ABCDE approach) was conducted alongside resuscitation measures. Aggressive fluid resuscitation with crystalloids and initiation of a massive transfusion protocol were undertaken. Simultaneously, cervical spine stabilisation was ensured. Pelvic examination revealed tenderness and bruising. Given the presence of hypotension responsive to fluids, neurological deficits, and pelvic instability on compression testing, a highly unstable pelvic injury was suspected. A pelvic binder was applied promptly, resulting in improved haemodynamic stability and reducing the need for inotropic support. Adjunct investigations, including an electrocardiogram (ECG), arterial blood gas (ABG), blood grouping and cross-matching, were performed concurrently. A bedside extended Focused Assessment with Sonography in Trauma (e-FAST) was negative, ruling out immediate life-threatening intraperitoneal or pericardial bleeding. However, retroperitoneal haemorrhage remained a concern due to pelvic involvement. Given the altered sensorium and suspicion of intracranial injury, the patient was shifted for a CT polytrauma protocol along with X-ray imaging of the right ankle.

CT findings

Head and face: Acute subdural haemorrhage (SDH) along the right tentorium and posterior falx (1.5 mm thickness)

with a linear component of subarachnoid haemorrhage (SAH) in the right temporoparietal region.

Spine and pelvis: Bilateral vertical sacral fractures, disruption of the pelvic ring, undisplaced fractures of the bilateral transverse processes of the L5 vertebra, a comminuted sacral fracture with piriformis muscle oedema, mildly displaced fractures of the right superior and inferior pubic rami and a right ischial fracture (Figures 1 and 2).

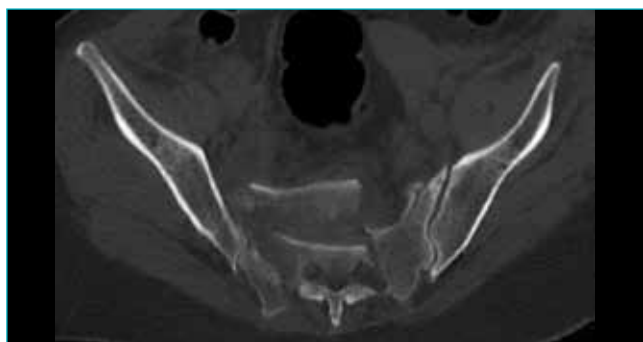


Figure 1: (Preoperative) Axial computed tomography (CT) image of the pelvis demonstrating bilateral vertically oriented fractures through the sacral alae with an associated transverse fracture component involving the sacral body. The fracture configuration is consistent with a U-shaped (H-type) sacral fracture pattern, indicative of spinopelvic instability, with clear cortical disruption extending across both sacral wings into the central sacrum.



Figure 2: (Preoperative) Three-dimensional (3D) volume-rendered computed tomography (CT) image of the pelvis demonstrating findings as described in Figure 1. The 3D reconstruction clearly delineates the extent of cortical disruption and fracture morphology involving the sacrum in relation to the pelvic ring.

Chest: No abnormalities.

Abdomen: Retroperitoneal haemorrhage with fat stranding; no visceral injury.

Right ankle X-ray: Displaced fracture of the calcaneum.

Definitive management

Following stabilisation, the patient was transferred to the Intensive Care Unit (ICU). A multidisciplinary team involving emergency medicine, orthopaedics, spine surgery, neurosurgery, anaesthesiology, and critical care was engaged. After ruling out cervical spine injury, central venous pressure (CVP) monitoring and arterial line placement were performed.

Surgical interventions

1. Lumbopelvic fixation (L4–S2) with L5–S1 laminectomy in view of neurological deficit, epidural haematoma, and S1 nerve root injury (Figure 3).
2. Right calcaneal fracture management: Initial debridement and stabilisation followed by definitive fixation using a sinus tarsi approach with K-wires and a lateral plate.



Figure 3: Postoperative anteroposterior radiograph of the lumbosacral spine and pelvis demonstrating posterior spinopelvic stabilisation. Bilateral pedicle screws are seen in the lower lumbar spine with extension into the sacrum and iliac bones, connected by longitudinal rods and a transverse connector, consistent with lumbopelvic fixation. The construct provides stabilisation of the previously identified U-shaped sacral fracture, with satisfactory alignment and appropriate positioning of the fixation construct.

Postoperative course

Postoperative care included haemodynamic and neurological monitoring, pain management, psychological evaluation and counselling, and early physiotherapy and rehabilitation. The patient demonstrated gradual neurological recovery and was shifted to the ward. She was discharged with advice on wound care, medications, and rehabilitation.

On follow-up, the patient showed complete neurological recovery with no residual disability.

Discussion

Sacral fractures are a critical subset of pelvic injuries, occurring in up to 45% of pelvic ring disruptions.² These fractures are often associated with high-energy trauma and carry a significant risk of morbidity due to associated injuries and neurological involvement.⁶ Vertical sacral fractures are commonly linked to vertical shear mechanisms and frequently result in instability of the pelvic ring.¹ However, bilateral vertical sacral fractures without transverse components are rare and represent a highly unstable injury pattern.³

Clinical challenges

These injuries are frequently underdiagnosed during initial trauma evaluation due to altered sensorium, the presence of multiple distracting injuries, and limitations of plain radiography. Delayed diagnosis can result in uncontrolled haemorrhage and irreversible neurological damage.⁴

Role of imaging

CT polytrauma protocols with three-dimensional reconstruction are now considered the gold standard for evaluating complex pelvic injuries. They allow

accurate fracture classification, detection of associated injuries, and preoperative planning. This approach is significantly more efficient compared to sequential imaging modalities, especially in unstable patients.⁵

Management principles

Management of unstable pelvic fractures involves early resuscitation, following Advanced Trauma Life Support (ATLS) guidelines (ACS, 2018)⁷ pelvic binder application to reduce haemorrhage, definitive stabilisation with lumbopelvic fixation to provide mechanical stability,^{8,9} and early surgical fixation to reduce complications. Neurological decompression may improve neurological outcomes in selected cases.¹⁰

Multidisciplinary care

Coordination between specialities is essential for optimal outcomes. Outcome depends on the timelines of intervention, severity of associated injuries, and the presence of neurological deficits.

This case demonstrates that early recognition, prompt stabilisation, and multidisciplinary intervention can result in excellent functional recovery, even in severe injury patterns.

Conclusion

This case highlights a rare and highly unstable pattern of bilateral vertical sacral fractures in the setting of high-energy trauma. Key learning points include the importance of early recognition in the ED, the critical role of CT polytrauma imaging, the need for rapid resuscitation and pelvic stabilisation, and the value of multidisciplinary management. The favourable outcome in this case underscores the importance of integrated trauma systems, a well-equipped ED, and coordinated care pathways in improving patient survival and functional recovery.

Krittika Bhatia, Niranjani V, Paresh Bang, Manoj Pahukar. Bilateral Vertical Sacral Fracture, A Highly Unstable Pelvic Injury in a Case of Accidental Fall from Height. MMJ. 2026, June. Vol 3 (2).

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References

1. Tile M. Pelvic ring fractures: should they be fixed? *J Bone Joint Surg Br.* 1988;70(1):1–12.
2. Denis F, Davis S, Comfort T. Sacral fractures: an important problem. Retrospective analysis of 236 cases. *Clin Orthop Relat Res.* 1988;227:67–81.
3. Bishop JA, Dangelmajer S, Corcoran-Schwartz I, et al. Sacral fractures: epidemiology and classification. *J Orthop Trauma.* 2010;24(8):e78–e83.
4. Routt ML Jr, Simonian PT, Ballmer F. A rational approach to pelvic trauma: resuscitation and early definitive stabilization. *Clin Orthop Relat Res.* 1995;(318):61–74.
5. Manson TT, Nascone JW, Sciadini MF, et al. Pelvic ring fractures and associated injuries in polytrauma patients. *Injury.* 2010;41(4):379–83.
6. Starr AJ, Griffin DR, Reinert CM, et al. Pelvic ring disruptions: prediction of associated injuries and mortality. *J Orthop Trauma.* 2002;16(8):553–61.
7. American College of Surgeons Committee on Trauma. Advanced Trauma Life Support (ATLS) Student Course Manual. 10th Edition. Chicago: American College of Surgeons; 2018.
8. Keating JF, Werier J, Blachut P, et al. Early fixation of the vertically unstable pelvis: the role of lumbopelvic fixation. *J Orthop Trauma.* 1999;13(2):107–13.
9. Käch K, Trentz O. Distraction spondylodesis of the lumbar spine in the treatment of sacral fractures. *Spine (Phila Pa 1976).* 1994;19(21):2425–30.
10. Zelle BA, Gruen GS, Brown S, et al. Sacral fractures with neurological injury: is early decompression beneficial? *Spine (Phila Pa 1976).* 2004;29(17):E397–E404.

Peroral Endoscopic Myotomy Followed by Antireflux Mucosectomy for Gastroesophageal Reflux in Identical Twins with Allgrove Syndrome

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Abstract:

Oesophageal achalasia is a relatively rare disease in children and has been treated with balloon dilatation, botulinum toxin injection, and Heller myotomy. Peroral endoscopic myotomy (POEM) has been the frontline treatment for achalasia cardia and has shown good long-term results in adults and even in the paediatric population. This rare case relates to two female children (identical twins) aged 13 years, one of whom presented with dysphagia, vomiting, nasal regurgitation, and weight loss. The other twin, on detailed history, also had similar symptoms. Both patients underwent oesophagogastroduodenoscopy, barium swallow, and oesophageal manometry, which suggested type I achalasia in the former; the other had type II achalasia cardia. Both gave a history of hyperpigmentation of the knuckles, under the eyes, and elbows. Serum cortisol levels were low, with elevated adrenocorticotrophic hormone (ACTH) levels in one, while the other had preserved adrenal function. Their mother gave a history that neither had shed tears since birth (positive Schirmer's test), consistent with all features of Allgrove syndrome. Both successfully underwent POEM and had resolution of symptoms with weight gain. At three months, both developed gastroesophageal reflux, which needed antireflux mucosectomy in one, and the other responded to medical therapy. This is a rare case of Allgrove syndrome with multisystem involvement and achalasia cardia requiring urgent POEM and antireflux therapy.

Key words: Allgrove Syndrome, Achalasia Cardia, Adrenal Insufficiency, Alacrimia, Peroral Endoscopic Myotomy.

Introduction

Allgrove syndrome (triple A syndrome) is a rare autosomal recessive disorder with a prevalence as low as 1/10,00,000 individuals and presents with a clinical triad of achalasia, alacrimia, and adrenal insufficiency, seen in about 70% of cases.^{1,2} The disease has no known cure, and treatment relies on managing symptoms. Peroral endoscopic myotomy (POEM) is a novel clinical technique developed in Japan and used to treat oesophageal achalasia and oesophageal motility disorders.³ Although there are

limited data, POEM in children has shown encouraging success rates and, with further studies, may become the mainstay of paediatric achalasia treatment.³ This is an unusual case of undiagnosed triple A syndrome with a notable gap between initial symptoms and diagnosis, treated with paediatric POEM, which resulted in the development of gastroesophageal reflux needing antireflux mucosectomy (ARMS).

Case Report

A 13-year-old female born to a consanguineous marriage presented with complaints of progressive

dysphagia to solids and liquids, occasional vomiting, nasal regurgitation, and weight loss of ~10 kg over two years (body mass index [BMI] 15 kg/m²), aggravated in the last four months (Eckardt Symptom Score [ESS] 7). On general examination, she had pallor and hyperpigmented knuckles, with stable vital signs.

Barium swallow showed a “bird-beak” appearance of the oesophagus. Manometry showed oesophageal aperistalsis with an elevated integrated relaxation pressure (IRP) of 21 mmHg, suggesting type I achalasia cardia. An upper endoscopy revealed a dilated oesophagus with liquid residue and resistance while passing the scope across the gastroesophageal junction (GEJ). Her computed tomography (CT) abdomen was unremarkable. She had a history of dry eye symptoms since birth; Schirmer’s test was positive for alacrimia. There was no peripheral neuropathy, and an X-ray of the feet did not show osteoporotic changes. Serum cortisol levels were low, with elevated adrenocorticotrophic hormone (ACTH) levels. The diagnosis was triple A (AAA) syndrome.

As per detailed family history, she had an identical twin sister who had similar symptoms of dyspepsia, nasal regurgitation, and weight loss (ESS 6). She also reported a history of alacrimia since childhood and had hyperpigmented knuckles, elbows, ankles, and knees. Her barium swallow, was suggestive of achalasia cardia. Her oesophageal manometry showed failed peristalsis in all swallows with pan-oesophageal pressurisation in > 20% and an elevated median IRP of 23 mmHg. Her adrenal function was normal, while Schirmer’s test was positive. Neither had any signs of neurological involvement. Another sibling, a 16-year-old male, was apparently healthy and without any such symptoms.

The identical twins underwent posterior POEM for achalasia, which involved adequate submucosal tunnelling, posterior myotomy with a 2 cm gastric myotomy, and closure of the mucosal incision with haemoclips (Medorah, India). Both procedures were uneventful. Postoperatively, they were discharged on Day 2 on a liquid diet and transitioned to a soft diet.

Adrenal insufficiency was treated with oral hydrocortisone (Hisone 5 mg) once daily in the first sibling. After a month, both had an ESS of 2, and endoscopy showed a lax lower oesophageal sphincter, allowing easy scope passage. The first child had Grade C oesophagitis, and the second had Grade A oesophagitis. Proton pump inhibitors (PPIs) were prescribed to both; however, the

former developed PPI-dependent gastroesophageal reflux disease (GERD). After 6 months post-POEM, the first child underwent ARMS. A 270° mucosal resection was performed with cap endoscopic mucosal resection (EMR) after submucosal injection along the cardia. The procedure was uneventful, and the patient was discharged on Day 2. After one month, there was improvement in symptoms and PPIs were stopped. Endoscopy showed no reflux oesophagitis, with a GEJ flap valve and scope grip sign.

Discussion

We present a rare scenario of twins with triple A syndrome who successfully underwent POEM for achalasia. Given its rarity, the long-term outcomes of POEM among the paediatric population are not well described.³⁻⁶ Both patients showed improvement in symptoms of achalasia. We encountered PPI-dependent GERD in one of the patients who was on steroids for adrenal insufficiency. ARMS was performed and showed a good, durable response. Other options to be considered in young patients with achalasia include concomitant fundoplication (POEM-F) or laparoscopic Heller myotomy (LHM) with Dor fundoplication. We offered POEM as primary treatment and performed an antireflux procedure only in the severely symptomatic patient. This case report highlights the usefulness of third-space endoscopy (TSE) in the paediatric population, along with the safety and efficacy of ARMS post-POEM. To our knowledge, there are limited data on such therapeutic options in the paediatric population.

Patients presenting with triple A syndrome often have abnormal or borderline adrenal function, but only a few develop adrenal insufficiency.⁴ There are no specific guidelines for surveillance, but these may need lifelong follow-up based on clinical symptoms. Genetic studies were not conducted in our patients, and the diagnosis was based on the classical triad of symptoms. Allgrove syndrome is a very rare condition, with limited mention of POEM for achalasia.^{7,8} Children presenting with failure to thrive and dysphagia should be evaluated for achalasia. POEM can be offered as a primary treatment modality. We also demonstrated good safety and efficacy of ARMS post-POEM in the paediatric population.

Declarations

Funding: None.

Conflict of Interest: None.

Conclusion

This case highlights a rare presentation of triple A syndrome in identical twins with oesophageal achalasia successfully managed using POEM. The development of post-POEM gastroesophageal reflux, effectively treated with ARMS in one patient, underscores the importance of vigilant follow-up and individualised management. Our experience supports the safety and efficacy of TSE in the paediatric population and emphasises its expanding role in managing complex motility disorders and their complications.

Gaurav Patil, Ankit Dalal, Amol Vadgaokar. Peroral Endoscopic Myotomy Followed by Antireflux Mucosectomy for Gastroesophageal Reflux in Identical Twins with Allgrove Syndrome. *MMJ*. 2026, June. Vol 3 (2).

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References

1. Roucher-Boulez F, Brac de la Perriere A, Jacquez A, *et al*. Triple-A syndrome: a wide spectrum of adrenal dysfunction. *Eur J Endocrinol*. 2018;178(3):199–207.
2. Vallet AE, Verschueren A, Petiot P, *et al*. Neurological features in adult Triple-A (Allgrove) syndrome. *J Neurol*. 2012;259(1):39–46.
3. Inoue H, Shiwaku H, Iwakiri K, *et al*. Clinical practice guidelines for peroral endoscopic myotomy. *Dig Endosc*. 2018;30(5):563–79.
4. Mencin AA, Sethi A, Barakat MT, *et al*. Peroral Endoscopic Myotomy (POEM) in Children. *J Pediatr Gastroenterol Nutr*. 2022;75(3):231–6.
5. Wood LS, Chandler JM, Portelli KE, *et al*. Treating children with achalasia using per-oral endoscopic myotomy (POEM): Twenty-one cases in review. *J Pediatr Surg*. 2020;55(6):1006–12.
6. Nabi Z, Ramchandani M, Basha J, *et al*. POEM Is a Durable Treatment in Children and Adolescents with Achalasia Cardia. *Front Pediatr*. 2022;10:812201.
7. Yadav P, Kumar D, Bohra GK, *et al*. Triple A syndrome (Allgrove syndrome) - A journey from clinical symptoms to a syndrome. *J Family Med Prim Care*. 2020;9(5):2531–4.
8. Singh K, Puri RD, Bhai P, *et al*. Clinical heterogeneity and molecular profile of triple A syndrome: a study of seven cases. *J Pediatr Endocrinol Metab*. 2018;31(7):799–807.

Severe Acute-on-Chronic Hypercapnic Respiratory Failure in Long-Standing Bronchiectasis: A Case Report

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Abstract:

Acute worsening of bronchiectasis may lead to critical ventilatory failure, particularly in patients with chronic carbon dioxide (CO₂) retention. Markedly elevated partial pressure of carbon dioxide in arterial blood (PaCO₂) levels above 150 mmHg are uncommon and potentially fatal. We describe a 71-year-old male with established bronchiectasis who developed profound acute-on-chronic hypercapnic respiratory failure, with PaCO₂ peaking at 156 mmHg. Prompt initiation of non-invasive ventilatory support, targeted oxygen therapy, antimicrobial treatment, and airway clearance measures resulted in clinical stabilisation. This case emphasises the reversibility of even extreme hypercapnia when managed early and appropriately.

Key words: Bronchiectasis, Acute Exacerbation, Hypercapnia, Type II Respiratory Failure, Non-Invasive Ventilation.

Introduction

Bronchiectasis is a chronic and progressive airway disorder characterised by irreversible bronchial dilatation caused by recurrent airway inflammation and infection. The disease is associated with impaired mucociliary clearance, chronic sputum production, repeated pulmonary infections, and progressive airflow limitation.¹ Acute infective exacerbations are major contributors to morbidity and mortality, frequently resulting in hospitalisation and respiratory compromise.

In advanced bronchiectasis, chronic hypoventilation and ventilation–perfusion mismatch may culminate in hypercapnic (Type II) respiratory failure. Although moderate carbon dioxide (CO₂) retention is commonly observed in chronic respiratory disorders, extremely elevated partial pressure of carbon dioxide in arterial blood (PaCO₂) levels above 150 mmHg are rarely documented in the literature and may lead to altered sensorium, cardiovascular instability, and respiratory arrest.²

Non-invasive ventilation (NIV) has become an established therapeutic intervention for acute hypercapnic respiratory failure by improving alveolar ventilation, reducing the work of breathing, and decreasing the requirement for invasive mechanical ventilation.³ We present a case of severe acute-on-chronic hypercapnic respiratory failure in a patient with long-standing bronchiectasis, successfully managed with early NIV and supportive care.

Case Report

A 71-year-old male with a seven-year history of bronchiectasis presented with sudden worsening of breathlessness over the past day, associated with fever and increased productive cough over the preceding 5–6 days. The patient had been receiving long-term low-flow oxygen therapy at home (1 L/min) and intermittent bilevel positive airway pressure (BiPAP) support. On admission, the patient was tachypnoeic with reduced oxygen saturation on room air. Bilateral

diffuse rhonchi and basal crackles were noted on chest auscultation. Cardiovascular examination was unremarkable, and peripheral oedema was absent.

Investigations

Arterial blood gas (ABG) analysis demonstrated severe respiratory acidosis with progressive hypercapnia. Initial ABG showed a pH of 7.17, PaCO₂ of 100 mmHg, partial pressure of arterial oxygen (PaO₂) of 35 mmHg, and bicarbonate (HCO₃) of 35 mmol/L. Subsequent monitoring revealed transient improvement followed by worsening hypercapnia, with peak PaCO₂ reaching 156 mmHg and bicarbonate 55 mmol/L, consistent with acute-on-chronic ventilatory failure.

Laboratory evaluation revealed haemoglobin of 13.5 g/dL, total leucocyte count of $10.6 \times 10^9/L$ with neutrophilic predominance (86%), and elevated inflammatory markers, suggestive of an infective exacerbation. Renal function remained preserved despite a mild elevation in blood urea levels. Chest radiography demonstrated bilateral lower-zone fibrotic changes with patchy opacities suggestive of superimposed infection (Figure 1).



Figure 1: Chest radiograph showing bilateral lower-zone fibrotic changes with patchy opacities suggestive of infective exacerbation in long-standing bronchiectasis.

Diagnosis

Acute infective exacerbation of bronchiectasis complicated by severe acute-on-chronic hypercapnic respiratory failure.

Management

The patient was managed in the Intensive Care Unit (ICU) with carefully titrated oxygen therapy targeting oxygen saturation between 88% and 92%. NIV was initiated promptly using BiPAP support. Additional treatment included broad-spectrum intravenous (IV) antibiotics, inhaled bronchodilators, nebulisation, airway clearance

therapy, and intensive chest physiotherapy. Serial ABG monitoring was performed to assess the therapeutic response. Endotracheal intubation was avoided due to gradual clinical and biochemical improvement.

Outcome

Over subsequent days, progressive reduction in PaCO₂ levels and correction of respiratory acidosis were observed. Respiratory distress improved, oxygen requirements decreased, and the patient was successfully transferred out of the ICU after stabilisation.

Discussion

Bronchiectasis predisposes patients to recurrent respiratory infections, mucus retention, and chronic airflow obstruction, all of which contribute to progressive ventilatory impairment.⁴ Long-standing disease may lead to chronic CO₂ retention with renal metabolic compensation. However, acute infective exacerbations can precipitate sudden ventilatory decompensation and severe hypercapnic respiratory failure.

Extreme hypercapnia is associated with significant physiological consequences, including cerebral vasodilation, altered mental status, increased intracranial pressure, and cardiovascular compromise.⁵ The successful outcome in this case highlights the importance of early recognition and prompt intervention. Current evidence supports the use of NIV as first-line therapy in acute hypercapnic respiratory failure because it improves gas exchange, reduces respiratory muscle fatigue, shortens the duration of ICU stay, and decreases mortality.⁶

Careful oxygen titration is equally important because uncontrolled oxygen administration may worsen hypercapnia through increased ventilation–perfusion mismatch and reduced hypoxic respiratory drive.⁷ In the present case, timely institution of NIV, controlled oxygen therapy, antimicrobial treatment, and chest physiotherapy contributed to rapid stabilisation and the avoidance of invasive mechanical ventilation.

Conclusion

Severe acute-on-chronic hypercapnic respiratory failure may complicate infective exacerbations of bronchiectasis. Even markedly elevated PaCO₂ levels may be reversible with early recognition and aggressive non-invasive management. Prompt initiation of NIV, controlled oxygen administration, and treatment of the underlying infection are critical for favourable outcomes.

Azhar Khan, Sanjay Kriplani, Manoj Pethe. Severe Acute-on-Chronic Hypercapnic Respiratory Failure in Long-Standing Bronchiectasis: A Case Report. MMJ. 2026, June. Vol 3 (2).

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References

- Chalmers JD, Aliberti S, Blasi F. Management of bronchiectasis in adults. *Eur Respir J*. 2015;45(5):1446–62.
- Hatipoğlu U, Aboussouan LS. Chronic hypercapnic respiratory failure and non-invasive ventilation in people with chronic obstructive pulmonary disease. *BMJ Med*. 2022;1(1):e000146.
- Sankari A, Bora V. Noninvasive Ventilation. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026. Available at: <https://www.ncbi.nlm.nih.gov/books/NBK578188/>. Accessed on: 15th May 2026.
- Bird K, Memon J. Bronchiectasis. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026. Available at: <https://www.ncbi.nlm.nih.gov/books/NBK430810/>. Accessed on: 15th May 2026.
- Almanza-Hurtado A, Polanco Guerra C, Martínez-Ávila MC, et al. Hypercapnia from Physiology to Practice. *Int J Clin Pract*. 2022;2022:2635616.
- Mas A, Masip J. Noninvasive ventilation in acute respiratory failure. *Int J Chron Obstruct Pulmon Dis*. 2014;9:837–52.
- Abdo WF, Heunks LM. Oxygen-induced hypercapnia in COPD: myths and facts. *Crit Care*. 2012;16(5):323.

Integrating Chrono-Nutrition with Oral Semaglutide Therapy in the Management of Extreme Obesity: A Case Report

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Abstract:

Extreme obesity in youth causes serious metabolic, functional, and psychosocial problems that calorie-based diets alone often do not fully address. Chrono-nutrition, which aligns food intake with circadian rhythms, improves metabolic efficiency and diet adherence. We report the case of a 19-year-old man with extreme obesity (body mass index [BMI] 60.4 kg/m²) and prediabetes. The patient had a history of psychiatric illness and restrictive dieting, contributing to weight gain. A personalised chrono-nutrition-based dietary intervention was combined with oral semaglutide therapy. Over a period of 6 months, the patient achieved a weight reduction of 35 kg, with improved glycaemic parameters, lipid levels, body measurements, physical function, and mental health. This case suggests that chrono-nutrition may be a feasible, tolerable, and sustainable adjunct to medication for managing extreme obesity in young adults.

Key words: Extreme Obesity, Chrono-Nutrition, Time-Restricted Eating, Oral Semaglutide, Young Adults, Prediabetes.

Introduction

Obesity among Indian adolescents and young adults is rising, leading to risks like insulin resistance, dyslipidaemia, type 2 diabetes, and cardiovascular disease.¹ Managing extreme obesity is challenging because lifestyle interventions often fail due to metabolic adaptation, poor tolerance, and psychological burden.

Chrono-nutrition emphasises the timing and distribution of food intake in synchrony with circadian rhythms, thereby optimising glucose metabolism, insulin sensitivity, and energy utilisation.² Emerging evidence suggests that meal timing may influence

metabolic outcomes independent of calorie intake.³ However, clinical reports integrating chrono-nutrition into obesity management, particularly in young adults with extreme obesity, remain limited.⁴ This case demonstrates that chrono-nutrition can serve as a central therapeutic framework for managing extreme obesity, particularly when combined with pharmacotherapy.

Case Report

A 19-year-old male presented in April 2025 for nutritional management of severe obesity. His height was 181 cm, and his body weight was 198 kg, corresponding to a body mass index (BMI) of 60.4 kg/m². He reported

persistent fatigue, limited mobility, difficulty walking long distances, and significant social withdrawal.

Weight gain began in late adolescence after psychiatric treatment, with decreased activity and irregular eating. In 2020, the patient attempted rapid weight loss via extreme calorie restriction (700–800 kcal/day), losing 22 kg temporarily, followed by weight regain over subsequent years. There was no history of bariatric surgery, and the family history was non-contributory.

Dietary assessment revealed irregular meal timings, frequent late-evening eating, high intake of refined carbohydrates and sugar-sweetened beverages, and frequent consumption of fast food. Physical activity was absent. Baseline clinical and biochemical parameters are summarised in Table 1.

Parameter	Value
Weight	198 kg
BMI	60.4 kg/m ²
Waist circumference	162 cm
Waist-to-hip ratio	1.20
HbA1c	6.4%
Fasting plasma glucose	116 mg/dL
Total cholesterol	240 mg/dL
Triglycerides	260 mg/dL
HDL-cholesterol	32 mg/dL
LDL-cholesterol	150 mg/dL

Table 1: Baseline clinical and laboratory parameters. **Abbreviations:** BMI: Body Mass Index; HbA1c: Glycated Haemoglobin; HDL: High-Density Lipoprotein; LDL: Low-Density Lipoprotein.

Intervention

Pharmacological support: Oral semaglutide was initiated at 3 mg once daily and gradually titrated to 14 mg/day over eight weeks. The patient experienced mild to moderate nausea during dose escalation, particularly in the first 2–3 days following dose increases.

Chrono-nutrition-led dietary strategy: The intervention focused on meal timing, distribution, and gastrointestinal tolerance rather than strict macronutrient targets, in line with Indian Recommended Dietary Allowance (RDA) guidelines. With an estimated

basal metabolic rate of ~2650 kcal/day, energy intake was gradually reduced from 2000 to 1700 kcal/day and maintained to support metabolic stability and avoid rebound restriction. Irregular meal patterns, including late-night eating and skipping meals, were associated with increased nausea and reduced intake, likely influenced by semaglutide-induced gastric slowing. A structured 10-hour eating window with earlier dinner timing was introduced. During dose escalation, meals were kept small, low in fat, and easily digestible, improving tolerance, adherence, and overall dietary compliance.

Macronutrient distribution (Prescribed vs actual intake): In April–May, actual energy intake was lower than prescribed, with greater variability in carbohydrate and protein intake, indicating inconsistent adherence. During June–July, total energy intake remained slightly below the prescribed 1800 kcal, but macronutrient distribution became more stable, particularly with improved protein intake (20%–30%).

By August–October, actual intake closely matched the prescribed targets (Figure 1), with macronutrient distribution aligning at approximately 45% carbohydrate, 30% protein, and 25% fat. Overall, Figure 2 illustrates progressive dietary stabilisation and improved adherence across the intervention period.

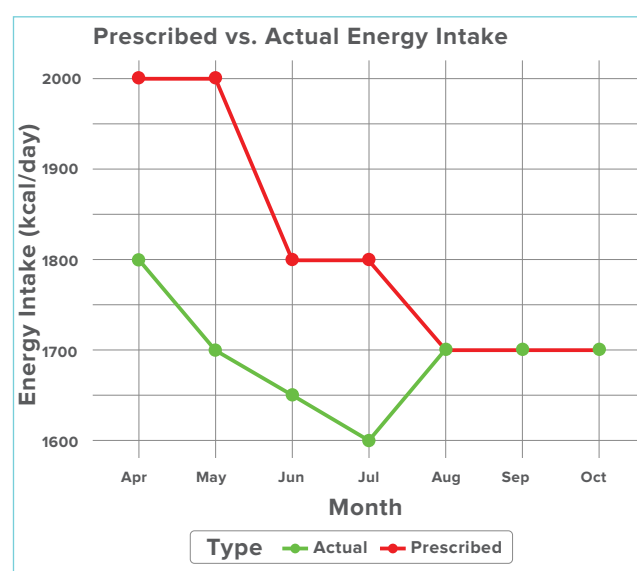


Figure 1: Adherence to calorie prescription over time.

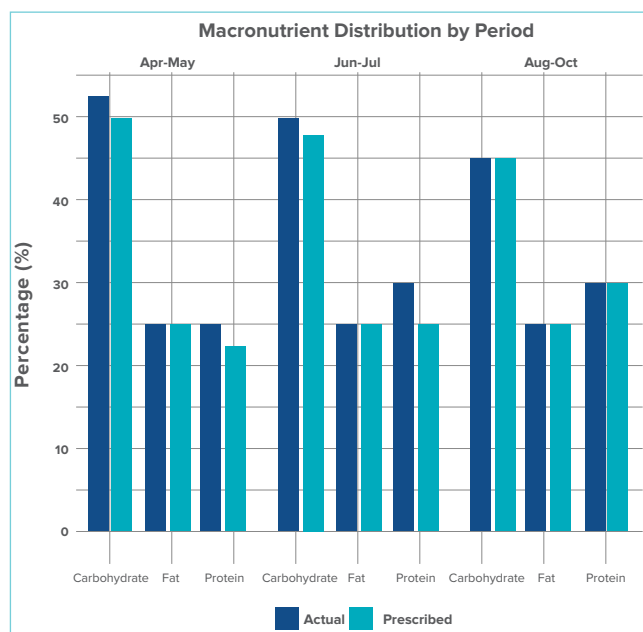


Figure 2: Prescribed vs. actual macronutrient distribution over time.

Physical activity: The patient began with 20 minutes of daily walking, gradually increasing to 45 minutes per day by the fifth month. Light resistance exercises were introduced four days a week to support functional capacity.

Outcomes

Over seven months, body weight reduced from 198 kg to 163 kg (–35 kg; 17.7% reduction). Weight loss was most pronounced during the first three months and became more gradual thereafter (Figure 3). Improvements in clinical and biochemical parameters are detailed in Table 2.



Figure 3: Progressive reduction in body weight over a 7-month follow-up period.

Outcome parameter	Improvement
HbA1c	Reduced from 6.4% to 5.3%
Triglycerides	Decreased from 260 mg/dL to 145 mg/dL
HDL-cholesterol	Increased from 32 mg/dL to 44 mg/dL
Waist circumference	Reduced from 62 cm to 40 cm
Clinical outcomes	Improved mobility, sleep quality, confidence, and social engagement

Table 2: Improvement in clinical and biochemical parameters post-intervention. **Abbreviations:** HbA1c: Glycated Haemoglobin; HDL: High-Density Lipoprotein.

Discussion

Glucagon-like peptide-1 (GLP-1) receptor agonists support appetite suppression; however, sustained weight loss depends largely on dietary tolerance and adherence. In this case, focusing on meal timing, food quality, and individual tolerance — rather than strict dietary restriction — resulted in significant weight loss and metabolic improvement. Chrono-nutrition may have enhanced metabolic efficiency by aligning carbohydrate intake with periods of higher insulin sensitivity and reducing late-evening caloric intake. Evidence suggests that earlier energy consumption improves glycaemic control and supports weight loss, independent of calorie restriction.⁵ Importantly, this approach avoided extreme dietary restriction, preventing prior patterns of weight regain.

Conclusion

This case highlights chrono-nutrition as a practical, patient-centred strategy for managing severe obesity. Individualised macronutrient planning, combined with structured meal timing, supported metabolic adaptation and improved energy levels. Overall, this approach achieved meaningful clinical improvements and may serve as an effective adjunct to pharmacotherapy, particularly in settings where long-term adherence to conventional diets is challenging.

Purva Singh, Swati Waghdhare, Chahat Arora, Vinita Jha. Integrating Chrono-Nutrition with Oral Semaglutide Therapy in the Management of Extreme Obesity: A Case Report. MMJ. 2026, June. Vol 3 (2).

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References

1. Love KM, Jahn LA, Hartline LM, *et al.* Impact of Free Fatty Acids on Vascular Insulin Responses Across the Arterial Tree: A Randomized Crossover Study. *J Clin Endocrinol Metab.* 2024;109(4):1041–50.
2. Rodrigues J, Magalhães V, Santos MP, *et al.* Weight loss in patients with severe obesity after bariatric surgery-the potential role of the chrono-nutrition, chronotype and the circadian misalignment: A study protocol of the ChronoWise prospective cohort. *PLoS One.* 2024;19(11):e0313096.
3. Mentzelou M, Papadopoulou SK, Psara E, *et al.* Chrononutrition in the Prevention and Management of Metabolic Disorders: A Literature Review. *Nutrients.* 2024;16(5):722.
4. Katsi V, Papakonstantinou IP, Soulaïdopoulos S, *et al.* Chrononutrition in Cardiometabolic Health. *J Clin Med.* 2022;11(2):296.
5. Morris CJ, Purvis TE, Mistretta J, *et al.* Effects of the Internal Circadian System and Circadian Misalignment on Glucose Tolerance in Chronic Shift Workers. *J Clin Endocrinol Metab.* 2016;101(3):1066–74.

An Unusual Spontaneous Porto-Systemic Shunt Between the Left Portal Vein and Pericardial Venous System in Decompensated Chronic Liver Disease: Radiological and Intraoperative Correlation

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Abstract:

Spontaneous porto-systemic shunts (SPSS) are common vascular adaptations in patients with portal hypertension and cirrhosis, typically occurring through recognised collateral pathways such as splenorenal, gastrosplenic, or paraumbilical routes; however, atypical thoracic venous shunts are extremely rare and may have important implications during liver transplantation. We report a rare case of a transdiaphragmatic SPSS arising from the intrahepatic left portal vein and draining into the pericardiophrenic venous system in a patient with hepatitis B-related decompensated cirrhosis who underwent living donor liver transplantation. Preoperative triphasic computed tomography (CT) demonstrated a large tortuous collateral vessel originating from the intrahepatic portion of the left portal vein, extending along the left coronary ligament, traversing the left hemidiaphragm, and draining into the pericardial venous system. During recipient hepatectomy, the shunt was carefully dissected from the left lobe of the liver and the left hemidiaphragm, to avoid a sudden increase in portal pressure during dissection, it was preserved during the early stages of surgery and ligated only after completion of the major dissection, immediately before division of the middle and left hepatic vein confluence. This case highlights a rare transdiaphragmatic porto-systemic collateral with an intrahepatic portal origin draining into the pericardiophrenic venous system and emphasises the importance of preoperative identification of unusual vascular variants for safe surgical planning and maintenance of portal haemodynamic stability during liver transplantation.

Key words: Spontaneous Porto-Systemic Shunt, Transdiaphragmatic Shunt, Pericardiophrenic Vein, Portal Hypertension, Cirrhosis, Hepatitis B, Living Donor Liver Transplantation.

Introduction

Spontaneous porto-systemic shunts (SPSS) are a well-recognised vascular adaptation in patients with portal hypertension and cirrhosis. These collateral pathways develop due to a combination of reopening of embryological

venous channels and angiogenesis driven by sustained portal hypertension. The prevalence of SPSS in cirrhotic patients has been reported to be approximately 60%, with large shunts (> 8–10 mm) present in nearly half of these cases.¹

The most commonly described SPSS include splenorenal, gastorenal, paraumbilical, and mesocaval shunts. These pathways decompress the portal venous system but may also lead to complications such as hepatic encephalopathy, portal steal phenomenon, and altered portal haemodynamics following liver transplantation.²

While typical collateral pathways are well documented, unusual routes of spontaneous shunts are rarely encountered. Collaterals extending through diaphragmatic venous channels into mediastinal or pericardial venous systems are exceedingly uncommon and sparsely reported in the literature. Identification of such variants is clinically relevant, particularly in patients undergoing liver transplantation, where unrecognised collateral vessels may lead to significant intraoperative bleeding or altered portal haemodynamics.

Here, we present a rare case of a large SPSS arising from the left intrahepatic portal vein and draining into the pericardial venous system, identified preoperatively on triphasic computed tomography (CT) and confirmed intraoperatively during living donor liver transplantation (LDLT).

Case Report

A 51-year-old male with hepatitis B–related chronic liver disease presented with progressive abdominal distension, jaundice, and generalised weakness. His clinical course had been complicated by recurrent ascites and episodes of upper gastrointestinal bleeding requiring endoscopic variceal ligation. He also had evidence of renal dysfunction consistent with chronic kidney disease. The patient was evaluated for liver transplantation due to decompensated cirrhosis with portal hypertension.

On presentation to our centre, he had features of advanced liver disease including ascites, splenomegaly, and sarcopenia. Upper gastrointestinal endoscopy demonstrated residual oesophageal varices and portal hypertensive gastropathy. Pretransplant evaluation revealed a Model for End-Stage Liver Disease (MELD) score of 29 and Child–Pugh class C disease, consistent with advanced decompensated cirrhosis. The patient was planned for LDLT, with his son as the donor.

As part of routine preoperative vascular evaluation, a triphasic CT scan of the abdomen was performed. Portal venous phase images demonstrated an unusual vascular

channel arising from the intrahepatic segment of the left portal vein. The vessel formed a large tortuous SPSS that extended superiorly along the left coronary ligament, traversed the left hemidiaphragm, and drained into the pericardial venous plexus (Figure 1A and B). The course of the vessel suggested communication with mediastinal/pericardiophrenic venous channels. No evidence of portal vein thrombosis was noted.

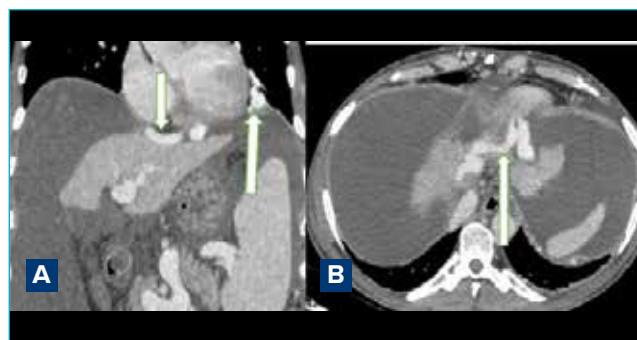


Figure 1: Triphasic computed tomography (CT) scan of the abdomen (portal venous phase): **A.** Coronal reconstruction demonstrating a large tortuous spontaneous porto-systemic shunt arising from the intrahepatic portion of the left portal vein, coursing superiorly along the left coronary ligament, traversing the left hemidiaphragm, and extending into the pericardial venous system; **B.** Axial image in the portal venous phase depicting the same collateral vessel extending cranially from the left portal vein towards the pericardial venous plexus, consistent with a transdiaphragmatic porto-systemic shunt.

The patient subsequently underwent LDLT. During recipient hepatectomy, careful exploration of the suprahepatic and left diaphragmatic region revealed a large tortuous collateral vessel corresponding to the shunt identified on CT imaging. Meticulous dissection was performed to separate the shunt from the left lobe of the cirrhotic liver and the left hemidiaphragm (Figure 2).



Figure 2: Intraoperative photograph demonstrating the spontaneous porto-systemic shunt following meticulous dissection and separation from the left lobe of the liver and the left hemidiaphragm during recipient hepatectomy.

Given the potential haemodynamic role of this collateral in decompressing the portal venous system, the shunt was intentionally preserved during the initial stages of the hepatectomy. Maintaining the shunt patency allowed continued decompression of the portal circulation during mobilisation of the cirrhotic liver and prevented a sudden rise in portal pressure. Once the major dissection required for explant hepatectomy was completed, the shunt was ligated immediately prior to ligation of the middle hepatic vein–left hepatic vein (MHV–LHV) confluence. This approach enabled controlled interruption of the collateral while minimising the risk of portal hypertension-related bleeding during the earlier phases of dissection. The intraoperative findings confirmed the presence of a large SPSS consistent with the preoperative radiological description.

Discussion

SPSS develop as a compensatory response to sustained portal hypertension and represent structural remodelling of the splanchnic venous circulation. Their presence reflects progressive haemodynamic adaptation in cirrhosis, allowing diversion of portal venous blood into systemic veins. Radiological studies have demonstrated that SPSS are common in advanced liver disease and increase in prevalence and size with worsening portal hypertension and hepatic dysfunction.^{3,4}

Most SPSS follow predictable anatomical routes, including splenorenal, gastrosplenic, paraumbilical, and mesocaval pathways. However, unusual collateral routes may occasionally develop through less common venous communications. One such rare pathway involves transdiaphragmatic porto-systemic shunting into thoracic venous channels. The diaphragm contains an extensive venous network composed of the inferior phrenic, pericardiophrenic, internal thoracic, and intercostal veins. These vessels form potential anastomotic channels between the abdominal and thoracic venous systems and may enlarge under conditions of elevated portal pressure. A transdiaphragmatic porto-systemic shunt draining into the pericardiophrenic vein was first described radiologically by Minami and colleagues.⁵ In their report, the collateral pathway originated from abdominal portal venous tributaries and passed through the inferior phrenic vein, traversing the diaphragm before draining into the pericardiophrenic vein within the thorax. The authors emphasised the rarity of this collateral pathway and noted that only one similar case had been previously described in the literature. The

pericardiophrenic vein may communicate with the internal thoracic and azygos venous systems, thereby providing an alternative route for portal decompression in patients with portal hypertension.⁵

The anatomical basis for this pathway lies in the venous drainage pattern of the diaphragm. The inferior phrenic veins typically drain directly into the inferior vena cava or into the left renal vein, often via the left adrenal vein. However, they may form anastomoses with the pericardiophrenic and mediastinal venous systems, creating a potential collateral route between the portal and systemic circulations. Despite these anatomical connections, transdiaphragmatic porto-systemic shunts remain extremely uncommon, likely because the inferior phrenic veins most frequently terminate directly into the inferior vena cava or hepatic veins rather than forming large mediastinal communications.

Compared with previously described cases, the present case demonstrates a distinct anatomical origin of the shunt directly from the intrahepatic left portal vein, extending along the left coronary ligament, traversing the left hemidiaphragm, and draining into the pericardial venous system. In contrast, the shunts described by Minami *et al.*⁵ predominantly arose from extrahepatic portal tributaries such as the splenic, gastric, or adrenal venous systems. This difference highlights a rare intrahepatic origin of a transdiaphragmatic porto-systemic collateral. Recognition of atypical SPSS is particularly important in the setting of liver transplantation. Large collateral vessels may serve as major decompressive pathways, and abrupt interruption during dissection can result in sudden increases in portal pressure and bleeding from portal venous tributaries. Furthermore, persistent large SPSS after transplantation may divert portal inflow away from the graft, leading to the portal steal phenomenon, which can compromise graft perfusion and function.^{6,7}

In the present case, preoperative triphasic CT imaging allowed accurate delineation of the unusual collateral pathway, which facilitated careful intraoperative planning. The shunt was preserved during the initial stages of the hepatectomy to maintain portal decompression and was ligated only after completion of the major dissection, immediately prior to division of the middle and left hepatic vein confluence. This strategy allowed safe completion of the recipient hepatectomy while avoiding sudden portal hypertension or catastrophic bleeding during dissection.

Overall, this case highlights the importance of meticulous evaluation of cross-sectional imaging in transplant candidates, as recognition of rare collateral pathways may influence operative strategy and intraoperative haemodynamic management.

Declarations

Ethical approval

Ethical approval was not required for this case report according to institutional guidelines. The study was conducted in accordance with the principles of the Declaration of Helsinki.

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Authors' contributions

All authors contributed to the clinical management of the patient and preparation of the manuscript. All authors reviewed and approved the final manuscript.

Conclusion

This case highlights a rare transdiaphragmatic SPSS originating from the intrahepatic left portal vein and draining into the pericardiacophrenic venous system in a patient with decompensated cirrhosis undergoing LDLT. Recognition of such unusual collateral pathways on preoperative cross-sectional imaging is crucial for operative planning, as these shunts may serve as significant decompressive channels in portal hypertension. Strategic intraoperative management, including preservation of the shunt during early dissection and controlled ligation at an appropriate stage of hepatectomy, can help maintain portal haemodynamic stability and facilitate safe explantation. Awareness of these rare vascular variants is important for transplant surgeons and radiologists involved in the management of advanced portal hypertension.

Soumyadip Sain, Karisangal Ramaswamy Vasudevan, Piyush Kumar Sinha, Rohit Saini, Manmohan Singh Rajput, Saurabh Kumar. An Unusual Spontaneous Porto-Systemic Shunt Between the Left Portal Vein and Pericardial Venous System in Decompensated Chronic Liver Disease: Radiological and Intraoperative Correlation. MMJ. 2026, June. Vol 3 (2).

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References

1. Juncu S, Minea H, Girleanu I, et al. Clinical implications and management of spontaneous portosystemic shunts in liver cirrhosis. *Diagnostics*. 2024;14(13):1372.
2. Philips CA, Rajesh S, Augustine P, et al. Portosystemic shunts and refractory hepatic encephalopathy: patient selection and current options. *Hepat Med*. 2019;11:23–34.
3. Simón-Talero M, Roccarina D, Martínez J, et al. Association between spontaneous portosystemic shunts and complications of cirrhosis. *Gastroenterology*. 2018;154:1694–705.
4. Dajti E, Renzulli M, Marasco G, et al. Spontaneous portosystemic shunts in cirrhosis: Clinical and radiological relevance. *Dig Liver Dis*. 2022;54:1205–14.
5. Minami M, Kawauchi N, Itai Y, et al. Transdiaphragmatic portosystemic shunt to the pericardiacophrenic vein. *AJR Am J Roentgenol*. 1993;161(3):569–71.
6. Praktinjo M, Simón-Talero M, Römer J, et al. Total area of spontaneous portosystemic shunts independently predicts complications of liver cirrhosis. *Hepatology*. 2020;72:675–86.
7. Nardelli S, Riggio O, Gioia S, et al. Spontaneous porto-systemic shunts in liver cirrhosis: Clinical and therapeutical aspects. *World J Gastroenterol*. 2020;26(15):1726–32.

Management of Conversion of Atrioventricular Block to Complete Heart Block During One-Lung Ventilation in Thoracic Surgery: A Case Report

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Abstract:

Complete atrioventricular (AV) block during one-lung ventilation (OLV) is a rare but life-threatening complication. We report the case of a 71-year-old male with pre-existing right bundle branch block (RBBB) undergoing left lower lobectomy who developed atropine-refractory complete heart block after two hours of OLV. Following a transient episode of asystole, return of spontaneous circulation (ROSC) was achieved with cardiopulmonary resuscitation (CPR) and adrenaline administration; however, persistent bradycardia required transcutaneous pacing (TCP) (70/min, 30 mA) and an isoprenaline infusion. The patient subsequently required transvenous pacing in the Intensive Care Unit (ICU). This case underscores the importance of preparedness for conduction abnormalities during high-risk thoracic surgeries, particularly with pre-existing RBBB, and highlights the role of TCP in refractory AV block.

Key words: Complete Atrioventricular Block, One-lung Ventilation, Thoracic Surgery, Transcutaneous Pacing, Right Bundle Branch Block.

Introduction

Complete atrioventricular (AV) block during surgery is a rare yet life-threatening condition that can pose significant challenges, particularly in patients with pre-existing cardiac conditions. Conduction disturbances during anaesthesia may arise due to underlying structural conduction abnormalities, autonomic imbalance, electrolyte disturbances, myocardial ischaemia, or direct surgical manipulation near the cardiac conduction pathways. Patients with pre-existing bundle branch block, especially right bundle branch block (RBBB), may be particularly vulnerable to progression towards higher-grade AV block under perioperative stress conditions.

Thoracic surgeries requiring one-lung ventilation (OLV) introduce additional physiological challenges that

may predispose patients to cardiovascular instability. OLV results in altered pulmonary vascular resistance, ventilation-perfusion mismatch, hypoxaemia, and increased right ventricular afterload, all of which can adversely affect myocardial oxygen supply-demand balance. Furthermore, mediastinal manipulation and traction during thoracic procedures can enhance vagal stimulation, precipitating severe bradyarrhythmia and conduction abnormalities in susceptible individuals. Although transient bundle branch blocks and arrhythmias during surgery have been described in the literature, complete AV block occurring specifically during OLV remains exceedingly rare. It can lead to significant haemodynamic instability and is often refractory to vagolytic medications.¹

Prompt recognition and immediate intervention are critical because atropine-resistant AV block may rapidly progress to profound bradycardia, circulatory collapse, and asystole. In such situations, transcutaneous pacing (TCP) serves as an important bridge until definitive transvenous or permanent pacing can be established. Awareness of this rare but life-threatening complication is therefore essential for anaesthesiologists managing high-risk thoracic surgical patients.

A meticulous plan of action to manage such a crisis intraoperatively is vital for optimal patient care and outcomes. Very few studies are available to date on this condition, and none of them describes its occurrence during OLV. Here, we present the case of a 71-year-old male posted for left lower lobectomy with a history of lower anterior resection and hepatic metastasectomy. The patient developed complete heart block after two hours of OLV, which was managed promptly with TCP.

Case Report

A 71-year-old male with a history of lower anterior resection for carcinoma of the sigmoid colon six years earlier and hepatic metastasectomy five years earlier presented with left lung metastasis. He was scheduled for left lower lobectomy. The patient was a known case of hypertension, which was optimised on tablet amlodipine 5 mg once daily (OD), and hypothyroidism for which he was on tablet thyronorm 50 mcg OD. On preoperative assessment, his electrocardiogram (ECG) revealed RBBB, for which a cardiology consultation was taken for perioperative risk stratification. A two-dimensional echocardiogram (2D echo) was done, which was normal with left ventricular ejection fraction (LVEF) 55%–60%, and the patient was stratified under moderate risk of major adverse cardiovascular events (MACE). The patient had received neoadjuvant chemotherapy with two cycles of capecitabine plus oxaliplatin (CAPOX) and folinic acid, fluorouracil, and irinotecan (FOLFIRI), with the last dose administered six weeks prior to evaluation. Pre- and post-ECG revealed normal findings, with an ejection fraction within the range of 55%–60%, no regional wall motion abnormalities (RWMA), and normal chamber dimensions.

On the day of surgery, the patient was transferred to the operating theatre after confirming nil per os (NPO) status. All standard American Society of Anesthesiologists (ASA) monitors, including ECG, pulse oximetry, and non-invasive blood pressure monitoring, were connected. The patient had a baseline heart rate of 45/min. An 18 G cannula was secured. An epidural was placed at T6–T7 level in the

lateral position. Patient was preoxygenated using transnasal humidified rapid-insufflation ventilatory exchange (THRIVE) with settings of 100% fraction of inspired oxygen (FiO_2) and flow rate of 30 L/min till end-tidal oxygen concentration (EtO_2) of 90%. After adequate preoxygenation, intravenous induction was started using injection fentanyl (2 mcg/kg), injection propofol titrated to loss of verbal response and injection rocuronium (0.6 mg/kg) and the patient's trachea was intubated using a right double-lumen tube (DLT) of 39 Fr under videolaryngoscope guidance. The position of the tube was confirmed with a fiberoptic bronchoscope, and the circuit was connected to the ventilator. Additionally, a 20 G arterial cannula was secured in the right upper limb to allow beat-to-beat haemodynamic monitoring and frequent blood gas analysis during OLV.

The patient was then positioned in the right lateral decubitus position, and all the pressure points were adequately padded to prevent pressure injury. OLV was initiated after the commencement of surgery. After 30 minutes of initiating OLV, the patient started desaturating gradually, which was managed by increasing FiO_2 and positive end-expiratory pressure (PEEP) to the ventilated lung. There was a requirement of intermittent continuous positive airway pressure (CPAP) to the non-ventilated lung as well to maintain $\text{SpO}_2 > 90\%$. The patient had intermittent arrhythmias and occasional ventricular premature complex (VPC) ($< 5/\text{rhythm}$) secondary to pericardial stimulation during video-assisted thoracic surgery (VATS), though he was haemodynamically stable throughout.

There was a sudden decrease in heart rate (minimum 32/min) as soon as the lobectomy specimen was removed, and he developed hypotension, for which injection atropine 1 mg was administered; however, there was no response, and the patient developed asystole. Cardiopulmonary resuscitation (CPR) was started according to the standard advanced cardiovascular life support (ACLS) guidelines in the lateral position with 1 mg of adrenaline administered every 3 minutes for a total of two cycles, following which the patient was positioned supine. Return of spontaneous circulation (ROSC) was achieved, but the patient was still having bradycardia and rhythm was depicting Mobitz type 1 (Wenckebach phenomenon) heart block, which got converted to complete heart block. Bradycardia was nonresponsive to injection atropine.

Immediate transcutaneous pads were applied, and pacing was initiated at a rate of 70/min and an output of 30 mA, along with isoprenaline at a rate of 4–10 $\mu\text{g}/\text{min}$ for pharmacological pacing. The patient's heart rate responded

to pacing, and he was haemodynamically stable thereafter. Arterial blood gas, electrolytes and cardiac enzymes showed no remarkable findings. A chest tube was inserted, and the DLT was changed to single-lumen tube (SLT), and the patient was shifted to the Intensive Care Unit (ICU) for further management.

A cardiology consultation was sought, and the patient underwent transvenous pacing in the ICU under radiological guidance (Figure 1). Pacing was given at a rate of 70/min with an output of 5 mA and a sensing threshold of 2 mV.



Figure 1: Chest X-ray of the patient showing the transvenous pacing wire (black arrow) after placement inside the ventricle.

He was weaned off the ventilator on postoperative day (POD) 1 and subsequently extubated without any evidence of hypoxic brain injury. All the laboratory investigations and vital parameters were within normal limits. The patient was shifted to the ward on POD 2 and was planned for permanent pacing by the cardiology team.

An implantable cardioverter-defibrillator (ICD) with cardiac resynchronisation therapy (CRT) (Figure 2) was inserted on POD 4, and the patient was discharged with the pacemaker in situ on POD 7.

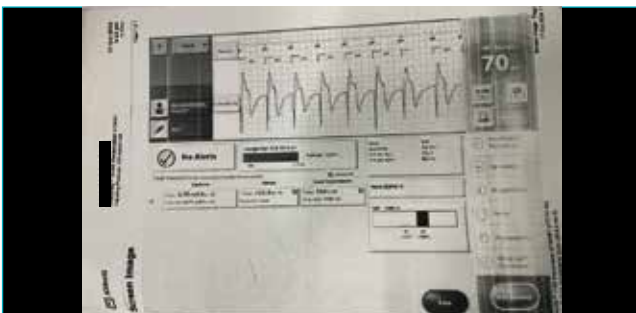


Figure 2: Mode of pacemaker.

Discussion

Intraoperative transient bundle branch blocks (BBBs) are mostly paroxysmal, with tachycardia-associated, rate-dependent left bundle branch block (LBBB) being the

more common type.² The bradycardia-dependent blocks caused by phase-4 block are rare and usually associated with structural heart disease.³ Acquired complete AV block involves blockade of the His-Purkinje system distal to the AV node. In this type of heart block, the ECG typically demonstrates a wide QRS complex and a relatively slow heart rate.⁴ However, in our case, the patient showed a normal QRS and severe bradycardia that was refractory to atropine administration. This rare and atypical AV block is referred to as paroxysmal AV block.⁵

The precise mechanism of paroxysmal AV block remains unclear but is thought to be related to the hyperreactivity of the AV node to vagotonic stimulation. Sudden severe bradycardia in the periprocedural setting is often caused by physical manipulations that increase vagal tone and is potentiated by the combination of vagotonic anaesthetics and the sympatholysis that accompanies almost all anaesthetics. The left lateral decubitus position in our case may have further contributed to the increase in vagal tone.

The transition to OLV leads to a reduction in ventilated lung volume, causing hypoxic pulmonary vasoconstriction and increased pulmonary vascular resistance. These changes can elevate right ventricular afterload and potentially compromise coronary perfusion, especially in patients with pre-existing cardiac conditions. The resultant myocardial ischaemia can disrupt the cardiac conduction system, leading to heart blocks. Additionally, surgical manipulation near the heart or major vessels can directly affect the conduction pathways, increasing the risk of intraoperative AV block.

A case reported by Morita *et al.*⁶ illustrates the management of intraoperative complete AV block during laparoscopic surgery. An 82-year-old patient developed a third-degree AV block unresponsive to atropine and TCP. The team successfully employed a transvenous temporary pacemaker, stabilising the patient's haemodynamic status and allowing the surgery to proceed without further complications.⁶

Medications such as digitalis and antiarrhythmic drugs, coronary artery disease, and ageing-related degenerative changes in the conduction system are common causes of paroxysmal AV block among various causes, including surgery, electrolyte imbalance, endocarditis, tumour, Chagas' disease, rheumatic heart disease, calcified aortic valve stenosis, myxoedema, and inflammatory and infiltrative heart diseases. ACLS in the lateral position is technically difficult. Manual compressions can be

performed over the lower sternum or the mid-axillary line, although repositioning the patient to the supine position remains optimal. In our case, initial lateral CPR achieved adequate circulation until repositioning.

The possible mechanism in this case may be attributed to pre-existing degenerative changes in the conduction system. This is inferred from the presence of a first-degree AV block in an elderly patient, which may have been precipitated by vagotonic stimuli such as surgical manipulation of the cardiac fibres while dissecting.

Learning Points

1. Patients with pre-existing RBBB undergoing thoracic surgery are at risk of progression to high-grade AV block, especially during OLV and mediastinal manipulation.
2. Preparedness with TCP pads and immediate pacing capability is essential.

Conclusion

This case highlights the importance of vigilance for conduction disturbances during OLV, especially in patients with baseline conduction defects. Prompt initiation of CPR, timely pacing, and interdisciplinary collaboration between anaesthesiology and cardiology teams can ensure favourable outcomes in such rare but critical events.

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3. ACLS in the lateral decubitus position is feasible; however, the patient should be repositioned to the supine position as soon as possible.
4. Meticulous review of anaesthetic and epidural medications is warranted, as high neuraxial block or local anaesthetic spread may exacerbate bradycardia.

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References

1. Epstein AE, DiMarco JP, Ellenbogen KA *et al.* ACC/AHA/HRS 2008 Guidelines for Device-Based Therapy of Cardiac Rhythm Abnormalities: A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Revise the ACC/AHA/NASPE 2002 Guideline Update for Implantation of Cardiac Pacemakers and Antiarrhythmia Devices): developed in collaboration with the American Association for Thoracic Surgery and Society of Thoracic Surgeons. *J Am Coll Cardiol.* 2008;117(21):e350–408.
2. Nasa P, Juneja D, Jain R, *et al.* Transient bundle branch block during the perioperative period-A meta-summary of case reports. *Indian J Anesth.* 2023;67(12):1123–5.
3. Frisch DR, Zimetbaum PJ, Josephson ME, *et al.* Alternating left bundle branch block and right bundle branch block during tachycardia: what is the mechanism?. *Heart Rhythm.* 2007;4(5):679–80.
4. Zipes DP. Special arrhythmias: diagnosis and treatment. In: Heart disease. 5th Edition. Edited by Braunwald E: Philadelphia, S.B. Saunders Company. 1997, p 687–93.
5. Shohat-Zabarski R, Iakobishvili Z, Kusneic J, *et al.* Paroxysmal atrioventricular block: clinical experience with 20 patients. *Int J Cardiol.* 2004;97(3):399–405.
6. Morita T, Kishikawa H, Sakamoto A. Management of third-degree atrioventricular block with intraoperative transvenous temporary pacemaker. *J Anesth Clin Res.* 2020;11(8):963.

Uncommon Presentation of Cervical Abscess Causing Melioidosis due to *Burkholderia pseudomallei* Infection in a Patient with Uncontrolled Diabetes Mellitus: A Case Report

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Abstract:

Burkholderia pseudomallei is a saprophytic Gram-negative organism and facultative intracellular bacterium found in soil and water, and is responsible for causing melioidosis. It has the ability to imitate various diseases such as tuberculosis, pneumonia, and other pyogenic infections, which frequently results in misdiagnosis and improper treatment. In India, it has been previously misdiagnosed as tuberculosis and *Pseudomonas* infection, which may account for underreporting in the country. A 48-year-old female patient with type 2 diabetes mellitus and a past history of left breast carcinoma, operated on two years ago, presented with a history of high-grade fever with chills, along with a runny nose, dry cough, and generalised weakness for the last four days. She also complained of throat pain and noticed a swelling over the right side of her neck. Culture was suggestive of *Burkholderia pseudomallei* species, which was sensitive to cephalosporins and doxycycline, and she was immediately started on intravenous (IV) Zavicefta (IV ceftazidime) and oral doxycycline, along with antipyretics and supportive treatment. After 10 days, as she was haemodynamically stable, she was discharged with oral antibiotics for a further two weeks. Uncontrolled diabetes mellitus is a known predisposing factor for severe or atypical infections, which makes this case relevant to clinicians. This case highlights an unusual pathogen in a high-risk host, and its occurrence in deep neck infections is uncommon. This case was reported because it represents an uncommon presentation of *Burkholderia* infection in a patient with uncontrolled diabetes, which is commonly underreported in our country.

Key words: *Burkholderia pseudomallei*, Gram-Negative Organism, Ultrasonography (USG) Neck, Great Mimicker, Ceftazidime, Doxycycline.

Introduction

Burkholderia pseudomallei is a saprophytic Gram-negative organism and facultative intracellular bacterium found in soil and water, and is responsible for causing melioidosis. The primary modes of transmission include percutaneous inoculation, inhalation, and

ingestion. Additionally, rare cases of transmission have been documented through breast milk, as well as sexual and vertical (mother-to-child) routes. Around 25%-40% of patients present with localised infections such as cutaneous and soft tissue abscesses, suppurative lymphadenitis, salivary gland abscesses,

joint involvement, pyomyositis, prostatic abscesses, and visceral organ abscesses involving the liver and spleen. These localised infections can sometimes rapidly advance to disseminated disease.¹ In severe instances, the disease may progress to a rapidly worsening multiple organ condition, potentially leading to death.² Cervical lymphadenopathy accounts for approximately 40% of localised melioidosis cases globally. Notably, in India, there have been multiple reports of melioidosis both mimicking and coexisting with tubercular cold abscesses.¹ Although *B. pseudomallei* is mainly endemic in regions of South-East Asia and northern Australia, diabetes mellitus stands out as the primary risk factor for developing melioidosis.³ Type 2 diabetes mellitus (T2DM) is present in approximately 39% of individuals diagnosed with melioidosis, with diabetic patients facing a 13-fold increased risk of infection compared to non-diabetics.⁴ Additional predisposing conditions include chronic kidney and lung diseases, liver disorders, malignancies, and heavy alcohol consumption. However, around 20% of adult cases occur in individuals without identifiable risk factors. Human-to-human transmission is uncommon, with most infections resulting from environmental exposure. The incidence of melioidosis is seasonal, rising notably during the rainy season. The incubation period typically ranges from 1 to 21 days, although cases with latency extending for decades have been documented.³ An environmental bacterium acts as an opportunistic pathogen in humans and tends to cause more severe disease in those with compromised immune systems.⁴

Burkholderia species are classified as non-fermenting Gram-negative bacilli and are sometimes mistakenly identified as *Pseudomonas*, which may account for underreporting in regions like India. It is observed especially in pneumonia, which is the most frequently reported form. Although once thought to be endemic only to Australia and parts of South Asia, such as Sri Lanka and Bangladesh, cases have been increasingly reported across Indian states, including Karnataka, Kerala, Maharashtra, Tamil Nadu, and Puducherry, particularly during the monsoon season and among rice field workers.⁵

Climate change — through increased rainfall, extreme weather events, and rising soil salinity and anthrosols — may contribute to the broader geographic spread and rising incidence of *B. pseudomallei*. The World Health Organization (WHO) South-East Asia Region

accounts for over 60% of the estimated global disease burden, with India bearing the highest share, estimated at 1.6 million disability-adjusted life years (DALYs). Notably, over 80% of affected individuals have diabetes mellitus, a figure higher than global averages, likely reflecting the growing diabetes epidemic in India.⁶

Case Report

A 48-year-old female patient presented with a background history of T2DM for five years, on regular medication, and a history of left breast carcinoma, which was operated on two years ago, followed by radiotherapy (20 cycles) and chemotherapy. She is currently on tamoxifen 20 mg once daily, along with oral hypoglycaemic agents. She presented with a history of high-grade fever with chills, along with a runny nose, dry cough, and generalised weakness for one week. There were no associated symptoms of headache, neck pain, abdominal pain, loose stools, or vomiting. Her symptoms persisted despite antibiotics prescribed by a local physician. She started complaining of throat pain as well and then noticed a swelling on the right side of her neck. There was no history of any recent travel.

She presented to the hospital on the tenth day. On presentation, she was febrile with a temperature of 102°F, pulse rate of 124/min, blood pressure of 100/60 mmHg, respiratory rate of 20/min, and oxygen saturation of 98% on room air. Respiratory system examination revealed pharyngitis with normal breath sounds and no added sounds. Other systemic examinations were unremarkable. On examination of her neck, there was a swelling of around 3 × 2 × 3 cm in the posterior triangle on the right side, consistent with a single, enlarged, non-matted, mobile, tender lymph node. On further evaluation by sonography of the neck, a hypoechoic lesion with peripheral vascularity measuring 3.1 × 1.4 × 2.9 cm (volume: 6.9 cc) was identified at the junction of the posterior triangle and the right supraclavicular region. Fine-needle aspiration cytology (FNAC) was performed, and a few millilitres of pus were aspirated. GeneXpert was negative, acid-fast bacilli (AFB) were not seen, and fungal elements were absent. Culture was suggestive of *B. pseudomallei* species, which was sensitive to cephalosporins and doxycycline. *B. pseudomallei* species was identified on Gram stain (Figure 1) and on MacConkey agar (Figure 2).



Figure 1: *Burkholderia pseudomallei* on Gram stain.



Figure 2: *Burkholderia pseudomallei* on MacConkey agar.

Laboratory findings included: fasting blood glucose: 264 mg/dL; postprandial blood glucose: 312 mg/dL; haemoglobin: 14.5 g/dL (normal range: 13–17 g/dL); haematocrit: 38.2% (40%–50%); white blood cell (WBC) count: 14,890/ μ L (4,000–10,000/ μ L); platelet count: 112×10^3 / μ L (150 – 400×10^3 / μ L); procalcitonin: 4.45 ng/mL (normal up to 0.05 ng/mL); serum glutamic oxaloacetic transaminase (SGOT): 69 U/L (normal range: 0–40 U/L); serum glutamic pyruvic transaminase (SGPT): 80 U/L (normal range: 0–40 U/L); bilirubin: 0.49 mg/dL (<1.2 mg/dL); gamma-glutamyl transferase (GGT): 43.4 U/L (normal range: 0–60 U/L); alkaline phosphatase: 104 U/L (normal range: 40–129 U/L); creatinine: 1.8 mg/dL (0.7–1.3 mg/dL); electrolytes: 134/4.1/103. Tropical fever panel (polymerase chain reaction [PCR], blood) was negative, urine routine was normal, chest X-ray was normal, and electrocardiogram (ECG) showed normal sinus rhythm.

The patient was immediately started on intravenous (IV) Zavicefta (IV ceftazidime–avibactam, 2.5 g three times daily) and oral doxycycline 100 mg twice daily, along with antipyretics and supportive treatment. The patient was immediately started on oral hypoglycaemic agents along with insulin, and her blood glucose levels were controlled. Her symptoms started improving gradually. After a few days, her vitals were haemodynamically

stable, and she was discharged with oral antibiotics for a further two weeks. On follow-up in the outpatient department, she was stable with no signs of infection.

Discussion

Melioidosis is often referred to as the 'great mimicker' due to its ability to imitate diseases such as tuberculosis, pneumonia, and other pyogenic infections, which frequently result in misdiagnosis and improper treatment. Even with suitable therapy, the mortality rate in severe cases ranges between 10% and 50%, highlighting the urgent necessity for prompt and precise diagnosis along with effective management.⁷ Diabetes alters key immune mechanisms essential for combating infections, including impairments in leukocyte and neutrophil function, suppression of macrophages and monocytes, and dysfunction of natural killer cells. These immune deficiencies lead to delayed activation and recruitment of immune cells needed to eliminate *B. pseudomallei*, allowing the pathogen to persist and adapt more easily in individuals with compromised immunity due to diabetes.⁴

B. pseudomallei closely resembles *Pseudomonas* species — common laboratory contaminants — which often leads to misidentification in microbiology labs. Due to the relatively low sensitivity of blood and tissue cultures (around 60%), approximately 40% of cases may be initially missed. Delayed diagnosis and difficulties in accurately identifying *B. pseudomallei* in the laboratory contribute significantly to the high mortality associated with melioidosis. In cases of acute bacteraemic melioidosis, the infection can disseminate through the bloodstream, causing abscesses in multiple organs, which can be detected using imaging techniques such as ultrasound or computed tomography (CT) scans.⁸ Despite this, the culture of blood, pus, or other body fluids remains the gold standard for confirming the diagnosis due to its high sensitivity.²

B. pseudomallei exhibits innate resistance to various antibiotic classes, such as aminoglycosides, rifamycins, penicillins, cephalosporins, and cationic peptides. The intensive phase of treatment typically involves IV administration of ceftazidime or a carbapenem for 10 to 14 days. This is followed by an eradication phase using oral trimethoprim–sulfamethoxazole for a minimum duration of three months, which may also be employed as a preventive measure.³

Conclusion

The cases that have been reported in India are sporadic and inconsistent, as there is limited awareness about the presentation and diagnosis among clinicians, as well as a scarcity of appropriate laboratory support. There are numerous reasons for the underdiagnosis of melioidosis.⁸ As it can mimic other conditions, it is commonly misdiagnosed. There is an increase in the prevalence of *Burkholderia* infection, suggesting its possible rise as a major public health issue, further intensified by the rising rates of diabetes, which could contribute to a greater overall disease burden.⁵

Nitin Rathod, Andrea Janice Fonseca, Snehal Sadanandan, Priyal Shah. Uncommon Presentation of Cervical Abscess Causing Melioidosis due to *Burkholderia pseudomallei* Infection in a Patient with Uncontrolled Diabetes Mellitus: A Case Report. MMJ. 2026, June. Vol 3 (2).

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References

1. Purushotham P, Mohanty S, Chappity P, et al. Identification and Characterization of *Burkholderia pseudomallei* from Localized Pyogenic Infections in Eastern India: A Clinico-Microbiological Study. *Am J Trop Med Hyg*. 2021;104(4):1252–9.
2. Deb S, Singh M, Choudhary J, et al. A Rare Case of a Knee Septic Arthritis by *Burkholderia pseudomallei* : A Case Report from a Tertiary Care Hospital of Andaman and Nicobar Island. *J Orthop Case Rep*. 2021;11(9):20–3.
3. Phillips ED, Garcia EC. *Burkholderia pseudomallei*. *Trends Microbiol*. 2024;32(1):105–6.
4. Uthaya Kumar A, Ahmad Zan M, Ng CL, et al. Diabetes and Infectious Diseases with a Focus on Melioidosis. *Curr Microbiol*. 2024;81(7):208.
5. Kumari S, Banu M, Ramanatha K, et al. Are *Burkholderia* Emerging Pathogens in patients with underlying morbidity: A case series. *Heliyon*. 2024;10(12):e33283.
6. Birnie E, Biemond JJ, Wiersinga WJ. Drivers of melioidosis endemicity: epidemiological transition, zoonosis, and climate change. *Curr Opin Infect Dis*. 2022;35(3):196–204.
7. Vijayakumar D, Vikraman H, Baby P, et al. Clinical and Microbiological Profile of Melioidosis in a Tertiary Care Hospital in Kerala, India. *Am J Trop Med Hyg*. 2025;112(4):849–53.
8. Mohapatra PR, Mishra B. Burden of melioidosis in India and South Asia: Challenges and ways forward. *Lancet Reg Health Southeast Asia*. 2022;2:100004.

Reconstruction of Synchronous Bilateral Buccal Mucosa Defects with a Single Free Anterolateral Thigh Flap with Intraoral Anastomosis

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Abstract:

Presence of synchronous primary tumours and oral potentially malignant lesions in the oral cavity over the bilateral buccal mucosa warrants surgical treatment and creates synchronous defects. Functional rehabilitation of such defects is challenging and requires free tissue transfer to reconstruct the bilateral buccal mucosa defects created from simultaneous resection of such lesions. Advances in perforator flap concepts now allow the harvesting of multiple skin islands from a single donor area without sacrificing the donor vessels. The vascular anatomy of the free anterolateral thigh (FALT) flap is variable, with several variations seen due to the presence of multiple musculocutaneous perforators, many of which originate from vessels other than the lateral circumflex artery, allowing for two separate skin paddles to be harvested from a single donor site. This case report presents a modified FALT flap harvesting technique and its application in reconstructing such extensive defects with the use of an intraoral anastomosis technique.

Key words: Anterolateral Thigh Flap, Bilateral Mucosal Defect, Intraoral Anastomosis.

Introduction

Free flaps have become a cornerstone in reconstructing oral malignancy defects, offering a broad spectrum of options, including chimeric and multiple free flaps. These advancements enable the reconstruction of complex defects with excellent aesthetic and functional outcomes.

However, certain practical challenges remain. The presence of synchronous primary tumours in the oral cavity is seen in 1%-11% of patients due to field cancerisation, and surgical treatment of these lesions creates synchronous defects with intervening normal tissue, which complicates the use of a single flap.^{1,2} Bilateral buccal mucosa defects often necessitate two separate flaps. Preoperative planning for such

defects can be particularly challenging, especially with reduced mouth opening seen in this group of patients due to the disease or pre-existing oral submucous fibrosis. Utilising two free flaps increases donor site morbidity, potentially requiring skin grafting. This also increases operative time and involves challenges in preoperative counselling. Another challenge arises with potentially malignant lesions, such as erythroleucoplakia, where treatment warrants the achievement of clear margins but does not necessitate neck dissection.³ Using a free flap in these cases requires neck exploration and tunnelling for the vascular pedicle, adding risks and complications. This case study explores these scenarios and highlights how expanding the limits of microvascular reconstruction can address them effectively.

Case Report

A male patient in his 50s, diagnosed preoperatively via incisional biopsy with right buccal mucosa squamous cell carcinoma underwent planned bite margin resection, including marginal mandibulectomy and upper alveolectomy. Preoperative mouth opening was less than 1 cm. During examination under anaesthesia, a superficial lesion was identified on the left buccal mucosa. An additional wide local excision of the left buccal mucosa was performed with adequate margins.

A frozen section confirmed moderate dysplasia, eliminating the need for a formal neck dissection. The left-sided defect measured 6 × 4 cm, leaving only skin and subcutaneous tissues (Figure 1).



Figure 1: Postextirpation defect over the left buccal mucosa following excision of the mucosal lesion.

As per the initial plan, the left anterolateral thigh (ALT) flap territory was explored via a non-committal incision. Two cutaneous perforators were identified — one from the oblique branch and one from the descending branch of the lateral circumflex femoral artery (LCFA) (Figure 2). Two separate skin islands were harvested on each of these perforators from the same donor area.



Figure 2: Harvest of free anterolateral thigh flap (FALT) with two cutaneous perforators — one from the oblique branch and one from the descending branch of the lateral circumflex femoral artery (LCFA) — subsequently separated and used individually.

The larger island, based on the oblique branch, was used to reconstruct the right-sided bite defect and was anastomosed to vessels in the right neck. A smaller paddle, measuring 6 × 5 cm, was harvested from the distal perforator. The pedicle was divided at its junction with the descending branch of the LCFA, resulting in a pedicle length of only 6 cm.

The distal continuation of the facial artery and vein within the left-sided intraoral defect was identified and used for microvascular anastomosis (Figures 3 and 4). The donor site was closed primarily. The postoperative period was uneventful, with timely initiation of oral intake and smooth suture removal. At the 6-month follow-up, the patient showed excellent cosmetic outcomes and significant improvement in mouth opening (Figure 5). No adjuvant therapy was required as final clinical staging for the left buccal mucosa was T2N0 as per the American Joint Committee on Cancer (AJCC) 8th Edition.



Figure 3: Inset of a smaller skin paddle of the free anterolateral thigh flap (FALT) from the distal perforator — descending branch of the lateral circumflex femoral artery (LCFA) — with intraoral anastomosis.



Figure 4: Postoperative appearance of the patient demonstrating the absence of neck incision on the left side.



Figure 5: Postoperative result at 6 months follow-up.

Discussion

Bilateral buccal mucosa defects following resection of synchronous oral lesions may require either two flaps or a chimeric configuration. Advances in perforator flap concepts now allow the harvesting of multiple skin islands from a single donor area without sacrificing the donor vessels.⁴ For example, the LCFA axis supports harvesting perforators from various branches: transverse (tensor fascia lata flap), oblique or descending (ALT flap), or rectus muscle branch (anteromedial thigh [AMT] flap).

Harvesting multiple flaps from a single donor site minimises morbidity and optimises outcomes while allowing primary closure. Potentially malignant lesions and conditions, such as leucoplakia, erythroplakia, oral submucous fibrosis, etc., have often been reconstructed using suboptimal methods like primary closure, skin grafting, or nasolabial flaps, which can lead to functional limitations such as trismus and cosmetic deformities. Full-thickness flaps are essential to prevent such complications, as local nasolabial flaps often fail to provide sufficient width to fill these defects.⁵

Microvascular free flaps, such as the radial forearm flap, medial sural artery flap, or distal ALT flap, offer the appropriate thickness and adaptability required. Intraoral microvascular anastomosis eliminates the need for unnecessary neck dissection and tunnelling, simplifying the procedure and reducing complications.⁶

The use of smaller, thinner microvascular free flaps with intraoral vascular anastomosis for premalignant lesions is gaining acceptance. The field of microsurgery is pushing boundaries, addressing challenges of depth, precision, and spatial limitations through perforator-based super microsurgery.

Conclusion

- Single donor site dual flap harvesting: Rebuilding bilateral oral defects without increasing donor site morbidity or needing multiple donor sites is possible by using two skin paddles from the ALT flap territory, which are based on different perforators.
- Intraoral microvascular anastomosis: When nodal dissection is not required, microvascular anastomosis within the oral cavity reduces surgical complexity and related risks by doing away with the need for neck dissection and pedicle tunnelling.
- Better results in premalignant lesions: Full-thickness microvascular free flaps, as opposed to more conventional techniques like skin grafts or nasolabial flaps, offer better functional and cosmetic results, particularly in premalignant conditions with field cancerisation or poor mouth opening.
- Problems with synchronous oral lesions: When defects are separated by healthy mucosa, field cancerisation can lead to synchronous lesions that need intricate reconstructions.

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DOI: <https://doi.org/10.62830/mmj3-02-24>

References

1. Gluckman JL. Synchronous Multiple Primary Lesions of the Upper Aerodigestive System. *Arch Otolaryngol.* 1979;105(10):597–8.
2. Peralta-Mamani M, Terrero-Pérez Á, Tucunduva RMA, *et al.* Occurrence of field cancerization in clinically normal oral mucosa: A systematic review and meta-analysis. *Arch Oral Biol.* 2022;143:105544.
3. Warnakulasuriya S. Oral potentially malignant disorders: A comprehensive review on clinical aspects and management. *Oral Oncol.* 2020;102:104550.
4. Huang JJ, Wallace C, Lin JY, *et al.* Two small flaps from one anterolateral thigh donor site for bilateral buccal mucosa reconstruction after release of submucous fibrosis and/or contracture. *J Plast Reconstr Aesthet Surg.* 2010;63(3):440–5.
5. Lin PY, Chen CC, Kuo YR, *et al.* Simultaneous reconstruction of head and neck defects following tumor resection and trismus release with a single anterolateral thigh donor site utilizing a lateral approach to flap harvest. *Microsurgery.* 2012;32(4):289–95.
6. Brandtner C, Bürger H, Hachleitner J, *et al.* The intraoral anastomosing technique in reconstructive surgery of the face – a consecutive case series of 70 patients. *J Craniomaxillofac Surg.* 2015;43(9):1763–8.

A Case Report of Metallosis-Related Aseptic Loosening of a Primary Total Knee Arthroplasty Implant Managed with Revision Total Knee Arthroplasty

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Abstract:

Metallosis is a rare but serious long-term complication following total knee arthroplasty (TKA), most commonly resulting from polyethylene insert wear that leads to unintended metal-on-metal articulation and subsequent metallic debris deposition. We present the case of a 70-year-old female who developed progressive pain, stiffness, and instability in her right knee, 19 years after undergoing primary TKA. Radiographic evaluation revealed loosening of both femoral and tibial components, while laboratory investigations ruled out infection. Intraoperatively, extensive metallosis was identified with diffuse, black-stained synovium, metallic debris accumulation, and complete wear of the medial polyethylene insert exposing the tibial tray. Both prosthetic components were found to be loose, accompanied by collateral ligament laxity. Thorough synovectomy and debridement were performed, followed by revision TKA using a constrained condylar knee prosthesis (Zimmer Rotating Hinge Knee [RHK]). Metallosis-associated inflammatory reaction can result in osteolysis, soft-tissue destruction, and eventual implant failure, making early diagnosis and timely intervention essential despite the non-specific clinical presentation. Revision arthroplasty with appropriately constrained implants can achieve satisfactory outcomes in cases associated with instability and severe component loosening.

Key words: Metallosis, Total Knee Arthroplasty, Aseptic Loosening, Polyethylene Wear, Revision Total Knee Arthroplasty, Rotating Hinge Knee.

Introduction

Metallosis is an uncommon but recognised complication following total knee arthroplasty (TKA), characterised by the deposition of metallic debris in peri-prosthetic tissues due to abnormal metal-on-metal articulation.¹ This phenomenon is most commonly associated with polyethylene wear or failure, leading to exposure of metallic components and subsequent abrasive interaction between prosthetic surfaces. The resulting metallic debris incites a chronic inflammatory response, termed metal-induced synovitis,

which may progress to osteolysis, soft tissue destruction, and eventual implant loosening.^{2,3}

Although metallosis is more frequently reported in total hip arthroplasty, its occurrence in TKA remains relatively rare, with limited cases described in the literature. The diagnosis is often delayed due to its insidious onset and nonspecific clinical presentation, including pain, swelling, and reduced joint function. Radiographic findings may suggest implant loosening or osteolysis, but a definitive diagnosis is typically established intraoperatively.

In this report, we present a rare case of metallosis-induced aseptic loosening in a long-standing primary TKA, highlighting its clinical presentation, intraoperative findings, and management with revision arthroplasty.

Case Report

A 70-year-old female patient presented with complaints of progressively increasing pain, stiffness, and difficulty in ambulation involving the right knee for one year. She had undergone a primary right TKA in January 2006 and had remained asymptomatic for several years postoperatively.

On clinical examination, the patient exhibited a painful range of motion with reduced flexion, joint line tenderness, and signs suggestive of instability. There was no history of trauma, fever, or systemic symptoms suggestive of infection.

Radiographic evaluation revealed features consistent with loosening of both femoral and tibial components, including radiolucent lines and possible osteolysis. Laboratory investigations, including inflammatory markers, were within normal limits, thereby reducing the likelihood of peri-prosthetic joint infection.

Based on clinical and radiological findings, a diagnosis of aseptic loosening of the TKA implant was made, and the patient was planned for revision arthroplasty.

Intraoperative findings

Intraoperatively, there was extensive black discolouration of synovial and peri-prosthetic tissues, characteristic of metallosis. The synovium appeared markedly thickened and inflamed, with visible metallic debris deposits. There was complete wear of the medial half of the polyethylene insert, exposing the underlying metal tibial tray, resulting in direct metal-on-metal articulation.

Both femoral and tibial components were found to be loose. Additionally, there was associated collateral ligament laxity, contributing to joint instability (Figures 1 and 2).

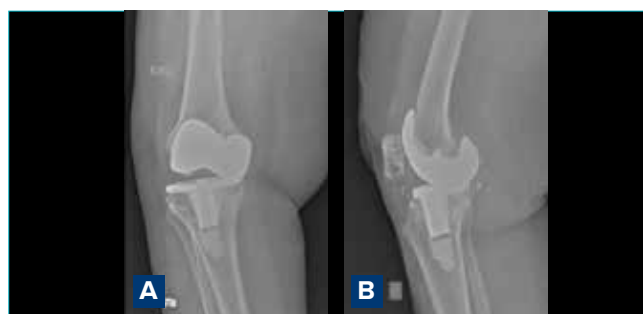


Figure 1A and B: Preoperative radiograph showing laxity and loosening of the implant.

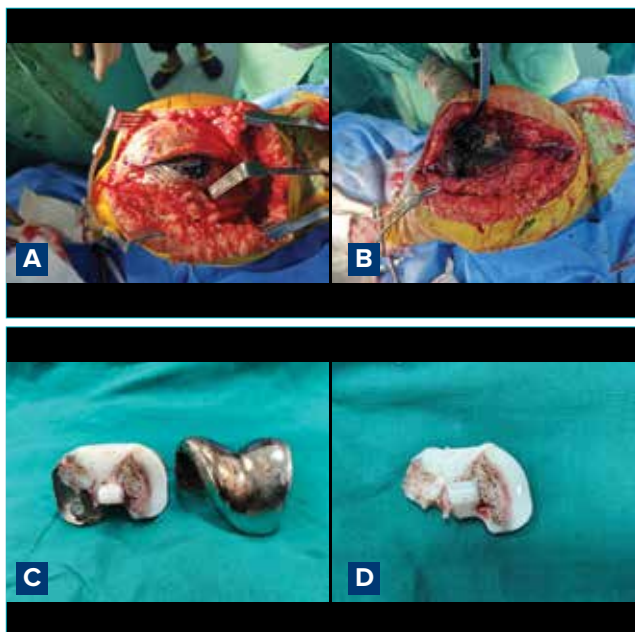


Figure 2A–D: Intraoperative finding of metallosis, polyethylene wear exposing the metal surface.

A thorough synovectomy and debridement of metallosis tissue were performed. The failed components were removed, and revision was carried out using a constrained condylar knee prosthesis (Zimmer Rotating Hinge Knee [RHK]), to address the ligamentous instability (Figures 3 and 4).⁴

Postoperative recovery was uneventful, and the patient demonstrated improved pain relief and functional outcome on follow-up.

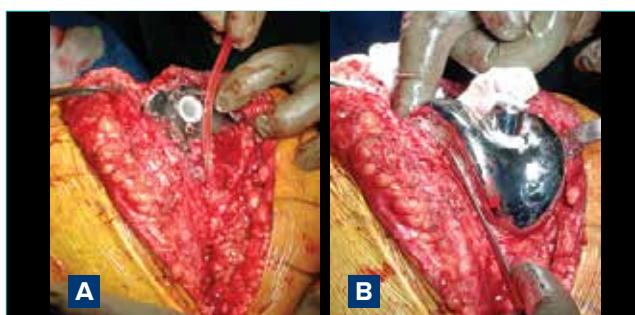


Figure 3A and B: Revision using a constrained condylar knee prosthesis (Zimmer Rotating Hinge Knee [RHK]).



Figure 4: Postoperative radiograph.

Discussion

Metallosis is a rare complication of TKA due to metal-on-metal contact secondary to polyethylene wear.⁵ It is caused by the infiltration and accumulation of metallic debris into the peri-prosthetic structures, deriving from friction between metallic prosthetic components.⁶ The metallic debris induce a massive release of cytokines from inflammatory cells, causing osteolysis and loosening of the prosthesis.^{7–9} Over time, extensive soft tissue involvement may also compromise ligamentous structures, further exacerbating joint instability.

Several risk factors have been implicated in the development of metallosis in TKA, including:¹⁰

- Polyethylene wear or fracture
- Malalignment of components
- Instability leading to abnormal loading
- Use of thinner polyethylene inserts
- Long implant survival duration

Clinically, patients typically present with pain, swelling, reduced range of motion, and sometimes instability. However, these symptoms are non-specific and overlap with other causes of TKA failure, making early diagnosis challenging.¹⁰

Radiographically, findings may include:¹⁰

- Radiolucent lines indicating loosening
- Osteolytic defects
- Component malposition
- "Metal-line sign" (a thin rim of linear density outlining the joint capsule) and the "Cloud sign" (amorphous cloudy densities within the soft tissues) in X-ray image.¹⁰

Advanced imaging modalities such as computed tomography (CT) or magnetic resonance imaging (MRI) may help detect soft tissue involvement, but definitive diagnosis is often made intraoperatively, as seen in our case.

Metallosis is more common in hip than in knee arthroplasty.¹⁰ In the present case, prolonged implant survival (approximately 19 years) likely contributed to progressive polyethylene wear, eventually leading to exposure of the tibial tray and subsequent metallosis. It highlights the importance of lifelong follow-up for TKA patients to detect polyethylene wear before it reaches the metal-on-metal stage.¹

The choice of a constrained or hinged implant is often a mechanical necessity. The chronic inflammatory environment associated with metallosis can compromise the collateral ligaments, making standard semi-constrained liners insufficient.⁴ Furthermore, the extensive osteolysis caused by cytokine-mediated bone resorption often leaves significant voids that require modular revision systems.³ Early diagnosis and aggressive synovectomy are critical to prevent "pseudotumour" formation and systemic toxicity from metal ion release.¹¹

Conclusion

Metallosis following TKA is an uncommon but potentially serious complication, most often resulting from polyethylene wear leading to unintended metal-on-metal articulation. Early recognition is crucial, as progressive metal debris-induced inflammation can cause osteolysis, implant loosening, and extensive soft-tissue damage. Timely revision surgery with appropriate implant selection can lead to favourable clinical outcomes.

Debasish Sarkar, Pradeep Bhosale. A Case Report of Metallosis-Related Aseptic Loosening of a Primary Total Knee Arthroplasty Implant Managed with Revision Total Knee Arthroplasty. MMJ. 2026, June. Vol 3 (2).

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References

1. Koonen L, Duit-van den Belt L, Veenstra K, *et al.* Late Onset Metallosis after Revision Total Knee Arthroplasty with Metal-Backed Patellar Component In Situ. *Arthroplast Today*. 2020;6(2):262–6.
2. Romesburg JW, Wasserman PL, Schoppe CH. Metallosis and Metal-Induced Synovitis Following Total Knee Arthroplasty: Review of Radiographic and CT Findings. *J Radiol Case Rep*. 2010;4(9):7–17.
3. Zhong Q, Pan X, Chen Y, *et al.* Prosthetic Metals: Release, Metabolism and Toxicity. *Int J Nanomedicine*. 2024;19:5245–67.
4. Gopi J, Harafan A, Roshan SH, *et al.* Severe Metallosis-Induced Osteolysis and Polyethylene Liner Dissociation as a Cause of Total Knee Replacement Failure. *J Orthop Case Rep*. 2026;16(1):208–11.
5. Rader CP, Löhr J, Wittmann R, *et al.* Results of total knee arthroplasty with a metal-backed patellar component: a 6-year follow-up study. *J Arthroplasty*. 1996;11(8):923–30.
6. Salem KH, Lindner N, Tingart M, *et al.* Severe metallosis-related osteolysis as a cause of failure after total knee replacement. *J Clin Orthop Trauma*. 2020;11(1):165–70.
7. Schiavone Panni A, Vasso M, Cerciello S, *et al.* Metallosis following knee arthroplasty: a histological and immunohistochemical study. *Int J Immunopathol Pharmacol*. 2011;24(3):711c19.
8. Burge AJ, Gold SL, Lurie B, *et al.* MR Imaging of Adverse Local Tissue Reactions around Rejuvenate Modular Dual-Taper Stems. *Radiology*. 2015;277(1):142–50.
9. Dapunt U, Giese T, Lasitschka F, *et al.* On the inflammatory response in metal-on-metal implants. *J Transl Med*. 2014;12:74.
10. Oliveira CA, Candelária IS, Oliveira PB, *et al.* Metallosis: A diagnosis not only in patients with metal-on-metal prostheses. *Eur J Radiol Open*. 2014;2:3–6.
11. Bogdonoff YM, Amirouche F. Addressing metallosis in knee arthroplasty: From diagnostic challenges to innovative treatments. *World J Orthop*. 2024;15(5):386–9.

Elastofibroma Dorsi in a Patient with Right Breast Carcinoma: A Potential Diagnostic Pitfall

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Abstract:

Elastofibroma dorsi is a rare benign soft tissue pseudotumour typically located in the infrascapular region deep to the serratus anterior and latissimus dorsi muscles. It is often detected incidentally on cross-sectional imaging and is usually asymptomatic. However, in oncological patients, it may mimic metastatic soft tissue disease and therefore represent a significant diagnostic pitfall. We report the case of an 80-year-old female with known right breast carcinoma who underwent staging contrast-enhanced computed tomography (CT) of the thorax. Imaging demonstrated an ill-defined, non-encapsulated lenticular soft tissue lesion in the right infrascapular region, deep to the latissimus dorsi and serratus anterior muscles, showing characteristic internal linear fat streaks and a striated internal architecture without calcification, necrosis, or adjacent bone destruction. Based on its typical morphology, location, and internal fat attenuation, a confident diagnosis of elastofibroma dorsi was established without the need for biopsy. This case emphasises the importance of recognising the characteristic CT and magnetic resonance imaging (MRI) appearances of elastofibroma dorsi in oncologic imaging to avoid misinterpretation as metastatic disease, thereby preventing erroneous upstaging and unnecessary invasive procedures.

Key words: Elastofibroma Dorsi, Breast Carcinoma, Infrascapular Mass, Soft Tissue Pseudotumour, Diagnostic Pitfall.

Introduction

Elastofibroma dorsi is a rare, benign soft tissue pseudotumour that typically arises in the infrascapular region, deep to the serratus anterior and latissimus dorsi muscles.¹ It is most commonly observed in elderly individuals, with a distinct female predominance. The lesion is widely considered reactive rather than truly neoplastic in origin.²

The proposed pathogenesis involves repetitive mechanical friction between the inferior pole of the scapula and the posterior thoracic wall, leading to fibroelastic tissue proliferation interspersed with fatty streaks.^{1,2} This explains both the characteristic

infrascapular location and the internal architectural pattern observed on imaging studies. A hereditary predisposition has also been suggested in a minority of cases.³

Despite its benign nature and indolent clinical course, elastofibroma dorsi assumes considerable importance in oncologic imaging. In patients with known malignancies such as breast carcinoma, the lesion may mimic soft tissue metastasis due to its chest wall location and soft tissue density on computed tomography (CT).^{4,5} Accurate recognition is therefore crucial to prevent misinterpretation and unnecessary intervention.

Case Report

An 80-year-old female, a known case of right breast carcinoma, was referred for staging evaluation. Contrast-enhanced CT of the thorax revealed an ill-defined, non-encapsulated soft tissue lesion in the right infrascapular region.⁶

The lesion was located deep to the latissimus dorsi muscle and serratus anterior muscle, and superficial to the ribs and intercostal muscles. Its anatomical relations were as follows:

- Anterior relation: Serratus anterior muscle
- Posterior relation: Latissimus dorsi muscle
- Medial relation: Rib cage and intercostal muscles
- Lateral relation: Subcutaneous fat plane

The lesion demonstrated a lenticular configuration with poorly defined margins and showed internal linear streaks of fat attenuation within a soft tissue matrix, producing a characteristic “striated” appearance.^{6,7} No calcification, necrosis, or adjacent bony erosion was noted. Given its typical location, morphology, and internal fat streaks, a diagnosis of elastofibroma dorsi was favoured over metastatic disease.

Discussion

Elastofibroma dorsi is a benign pseudotumour with characteristic imaging features that allow confident diagnosis in the majority of cases.⁷ It is most commonly located in the infrascapular region, typically unilateral, though it may be bilateral in up to 60% of cases when both sides are systematically imaged.⁴ On CT, the lesion appears as a poorly defined soft tissue mass with attenuation similar to skeletal muscle, interspersed with linear fat densities, reflecting its internal fibroelastic architecture.^{6,7} On magnetic resonance imaging (MRI), it demonstrates alternating fibrous (low signal intensity) and fatty (high signal intensity) components on both T1- and T2-weighted sequences, producing a layered or striated appearance.⁸

These imaging features directly reflect the histological composition of the lesion:

- Fat streaks: Entrapped adipose tissue within fibrous proliferation
- Poor margins: Reactive, non-encapsulated growth pattern
- Typical location: Repetitive scapulothoracic friction leading to fibroelastic hyperproliferation

Histologically, the lesion is composed of abnormal elastic fibres embedded in a collagenous stroma with interspersed adipose tissue.² Immunohistochemically, it demonstrates a non-neoplastic, reactive phenotype.⁹

In oncologic patients, particularly those with breast carcinoma, this lesion may be misinterpreted as a soft tissue metastasis owing to its chest wall location and soft tissue density.^{5,10} However, metastases can be distinguished by the following features:

- More aggressive or infiltrative margins
- Possible adjacent bone destruction or cortical erosion
- Absence of internal fat streaks
- Variable or intense contrast enhancement without fat signal

Recognition of elastofibroma dorsi is essential to avoid unnecessary biopsy, incorrect oncological staging, and overtreatment.^{11,12} When imaging features are pathognomonic, no further investigation or intervention is required. Surgical excision is reserved for symptomatic cases only.

Conclusion

Elastofibroma dorsi is a benign entity with characteristic imaging features that can be confidently diagnosed on cross-sectional CT or MRI. In patients with breast carcinoma undergoing staging evaluation, awareness of this entity is essential to avoid misinterpretation as metastatic disease.^{4,5} Accurate identification ensures appropriate oncological staging and prevents unnecessary diagnostic or therapeutic interventions.

Learning points

- Elastofibroma dorsi is a benign pseudotumour with a characteristic infrascapular location, deep to serratus anterior and latissimus dorsi
- Internal fat streaks (striated appearance) on CT are the key diagnostic imaging feature
- Non-encapsulated, poorly defined margins reflect its reactive, non-neoplastic nature
- Common in elderly females; can be bilateral in up to 60% of cases
- An important mimicker of soft tissue metastasis in oncologic patients
- Correct identification prevents erroneous upstaging and unnecessary biopsy

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References

1. Jarvi OH, Saxen AE. Elastofibroma dorsi. *Acta Pathol Microbiol Scand Suppl.* 1961;51(Suppl 144):83–4.
2. Giebel GD, Bierhoff E, Vogel J. Elastofibroma and pre-elastofibroma: a biopsy and autopsy study. *Eur J Surg Oncol.* 1996;22(1):93–6.
3. Muramatsu K, Ihara K, Hashimoto T, et al. Elastofibroma dorsi: diagnosis and treatment. *J Shoulder Elbow Surg.* 2007;16(5):591–5.
4. Brandser EA, Goree JC, El-Khoury GY. Elastofibroma dorsi: prevalence in an elderly patient population as revealed by CT. *AJR Am J Roentgenol.* 1998;171(4):977–80.
5. Chandrashekhara SH, Gamanagatti S. Imaging spectrum of elastofibroma dorsi: experience from a tertiary care center. *J Clin Imaging Sci.* 2015;5:28.
6. Kransdorf MJ, Meis JM, Montgomery E. Elastofibroma: MR and CT appearance with radiologic-pathologic correlation. *AJR Am J Roentgenol.* 1992;159(3):575–9.
7. Battaglia M, Vanel D, Pollastri P, et al. Imaging patterns in elastofibroma dorsi. *Eur J Radiol.* 2009;72(1):16–21.
8. Kransdorf MJ, Murphey MD. Imaging of Soft Tissue Tumors. 3rd Edition. Philadelphia: Lippincott Williams & Wilkins; 2014.
9. Nishio J, Iwasaki H, Ohjimi Y, et al. Elastofibroma dorsi: clinicopathological, cytogenetic and immunohistochemical analyses. *Pathol Int.* 2002;52(9):564–70.
10. Daigeler A, Vogt PM, Busch K, et al. Elastofibroma dorsi—differential diagnosis in chest wall tumours. *World J Surg Oncol.* 2007;5:15.
11. Kumar R, Madan R, Gupta A. Elastofibroma dorsi: a rare benign pseudotumour with characteristic imaging findings. *Indian J Radiol Imaging.* 2013;23(2):149–51.
12. Rao S, Pai MR. Elastofibroma dorsi: a clinicopathological study. *Indian J Pathol Microbiol.* 2008;51(3):379–81.

Total Skin Electron Therapy: Basic Technical Aspects for Radiation Therapists

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Abstract:

Total skin electron therapy (TSET) is a radiotherapy technique used to treat cutaneous lymphomas like mycosis fungoides. The aim was to analyse the treatment outcome and technical aspects of implementation. TSET is a specialised radiotherapy technique used to treat cutaneous T-cell lymphoma (CTCL) and other skin malignancies. It delivers a uniform dose of low-energy electrons (4–10 MeV) to the entire skin surface, minimising dose to underlying tissues. The treatment involves positioning the patient (often standing or lying down) at a distance from the linear accelerator to achieve large field size (36 × 36cm). Multiple beam angles are used to ensure uniform dose distribution. Dosimetry is complex, with careful planning required to achieve optimal coverage and minimise hot/cold spots. Common doses range from 30–40 Gy, delivered in fractions over several weeks. Treatment duration is typically several minutes per session. The goal of TSET is to provide effective palliation and disease control for patients with extensive skin involvement. It can help alleviate symptoms like itching, redness, and skin lesions. Common side effects include skin erythema, dryness, and potential temporary hair loss. Careful patient setup and monitoring are crucial for treatment success. TSET is often used in conjunction with other treatments like topical therapies or systemic agents. For patients with localised disease, other radiotherapy techniques like superficial X-rays or electron beams may be more suitable. However, TSET's ability to treat large areas makes it a valuable option for patients with widespread skin involvement. Patient selection is key for TSET. Those with early-stage CTCL or other skin cancers may benefit from localised treatments. Patients with more extensive disease or those who have failed other therapies may be candidates for TSET.

Key words: Mycosis Fungoides, Electron Radiation, Total Skin Electron Irradiation, Basic Technical Aspects.

Introduction

Total skin electron therapy (TSET) is a specialised radiation therapy technique used for treating cutaneous T-cell lymphoma (CTCL), specifically mycosis fungoides.¹⁻³ It aims to deliver a uniform dose of radiation to the entire skin surface while minimising exposure to underlying tissues and organs. Mycosis fungoides is the most common type of CTCL.³ TSET was developed at Stanford initially in 1960.¹ A four-field technique was used, which was later modified to a six-field technique.^{1,2}

Case Report

In 2014, we retrospectively reported one patient treated with TSET. The case involved a 53-year-old man with a known case of CTCL (mycosis fungoides) who presented with generalised lichenoid dermatitis, which later progressed to ulcerated nodules (Figure 1). The patient underwent a skin punch biopsy and immunochemistry. Microscopic examination revealed a completely eroded epidermis with overlying crusted exudate and marked irregular acanthosis, with apoptotic cells noted at all levels of the epidermis. For treatment, the

prescribed dose was 30 Gy in 20 fractions using 6 MeV high-dose total electron (HDTe) mode with a modified six-field technique. Multiple beams were employed to achieve a uniform dose distribution around the patient (Table 1).

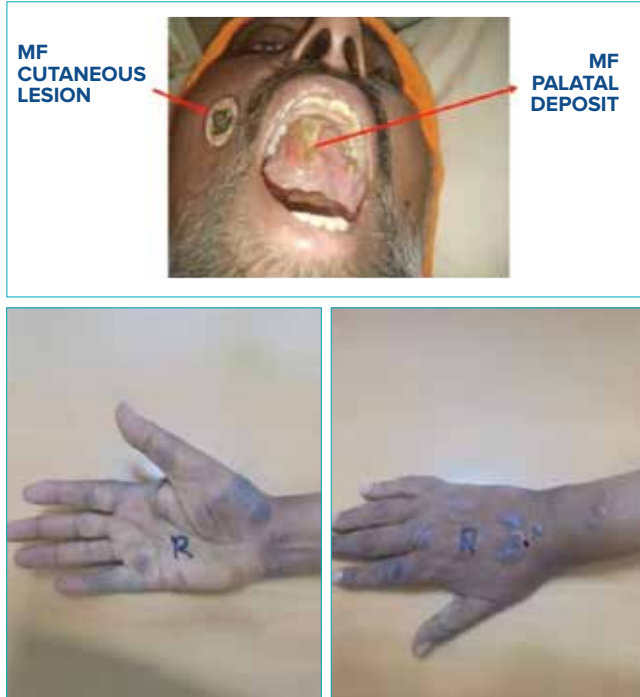


Figure 1: Clinical pictures of patient with mycosis fungoides.
Abbreviation: MF: Mycosis Fungoides.

Patient	Age/Sex	Diagnosis	Dose (Gy)/ Fraction
1	53 y/M	CTCL, mycosis fungoides	30 Gy/20#

Table 1: Dose, fractionation, and number of patients treated.
Abbreviations: CTCL: Cutaneous T-cell Lymphoma; M: Male; y: Year.

Prescription and treatment delivery

The patient was treated with TSET using a Varian Trilogy Linear Accelerator in 6 MeV high-dose electron mode, with a prescribed dose of 30 Gy delivered over 20 fractions.

First, the patient's skin was marked. The patient stood on a rotating platform at a source-to-skin (SSD) distance of 380 cm, and the frame position on the floor was marked. When positioned on the frame, the central axis was verified to pass through the patient's midline both vertically and horizontally at the level of the umbilicus, after which the patient was adjusted on the frame.

A modified six-field Stanford technique was employed using a 6 MeV modern linear accelerator in HDTe mode (Figure 2).¹² The patient stood on the TSET frame at a standard distance of 380 cm from the linear accelerator (LINAC) head. A 5 mm Perspex sheet was placed in front of the patient to attenuate and scatter the incident electrons. Dual-angle six fields were delivered with two gantry angles: 72° above and 108° below during each treatment cycle. Six treatment positions were used to maximise skin exposure and improve dose.

- Day 1: Anteroposterior (AP), right posterior oblique (RPO), left posterior oblique (LPO)
- Day 2: Posteroanterior (PA), right anterior oblique (RAO), left anterior oblique (LAO)

Following completion of 30 Gy in 20 fractions, a boost dose of 20 Gy in 10 fractions was delivered to self-shielded regions such as the soles, scalp, and perineum.

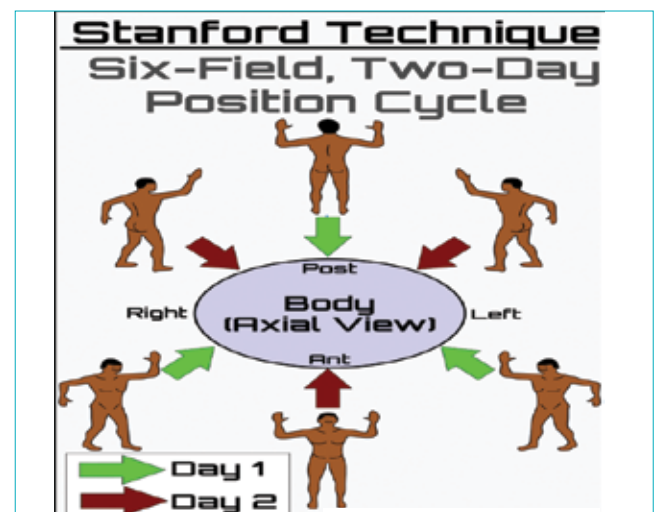


Figure 2: Clinical sketch of six treatment positions used for delivering total skin electron beam therapy (TSET).
Abbreviations: Ant: Anterior; Post: Posterior.

Discussion

TSET provides superior dose uniformity, ensuring complete exposure of the entire body surface while effectively irradiating self-shielding regions. Acute effects include generalised erythema, itching, oedema, moist desquamation and alopecia. Late effects may involve hyperpigmentation, dry skin, and necrosis of nails. Patient care during TSET should focus on hydration skin moisturisation, wearing light clothing and soft shoes, monitoring for infection, managing brittle or slow-growing nails, preventing hyperuricaemia, sun avoidance with a hat, weekly blood tests, and

prompt treatment of skin infections in consultation with a dermatologist.

For TSET planning pathways, it is suggested to use a treatment room with a large distance between the scatterer and the patient.²⁻⁵ The patient should be positioned at 2 cm to 7 cm from the scatterer to achieve a generally uniform dose across the treatment area, ensuring adequate dose uniformity over both the height and width of the patient. The geometric arrangement and patient positioning for the rotary-dual technique are illustrated in Figure 3.

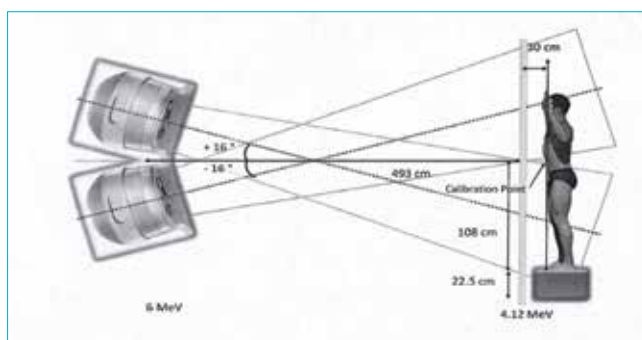


Figure 3: Patient setup and geometric conditions of the rotary-dual technique.

Conclusion

TSET is an effective and specialised radiotherapy technique for managing extensive cutaneous malignancies, particularly mycosis fungoides. Its ability to deliver a uniform dose to the skin while sparing deeper tissues makes it valuable for symptom relief and disease control. Successful outcomes depend on careful patient selection, precise treatment setup, and accurate dosimetry. Although associated with manageable side effects, appropriate supportive care and monitoring are essential. TSET continues to play a significant role in treating patients with widespread skin involvement.

Priyanka Kumari, Manish Mangal, Anusheel Munshi, Akash Goyal. Total Skin Electron Therapy: Basic Technical Aspects for Radiation Therapists. MMJ. 2026, June. Vol 3 (2).

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References

1. Karzmark CJ. Large-field superficial electron therapy with linear accelerators. *Br J Radiol.* 1964;37:302–5.
2. Piotrowski T, Malicki J. The rotary dual technique for total skin irradiation in the treatment of mycosis fungoides—a description of the applied method. *Rep Pract Oncol Radiother.* 2006;11(1):29–37.
3. Willemze R. Primary cutaneous lymphoma. *Curr Opin Oncol.* 2000;12:419–25.
4. BRAAMS R. Superficial radiation therapy of large skin areas. *Dermatologica.* 1958;117(4):204–14.
5. Kumar PP, Patel IS. Rotation technique for superficial total body electron beam irradiation. *J Natl Med Assoc.* 1978;70(7):507–9.



THE IMAGES

158

Visualisation: Magnetic Resonance Imaging as a Surrogate Marker in Spontaneous Cerebrospinal Fluid Rhinorrhoea – **Mohit Tamakuwala, Pratiksha Sachani, Mitusha verma, Deepak Patkar**

161

Beyond Adenoma: Imaging Clues to Pituitary Involvement in Systemic Sarcoidosis – **Mohit Tamakuwala, Mitusha Verma, Deepak Patkar**

Beyond Direct Leak Visualisation: Magnetic Resonance Imaging as a Surrogate Marker in Spontaneous Cerebrospinal Fluid Rhinorrhoea

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Abstract:

Spontaneous cerebrospinal fluid (CSF) rhinorrhoea is an increasingly recognised clinical entity defined by the leakage of CSF into the nasal cavity in the absence of trauma, surgery, or congenital skull base defects. This condition is strongly associated with idiopathic intracranial hypertension (IIH), particularly in middle-aged, obese women, where chronically elevated or pulsatile intracranial pressure leads to dural thinning and progressive skull base remodelling. We describe the radiological evaluation of a 34-year-old obese female who presented with a two-week history of intermittent, clear, watery nasal discharge from the right nostril, which exacerbated upon bending forward and was associated with a salty taste. This case was selected to underscore the pivotal role of magnetic resonance imaging (MRI) surrogate markers — such as empty sella, optic nerve sheath dilatation, and posterior globe flattening — in the diagnosis of underlying IIH. While high-resolution computed tomography (CT) is excellent for localising osseous defects, MRI and heavily T2-weighted sequences like constructive interference in steady state (CISS) are superior for identifying the markers of raised intracranial pressure. Recognising these features is critical for clinical management, as failure to address the underlying IIH significantly increases the risk of postoperative recurrence. Consequently, an integrated multidisciplinary approach involving both surgical repair and medical management of intracranial pressure is required for optimal patient outcomes. This case report illustrates how advanced cross-sectional imaging provides the necessary diagnostic information to guide these complex therapeutic decisions.

Key words: Spontaneous Cerebrospinal Fluid Rhinorrhoea, Idiopathic Intracranial Hypertension, Magnetic Resonance Imaging Surrogate Markers, Empty Sella, Skull Base Defect, Magnetic Resonance Cisternography.

Introduction

Spontaneous cerebrospinal fluid (CSF) rhinorrhoea is defined as the leakage of CSF into the sinonasal cavity without an identifiable inciting event, such as trauma, surgical intervention, neoplasm, or congenital malformation. Epidemiologically, this condition demonstrates a clear predilection for middle-aged, obese women, a demographic profile that mirrors that of idiopathic intracranial hypertension (IIH).¹

The pathophysiological basis of these spontaneous leaks is increasingly attributed to a chronic state of persistently elevated or pulsatile intracranial pressure. This physiological strain results in progressive dural thinning and gradual bone remodelling of the skull base.² When this process affects highly pneumatized regions, such as the cribriform plate or the sphenoid sinus, it can lead to the formation of focal osseodural defects and subsequent CSF fistulas.

Furthermore, the presence of arachnoid granulations adjacent to the ethmoid and sphenoid sinuses is believed to facilitate focal erosion, thereby predisposing these sites to dehiscence.

Case Report

A 34-year-old obese female presented for neuroimaging evaluation with a two-week history of intermittent, clear, watery discharge from the right nostril. The patient noted that the rhinorrhoea was predominantly elicited by bending forward and was consistently associated with a salty taste.

The clinical history was negative for head trauma, previous sinonasal or neurosurgical procedures, chronic sinusitis, or prior radiation therapy. While the patient reported a history of intermittent headaches, she denied fever, visual disturbances, or symptoms of meningeal irritation. A comprehensive neurological examination was unremarkable. Given the high clinical suspicion of a spontaneous CSF fistula, a diagnostic evaluation was initiated to localise the site of the leak and evaluate for radiological hallmarks of IIH using magnetic resonance imaging (MRI) (Figure 1A–D) and computed tomography (CT) (Figure 2A–C).³

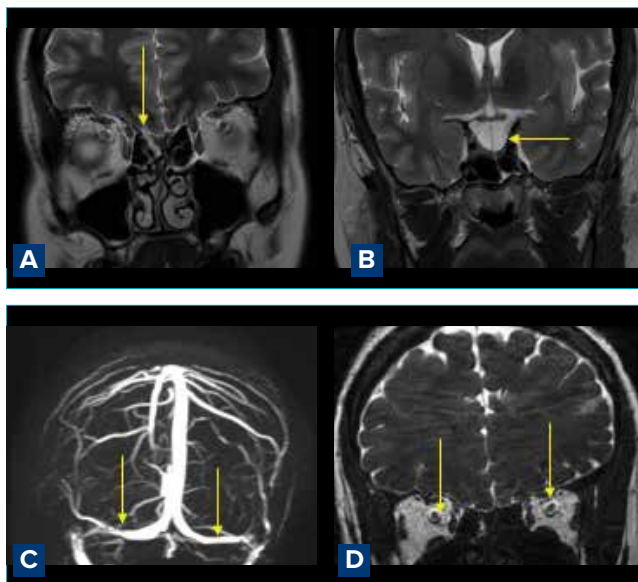


Figure 1: **A.** Magnetic resonance imaging (MRI) demonstrates a cerebrospinal fluid (CSF)-intensity linear tract extending inferior to the right cribriform plate, consistent with a CSF fistula (yellow arrow); **B.** MRI shows a partial empty sella (yellow arrow) and prominent CSF spaces within Meckel's caves, consistent with idiopathic intracranial hypertension (IIH); **C.** Magnetic resonance venography demonstrating stenosis along the lateral aspects of the bilateral transverse sinuses (yellow arrows), without evidence of venous sinus thrombosis; **D.** Prominence of perioptic CSF spaces with vertical tortuosity of the optic nerves.

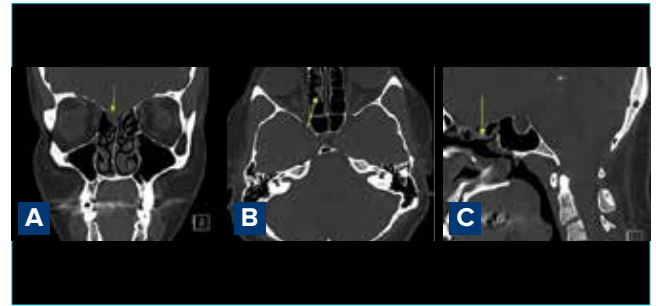


Figure 2A–C: Computed tomography (CT) images demonstrating asymmetrical, slight widening of the right olfactory fossa with a focal defect involving the right cribriform plate, concerning for a cerebrospinal fluid (CSF) fistula (yellow arrows): **A.** Coronal CT image demonstrating subtle widening of the right olfactory fossa with focal thinning of the right cribriform plate (yellow arrow), suspicious for a CSF fistula; **B.** Coronal high-resolution CT image showing focal dehiscence involving the right cribriform plate with adjacent widening of the olfactory fossa (yellow arrow), suggestive of the leak site; **C.** Coronal CT image demonstrating a focal defect along the right cribriform plate with asymmetry of the right olfactory fossa (yellow arrow), concerning for spontaneous CSF fistula.

Discussion

The aetiology of CSF rhinorrhoea is fundamentally categorised into traumatic and non-traumatic origins. While post-traumatic fractures remain the most frequent cause, non-traumatic aetiologies are relatively rare, comprising approximately 3% of all cases.⁴ Within this non-traumatic subset, spontaneous leaks are the most prevalent and are now recognised as a primary radiological manifestation of IIH.

In patients presenting with spontaneous leaks, the prevalence of MRI surrogate markers for IIH ranges from 60% to 80%. These markers include the empty sella sign, optic nerve sheath dilatation, posterior globe flattening, and transverse sinus stenosis.⁵ It is vital for the clinician to recognise that the fistula may act as a natural pressure release valve; consequently, the standard clinical symptoms of IIH may be absent until the defect is surgically closed.

Effective therapeutic management must address both the anatomical breach and the underlying physiological driver. While endoscopic surgical repair is the definitive treatment for the osseodural defect, the high risk of recurrence necessitates medical intervention to lower intracranial pressure. This typically involves aggressive weight reduction and the administration of acetazolamide to decrease CSF production. In the absence of a combined treatment approach, the repaired site remains vulnerable to the same pulsatile forces that caused the initial erosion.

Conclusion

The radiological evaluation of spontaneous CSF rhinorrhoea requires a dual focus: the precise localisation of the osseodural fistula and the systematic assessment for underlying IIH. Identifying surrogate markers such as the empty sella and considering anatomical variations like arachnoid pits and extensive sinus pneumatization are vital for characterising the aetiology of the leak.⁶ Recognising these features is essential for long-term management and the prevention of postoperative recurrence. Ultimately, achieving optimal patient outcomes requires a coordinated multidisciplinary approach that integrates high-resolution imaging, targeted surgical intervention, and medical management of intracranial pressure.

Mohit Tamakuwala, Mitusha Verma, Deepak Patkar. Beyond Direct Leak Visualisation: Magnetic Resonance Imaging as a Surrogate Marker in Spontaneous Cerebrospinal Fluid Rhinorrhoea. MMJ. 2026, June. Vol 3 (2).

DOI: <https://doi.org/10.62830/mmj3-02-30>

References

1. Hiremath SB, Gautam AA, Sasindran V, *et al.* Cerebrospinal fluid rhinorrhea and otorrhea: a multimodality imaging approach. *Diagn Interv Imaging.* 2019;100(1):3–15.
2. Schuknecht B, Simmen D, Briner HR, *et al.* Nontraumatic skull base defects with spontaneous CSF rhinorrhoea and arachnoid herniation: imaging findings and correlation with endoscopic sinus surgery in 27 patients. *AJNR Am J Neuroradiol.* 2008;29(3):542–9.
3. Vemuri NV, Karanam LS, Manchikanti V, *et al.* Imaging review of cerebrospinal fluid leaks. *Indian J Radiol Imaging.* 2017;27(04):441–6.
4. Goodier M, Lubbe D, Andronikou S, *et al.* Spontaneous lateral sphenoid cerebrospinal fluid fistula: MRI diagnosis. *S Afr J Radiol.* 2012;16(1):12–3.
5. Matsubara T, Akutsu H, Tanaka S, *et al.* A case of spontaneous cerebrospinal fluid rhinorrhea: Accurate detection of the leak point by magnetic resonance cisternography. *Surg Neurol Int.* 2014;5:54.
6. Almontasheri A, Al-Qahtani B, Aldajani N. Arachnoid pit and extensive sinus pneumatization as the cause of spontaneous lateral intrasphenoidal encephalocele. *J Clin Imaging Sci.* 2012;2:1.

Beyond Adenoma: Imaging Clues to Pituitary Involvement in Systemic Sarcoidosis

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Abstract:

Neurosarcoidosis is a rare manifestation of systemic sarcoidosis, with involvement of the pituitary–hypothalamic axis being particularly uncommon and often posing a diagnostic challenge due to its close resemblance to other sellar and suprasellar lesions, especially pituitary adenomas. We describe a case of a middle-aged patient who presented with headache, nausea, fever, anorexia, and hypothyroidism. Magnetic resonance imaging (MRI) revealed a large, lobulated sellar and suprasellar lesion that appeared isointense on both T1- and T2-weighted images with heterogeneous enhancement. Notably, there was interval development of significant infundibular stalk thickening measuring 8.5 mm, while the posterior pituitary bright spot was preserved. Further evaluation with multimodality imaging, including positron emission tomography-computed tomography (PET-CT) and ultrasound, demonstrated metabolically active cervical lymphadenopathy, hepatic involvement, and pulmonary ground-glass opacities. These systemic findings, in conjunction with histopathological confirmation, established the diagnosis of neurosarcoidosis. This case underscores the importance of a comprehensive multimodality imaging approach in distinguishing neurosarcoidosis from primary pituitary neoplasms. Recognition of key imaging features such as infundibular stalk thickening, along with evidence of systemic granulomatous disease, is essential for accurate and timely diagnosis, facilitating appropriate management and preventing misdiagnosis.

Key words: Neurosarcoidosis, Pituitary Gland, Infundibulum, Magnetic Resonance Imaging.

Introduction

Sarcoidosis is an idiopathic, multisystem granulomatous disorder characterised by non-caseating granulomas that most commonly affect the lungs and lymphatic system.¹ Central nervous system (CNS) involvement, termed neurosarcoidosis, is histologically present in up to 25% of systemic cases in postmortem studies, though it is clinically symptomatic in only about 5% of patients.¹ Isolated neurosarcoidosis without systemic disease is extremely rare, accounting for less than 1% of cases.^{1,2}

Imaging evidence of CNS involvement is detected in nearly 10% of systemic cases.¹ Magnetic resonance

imaging (MRI) is the modality of choice for assessing parenchymal, leptomeningeal, and hypothalamic–pituitary involvement.^{1,3} Pituitary or infundibular involvement may manifest as cystic or solid enhancing lesions or thickening of the pituitary stalk, often mimicking neoplastic conditions like pituitary adenoma, particularly in the sellar and suprasellar regions.^{1,4}

Case Report

Case presentation

A middle-aged patient presented with a history of headache, nausea, fever, loss of appetite, and endocrine dysfunction (hypothyroidism).^{1,2}

Imaging findings

MRI of the brain revealed a large, oval, lobulated lesion centred in the sellar and suprasellar region. The lesion appeared isointense on T1- and T2-weighted images and demonstrated inhomogeneous post-contrast enhancement (Figure 1A–D).¹ The lesion abutted the optic chiasm with minimal associated oedema and showed minor extension into the right cavernous sinus.^{3,4} A key finding was the interval development of infundibular stalk thickening, measuring 8.5 mm (Figure 1B), which was not present on a prior MRI dated two months earlier (Figure 2A and B).¹ The posterior pituitary bright spot was normal in location and signal on T1-weighted images (Figure 1A).^{1,4}

MRI findings:

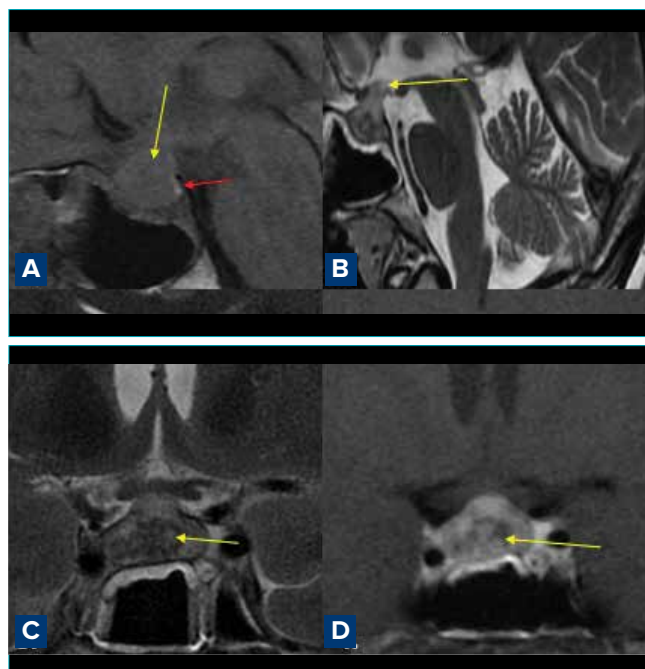


Figure 1A–D: Brain magnetic resonance imaging (MRI) demonstrates a large, oval, lobulated lesion centred in the sellar and suprasellar region, appearing isointense on both T1-weighted and T2-weighted sequences, with inhomogeneous post-contrast enhancement: **A.** Red arrow – Preserved posterior pituitary bright spot in its normal anatomical location on T1-weighted imaging; **B.** Marked thickening of the infundibular stalk, measuring approximately 8.5 mm; **C.** Coronal post-contrast image demonstrating heterogeneous enhancement of the sellar–suprasellar lesion with extension towards the optic chiasm; **D.** Sagittal post-contrast image showing superior extension of the lesion with mild mass effect on the optic apparatus.

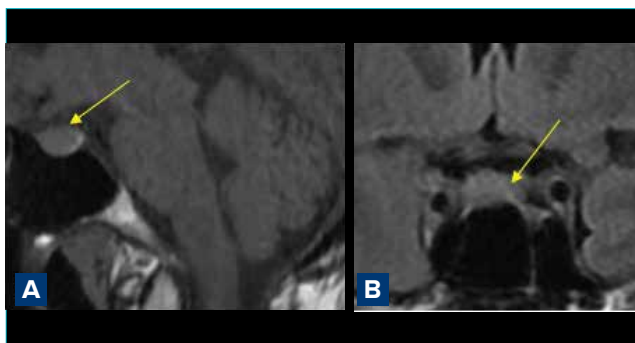


Figure 2A and B: Comparison with imaging performed two months earlier demonstrates a mild superior convexity of the pituitary gland. The gland appears normal in size and signal intensity, with no evidence of stalk thickening at that time.

Cervical screening:

Further screening revealed multiple enlarged, partly necrotic cervical lymph nodes on MRI (Figure 3A and B).²

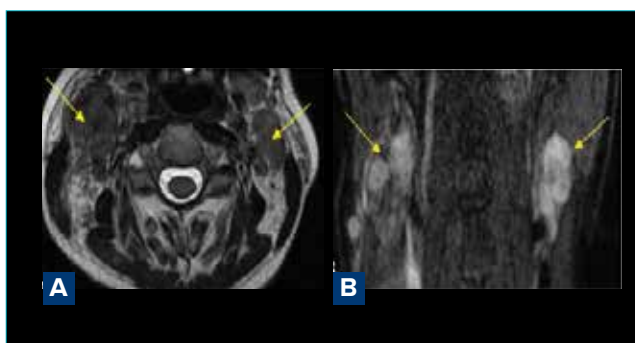


Figure 3A and B: Imaging reveals multiple enlarged, partly necrotic cervical lymph nodes.

CT/PET-CT findings:

Positron emission tomography-computed tomography (PET-CT) confirmed metabolically active cervical lymphadenopathy (levels II–V), peripherally enhancing hepatic lesions in segments II, III, VII, and VIII, and pulmonary abnormalities including interlobular septal thickening and ground-glass opacities (Figures 4 and 5).²

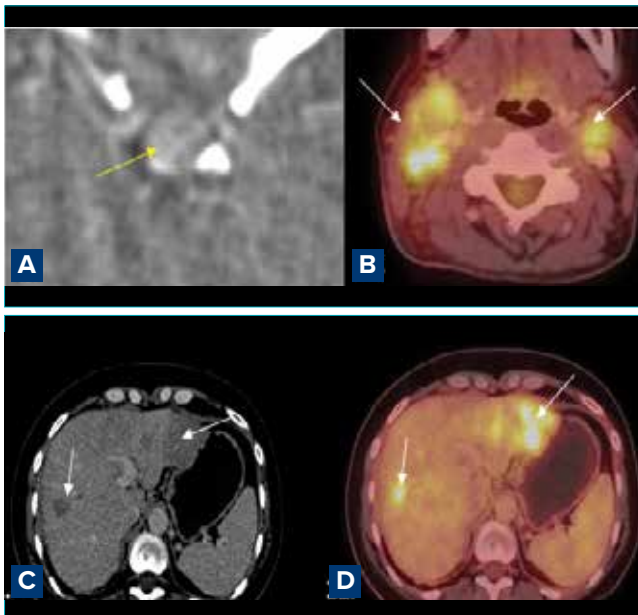


Figure 4: **A.** Computed tomography (CT) imaging showing an inhomogeneously enhancing lesion replacing the pituitary gland, with minimal suprasellar extension; **B.** Positron emission tomography-computed tomography (PET-CT) neck showing metabolically active conglomerate cervical lymph nodes, involving nodal levels II–V on the right and level II on the left; **C, D.** PET-CT liver showing multiple peripherally enhancing, metabolically active lesions involving hepatic segments II, III, VII, and VIII.

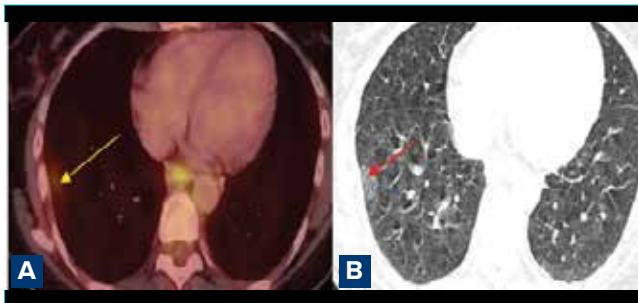


Figure 5A and B: Positron emission tomography-computed tomography (PET-CT) lungs demonstrating patchy ground-glass attenuation with interlobular septal thickening in the superior segment of the right lower lobe.

Ultrasonography (USG) neck findings:

Ultrasound of the neck corroborated these findings, showing conglomerate nodes with partial central necrosis (Figure 6A–D).³ These multimodality findings, combined with systemic evaluation and histopathological confirmation, were consistent with neurosarcoidosis involving the pituitary gland.³

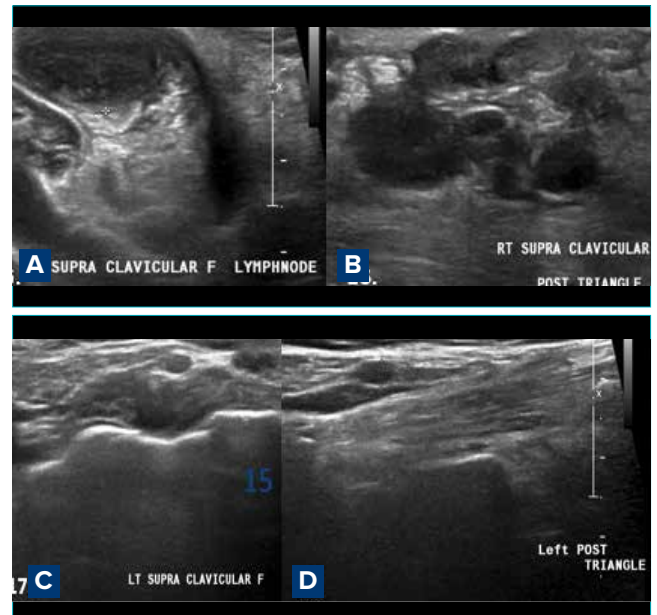


Figure 6A–D: Ultrasound of the neck corroborates the presence of multiple conglomerate lymph nodes in the right posterior triangle and supraclavicular region, with some showing partial central necrosis.

Discussion

Neurosarcoidosis of the hypothalamic–pituitary axis is rare and often diagnostically challenging.^{1,2} In this case, the preservation of the posterior pituitary "bright spot" suggested sparing of the neurohypophysis, while the rapid interval thickening of the infundibular stalk served as a primary clue for a granulomatous process rather than a typical pituitary adenoma.² The differential diagnosis includes lymphocytic hypophysitis, lymphoma, metastasis, and germinoma.²

A multimodality approach was pivotal.^{1,3} While MRI remains the gold standard for detailed CNS evaluation, PET-CT and ultrasound were essential for assessing the systemic disease burden and identifying accessible targets for tissue sampling.^{1,4} This case highlights that integrating characteristic imaging patterns across modalities facilitates the differentiation of neurosarcoidosis from neoplastic conditions, enabling the timely initiation of systemic therapy.^{3,4}

Conclusion

Neurosarcoidosis is a critical differential diagnosis for infiltrative sellar–suprasellar lesions, especially when accompanied by pituitary stalk thickening.^{1,3} This case underscores the importance of a comprehensive imaging strategy, utilising MRI, PET-CT, CT, and ultrasound, to establish a diagnosis of systemic sarcoidosis and avoid unnecessary surgical intervention for suspected primary pituitary neoplasms.^{3,4}

Mohit Tamakuwala, Mitusha Verma, Deepak Patkar. Beyond Adenoma: Imaging Clues to Pituitary Involvement in Systemic Sarcoidosis. MMJ. 2026, June. Vol 3 (2).

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References

1. Smith JK, Matheus MG, Castillo M. Imaging manifestations of neurosarcoidosis. *AJR Am J Roentgenol*. 2004;182(2):289–95.
2. Samuelsson K, Stiernstedt G, Söderman M. Neurosarcoidosis can occur without any other signs of sarcoidosis. *Lakartidningen*. 1992;89(38):3052–5.
3. Ginat DT, Dhillon G, Almast J. Magnetic resonance imaging of neurosarcoidosis. *J Clin Imaging Sci*. 2011;1:15.
4. Arle JE, Judkins AR, Kotapka MJ. Neurosarcoidosis presenting in the pituitary gland with normal endocrine studies. *Skull Base Surg*. 1999;9(2):149–53.
5. Al-Badri SG, Duhan A, Al-Taie RH, et al. Hypothalamic Neurosarcoidosis With Multisystem Involvement: Case Report and Literature Review. *Clin Case Rep*. 2025;13(10):e71106.



STUDENTS' CORNER

166

Clinical Signs – The Forgotten Art!! (Part II) –
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Clinical Signs – The Forgotten Art! (Part II)

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Abstract:

In an era of rapidly advancing diagnostic technologies, the value of bedside clinical examination is gradually diminishing, despite its enduring relevance in everyday medical practice. Careful observation and elicitation of physical signs remain fundamental to early diagnosis, prompt decision-making, and cost-effective patient care, particularly in resource-constrained settings. This review, “Clinical Signs – The Forgotten Art! (Part II),” revisits a selected collection of high-yield clinical signs that continue to hold substantial diagnostic importance across multiple specialities, including internal medicine, surgery, neurology, and dermatology. Emphasis has been placed on signs that are simple to elicit, clinically reliable, and frequently encountered in undergraduate and postgraduate medical training as well as routine clinical practice. For each clinical sign, the review discusses its historical origin, methodology of elicitation, pathophysiological basis, associated clinical conditions, and contemporary diagnostic relevance. In addition, the article highlights how bedside examination can complement modern investigations by guiding differential diagnosis, prioritising investigations, and enhancing physician-patient interaction. By re-emphasising these classical examination skills, this review aims to encourage clinicians and trainees to preserve the art of bedside medicine while integrating it effectively with current evidence-based diagnostic approaches and technological advancements in healthcare.

Key words: Clinical Signs, Bedside Diagnosis, Physical Examination, Clinical Pearls, Postgraduate Medicine.

Introduction

Even with significant advances in medical technology, the first clinical evaluation still depends heavily on bedside examination. The capacity to derive important diagnostic insights from basic physical signs remains a core competency of an effective clinician. However, with increasing dependence on imaging and laboratory investigations, many such signs are no longer routinely elicited, particularly in fast-paced clinical environments.¹⁻³

Unlike classical signs that are often descriptive and occasionally of limited sensitivity, there exists a subset of clinical signs that are highly practical, reproducible, and immediately informative. These signs frequently provide early diagnostic direction, help differentiate between competing clinical possibilities, and, in certain situations, may even obviate the need for urgent investigations.

For postgraduate trainees, mastery of these signs is particularly important. They form the backbone of clinical examinations such as objective structured clinical examinations (OSCEs) and viva voce, and more importantly, they cultivate a disciplined approach to patient evaluation. Recognising a ‘hung-up reflex’, eliciting a ‘Gower’s sign’, or identifying ‘Hoover’s sign’ in suspected functional weakness are examples of how bedside skills can directly influence clinical reasoning.

This review, as a continuation of the earlier discussion on forgotten clinical signs, shifts focus toward twelve high-yield, clinically actionable signs that every postgraduate student should be familiar with. These signs have been selected not only for their diagnostic value but also for their enduring relevance in everyday clinical practice.

Twelve High-Yield Clinical Signs Every Postgraduate Must Know

In modern clinical practice, rapid access to investigations has reduced reliance on bedside examination. However, certain clinical signs remain highly discriminative, elegant, and diagnostically powerful. This curated list highlights twelve such signs across multiple specialities that every postgraduate should confidently elicit and interpret.

1. Hung-up reflex (Woltman's sign) (Hypothyroidism)

First described by: Henry Woltman.

Finding: Delayed relaxation phase of deep tendon reflex, especially ankle jerk (Figure 1).

Significance: Suggestive of hypothyroidism.⁴



Figure 1: Delayed relaxation reflex.

2. Facial (Malar) rash in systemic lupus erythematosus (SLE) (Dermatology/Rheumatology)

Explained in classical dermatology by Ferdinand von Hebra.

Finding: Appearance of a butterfly rash over the cheeks and nose, sparing the nasolabial folds (Figure 2).

Significance: Suggestive of SLE.¹⁻³



Figure 2: Malar rash in systemic lupus erythematosus (SLE).

3. Gower's sign (Neurology)

First described by: William Richard Gowers.

Finding: The patient usually uses their hands to "climb up" the thighs while rising (Figure 3).

Significance: It is suggestive of proximal muscle weakness (e.g., Duchenne muscular dystrophy).⁵



Figure 3: Using hands to push on the legs to stand.

4. Lhermitte's sign (Neurology)

First described by: Jean Lhermitte.

Finding: An electric shock sensation appears on neck flexion (Figure 4).

Significance: Usually seen in multiple sclerosis and cervical cord lesions.⁵



Figure 4: Electric shock sensation on neck.

5. Cervical venous hum in severe anaemia

Finding: Continuous humming sound over the jugular veins, which is abolished by compression (Figure 5).

Significance: Suggestive of severe anaemia or a hyperdynamic circulation.⁶

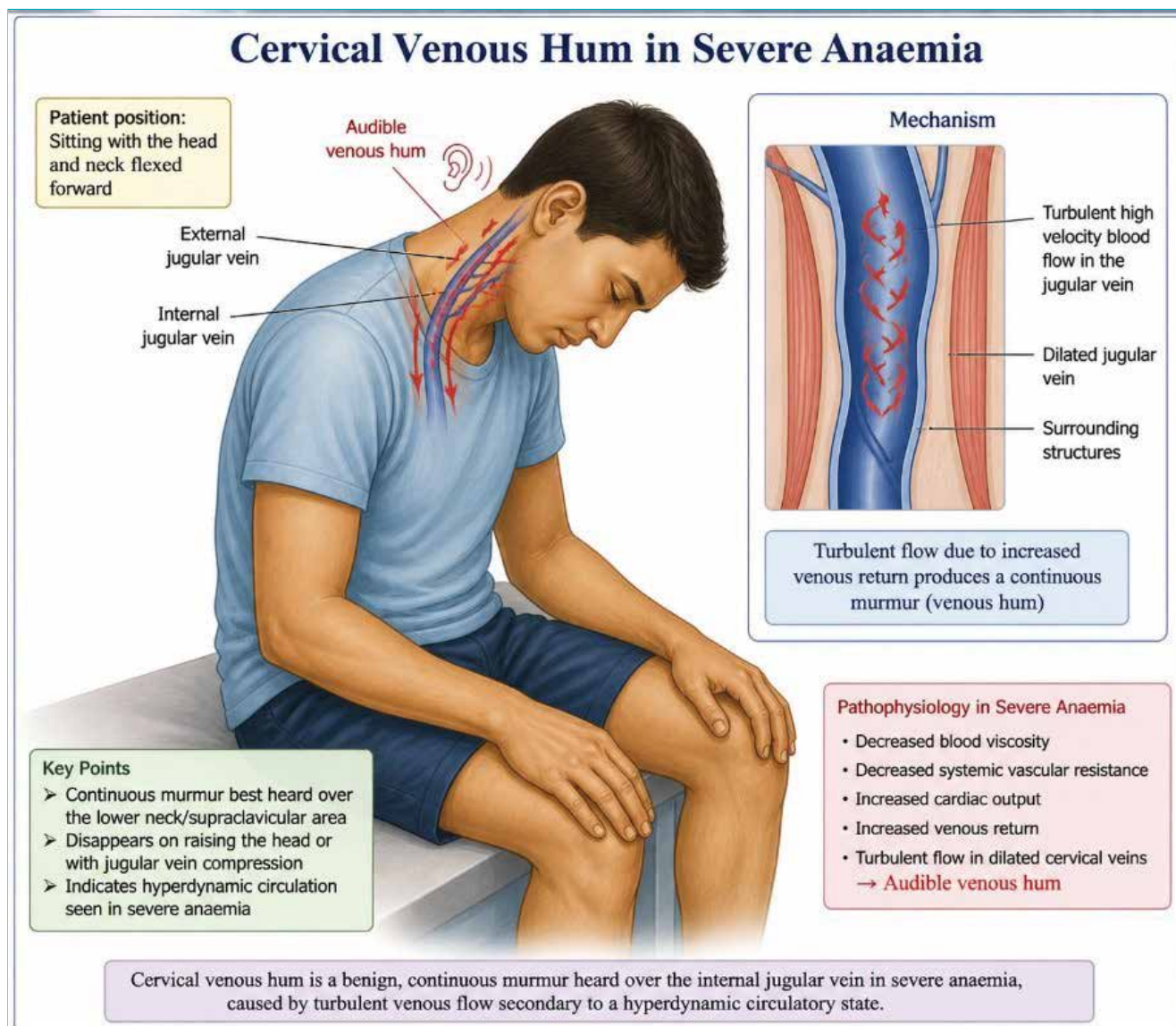


Figure 5: Cervical venous hum in severe anaemia

6. Hoover's Sign (Functional vs organic weakness) (Neurology)

First described by: Charles Franklin Hoover (1908).

Method:⁵

1. The patient lies supine.
2. The examiner places a hand under the heel of the "normal" leg.
3. The patient is asked to lift the "weak" leg against resistance.

Findings:⁵

- Organic weakness: Downward pressure is felt under the opposite heel.

- Functional (Non-organic) weakness: No pressure felt.

Principle: Based on crossed extensor reflex and synergistic muscle activation (Figure 6).

Clinical significance: Differentiates between:⁵

- True neurological weakness
- Functional (conversion disorder) weakness

Clinical pearl:

"Absence of involuntary extension in the contralateral limb suggests non-organic weakness."

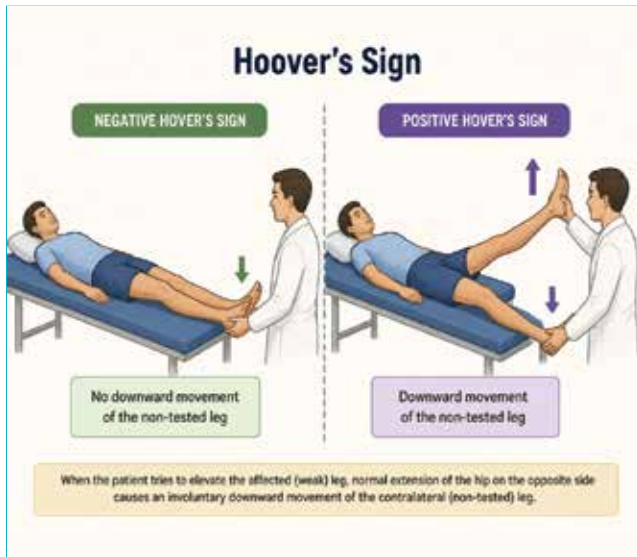


Figure 6: Hoover's sign

7. Spider naevi (Hepatology/Pregnancy)

Finding: Central arteriole with radiating vessels (Figure 7).

Significance: Seen in chronic liver disease and pregnancy (hyperoestrogenism).³



Figure 7: Spider naevi

8. Gingival hyperplasia

Finding: Overgrowth of gums (Figure 8).

Causes:

- Phenytoin
- Cyclosporine
- Leukaemia
- Pregnancy

Significance: Clue to a drug effect or systemic disease.⁷



Figure 8: Gingival hyperplasia

9. Transillumination test of the testis (Surgery/Urology)

Finding:

- Hydrocele → Transilluminates
- Tumour → Does not transilluminate

Significance: Differentiates cystic from solid scrotal swelling (Figure 9).^{2,3}



Figure 9: Hydrocele transillumination

10. Courvoisier's law (Palpable gallbladder) (Surgery)

First described by: Ludwig Courvoisier.

Finding: Palpable gallbladder with painless jaundice (Figure 10).

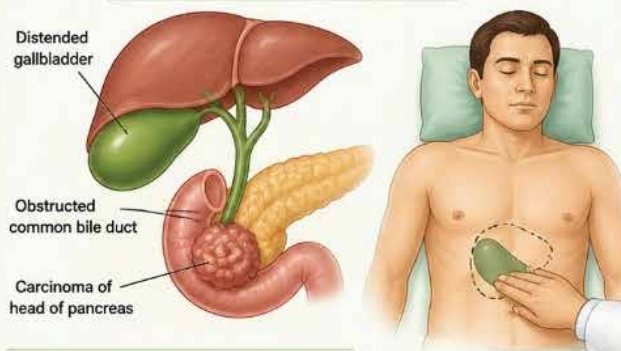
Significance: Suggestive of malignant obstruction (not gallstones).^{2,3}

Courvoisier's Law (Palpable Gallbladder)

A palpable, distended, non-tender gallbladder in a patient with obstructive jaundice suggests malignant obstruction of the distal bile duct.

MALIGNANT OBSTRUCTION

Example: Carcinoma head of pancreas

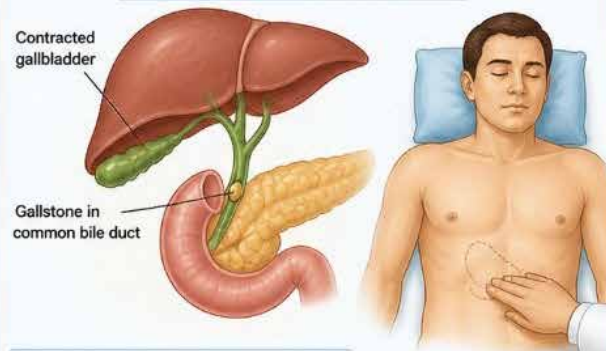


- Obstruction is gradual
- Gallbladder fills and becomes distended
- Remains palpable and non-tender

Palpable, distended, non-tender gallbladder

BENIGN OBSTRUCTION

Example: Gallstone in common bile duct



- Obstruction is often associated with chronic inflammation
- Gallbladder is fibrosed and contracted
- Usually not palpable

Gallbladder not palpable

COURVOISIER'S LAW

In a patient with obstructive jaundice, a palpable, non-tender gallbladder is highly suggestive of **malignant obstruction** of the distal bile duct.

KEY POINTS

- Palpable gallbladder + Obstructive jaundice → Think Malignancy
- Non-palpable gallbladder + Obstructive jaundice → Think **Benign cause** (e.g., gallstones, strictures due to inflammation)
- Important clinical sign to differentiate cause of obstruction.



Remember: Courvoisier's law is not absolute.

A palpable gallbladder may occasionally be felt in benign obstruction and may be absent in malignancy.

Figure 10: Palpable gallbladder with painless jaundice

11. Argyll Robertson pupil (Neurosyphilis)

First described by: Douglas Argyll Robertson.

Finding: Accommodation present, light reflex absent (Figure 11).

Significance: Classic finding of neurosyphilis.⁸

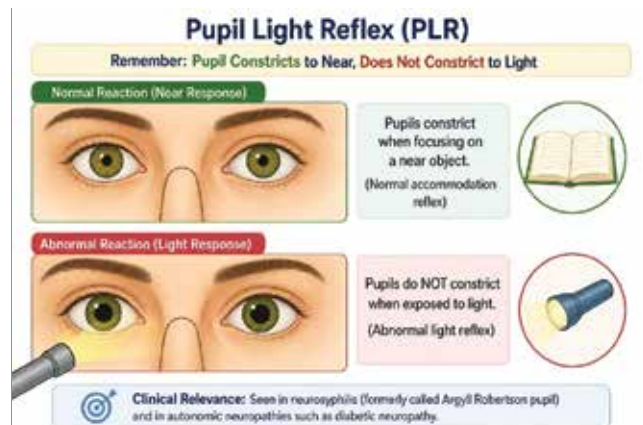


Figure 11: Argyll Robertson pupil

12. Internuclear ophthalmoplegia (INO) (Neurology)

Described by: David Cogan.

Finding:

- Failure of adduction of one eye.
- Nystagmus of the abducting eye (Figure 12).

Significance: Seen in multiple sclerosis.⁹

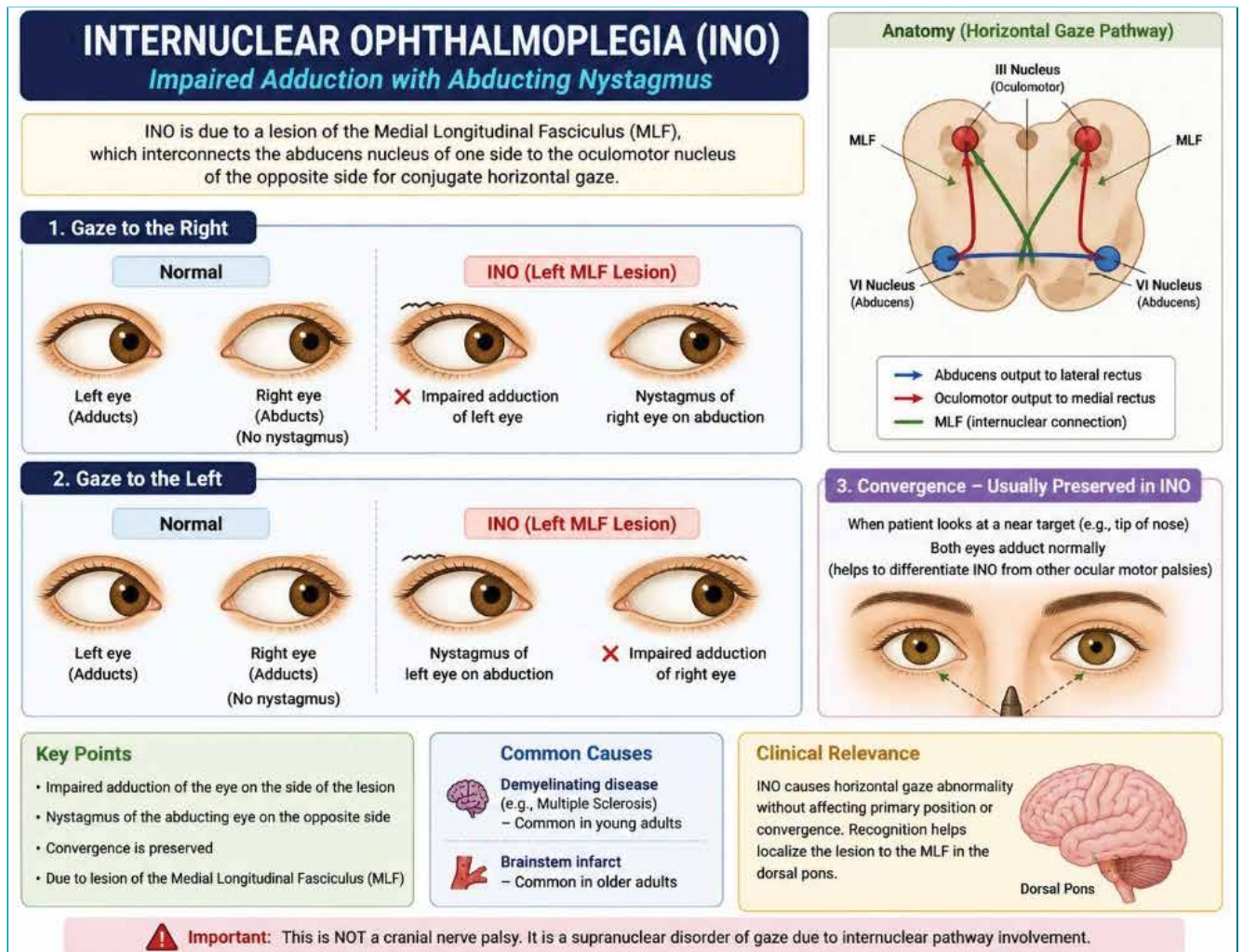


Figure 12: Internuclear ophthalmoplegia

Conclusion

This revised list emphasises clinically powerful, examination-relevant, and conceptually rich signs. Among them, Hoover's sign stands out as a brilliant example of how bedside examination can distinguish organic disease from functional disorder without any investigation.

"The best clinicians are not those who order the most tests, but those who observe the most carefully."

Narinder Pal Singh. Clinical Signs – The Forgotten Art! (Part II). MMJ. 2026, June. Vol 3 (2).

DOI: <https://doi.org/10.62830/mmj3-02-31>

References

1. Bickley LS. Bates' Guide to Physical Examination and History Taking. 13th Edition. Philadelphia: Wolters Kluwer; 2020.
2. Talley NJ, O'Connor S. Clinical Examination: A Systematic Guide to Physical Diagnosis. 8th Edition. Sydney: Elsevier; 2019.
3. Douglas G, Nicol F, Robertson C. Macleod's Clinical Examination. 14th Edition. Edinburgh: Elsevier; 2018.
4. Corona-Vázquez CP, Orozco-Puga P, Macias-Ortiz FG, *et al.* Hung-up reflex: the history of a clinical sign and differential diagnosis. *Acta Neurol Belg.* 2025;125(6):1521–4.
5. Gowers WR. A Manual of Diseases of the Nervous System. London: Churchill; 1886.
6. Shiota T, Sakamoto T, Amano K, *et al.* [Venous hum and innominate vein flow velocity in chronic anemia: a pulsed Doppler echocardiographic study]. *J Cardiol.* 1989;19(3):885–92.
7. Agrawal AA. Gingival enlargements: Differential diagnosis and review of literature. *World J Clin Cases.* 2015;3(9):779–88.
8. Dichter SL, Khan Suheb MZ, Shubert GS. Argyll Robertson Pupil. [Updated 2024 Jan 31]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026 Jan. Available at: <https://www.ncbi.nlm.nih.gov/books/NBK537179/>. Accessed on: 20th April 2026.
9. Feroze KB, Wang J. Internuclear Ophthalmoplegia. [Updated 2023 Jun 26]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026 Jan. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK441970/>. Accessed on: 20th April 2026.

Max Institute of Medical Education Announcements

June 2026

Max Institute of Medical Education (MIME), the educational division of Max Healthcare Institute Ltd., was established to address and strengthen the training needs of medical and non-medical professionals across healthcare organisations. MIME is committed to empowering medical, nursing, and paramedical professionals with the confidence, competence, and practical expertise required to deliver healthcare at the highest standards while ensuring patient safety.

Core Elements of Our Training



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Diplomate of National Board (DNB)

The National Board of Examinations has recognised Max Healthcare Institute Ltd. for practical training in DNB broad and super speciality courses across more than 40 disciplines in India. Currently, over 607 DNB residents are training across the Max Healthcare hospital network.



Internal Medicine Training – IMT (MRCP-UK)

A 3-year full-time postgraduate programme in Internal Medicine integrating the full Membership of the Royal Colleges of Physicians (MRCP) (UK) curriculum. This programme is a collaboration between Max Healthcare and the Joint Royal College of Physicians Training Board (JRCPTB-UK).

The programme delivers internationally benchmarked physician training equivalent to UK standards. Teaching and assessments are conducted by consultants trained through the Royal College of Physicians.

- **Current Enrolment:** 70 residents
- **Training Locations:** Max Super Speciality Hospitals – Delhi & Mumbai
- **Upcoming Session:** July 2026



RCOG – MHC Obstetrics & Gynaecology Programme

A joint initiative between Max Healthcare Institute Ltd. and the Royal College of Obstetricians and Gynaecologists (RCOG).

This programme is equivalent to:

- Basic training (ST1-2)
- Intermediate training (ST3-5) in the UK

The curriculum includes:

- RCOG curriculum framework
- Membership of the Royal College of Obstetricians and Gynaecologists (MRCOG) examinations
- RCOG e-Portfolio
- Annual Review of Competence Progression (ARCP) with UK external evaluation
- **Current Enrolment:** 15 residents
- **Training Locations:** Delhi & Lucknow
- **Upcoming Session:** July 2026



MEM–GWU International

A 3-year residency programme in Emergency Medicine, conducted by MIME in collaboration with The Ronald Reagan Institute of Emergency Medicine, USA, under George Washington University Medical Center.

The programme equips residents with the knowledge, clinical skills, and compassion required for effective emergency medical care.

- **Current Enrolment:** 90 residents
- **Training Locations:** Delhi, Noida, Gurugram, Lucknow, Dehradun, Mohali, Mumbai, & Nagpur
- **Admissions Open:** FY 2026–2029

Fellowship Courses (Non-NBE)

MIME offers advanced fellowship programmes across multiple specialities to enhance physician competency. Programme duration ranges from 6 months to 2 years.

- Abdominal & Transplant Imaging
- Aesthetic Medicine & Surgery
- Bariatric Anaesthesia
- Breast Imaging
- Critical Care Medicine
- Computed Tomography (CT) and Magnetic Resonance Imaging (MRI)
- Emergency Medicine
- Dialysis
- Orthopaedic Oncology & Reconstruction
- Foot & Ankle
- Gastroenterology
- General Nephrology
- Gynaecological Onco-Surgery
- Gastrointestinal (GI) Endoscopy
- Head & Neck Surgery
- Hip & Knee
- Pulmonology
- Radiology
- In Vitro Fertilisation (IVF)
- Robotic & Renal Transplant
- Neuro Imaging
- Non-invasive Cardiology
- Pain Management
- Rheumatology
- Robotics
- Spine Surgery
- Surgical Oncology
- Transplant Hepatology
- Ultrasound-Guided Regional Anaesthesia (UGRA)
- Uro-Oncology & Robotic Surgery
- Women's Imaging and more

Open Fellowships – July & August Intake

Post-Graduate (PG) Diploma & Master of Science (MSc) Courses

MIME offers full-time postgraduate programmes designed to provide advanced knowledge, industry exposure, and strong career opportunities in healthcare.

Admissions Open: FY 2026–2028

Programmes Offered

- PG Diploma & Master of Public Health – Certified by the Academy of Scientific and Innovative Research (AcSIR)
- PG Diploma & Master of Healthcare Quality Management – Certified by AcSIR
- PG Diploma & MSc in Clinical Research – Certified by the Regional Centre for Biotechnology
- PG Diploma in Artificial Intelligence (AI) in Healthcare – In collaboration with Bennett University

Eligibility

Bachelor's degree/Graduation in science

Duration

- PG diploma: 1 Year
- MSc programme: 2 Years

PG Diploma in AI in Healthcare

A pioneering programme launched in collaboration with Bennett University to prepare healthcare professionals for the digital future of medicine.

Programme Highlights

- AI & machine learning
- Deep learning & predictive analytics
- Computer vision & natural language processing (NLP)
- AI-enabled diagnostics
- Clinical decision support systems
- Real-world healthcare applications

The programme combines technical expertise with clinical relevance, preparing professionals for technology-driven healthcare transformation.

PhD Programmes

MIME is affiliated with the AcSIR, an Institution of National Importance established by an Act of Parliament, Government of India.

Research Areas

- Medical research
- Public health
- Biological sciences

NCVET Programmes

In collaboration with the National Council for Vocational Education and Training (NCVET), MIME has launched AI-focused healthcare certificate programmes through the Skill India Digital Hub (SIDH) digital learning platform.



Programmes

- Foundation Course in AI for Digital Health
- Applied AI for Healthcare Systems

These programmes focus on:

- AI in healthcare operations
- Machine learning concepts
- Predictive analytics
- Clinical decision support systems
- Ethical AI & patient privacy
- Digital health workflows

Observerships

Customised observership programmes are available across various clinical departments for Indian and international medical graduates. These programmes focus on practical exposure and skill enhancement under departmental mentorship.

Internships

Hands-on internships are available for durations ranging from 1 to 6 months.

Allied Health

- Physiotherapy
- Dietetics
- Psychology

Support Services

- Biomedical engineering
- Service excellence
- Human resources
- Finance
- Medical records
- Information technology
- Fire & safety
- Healthcare supply chain management

Life Saver Training Programmes

Max Healthcare Institute is an International Training Centre certified by the American Heart Association.

Courses Offered

- Basic Life Support (BLS) – Provider & Instructor
- Advanced Cardiac Life Support (ACLS) – Provider & Instructor
- Paediatric Advanced Life Support (PALS) – Provider & Instructor

Upcoming Training – June 2026

Location: Max Super Speciality Hospital, Saket

- 23rd June – BLS Provider (HeartCode)
- 23rd–24th June – ACLS Provider Course with Video Prework
- 25th June – BLS Instructor
- 26th June – ACLS Instructor

Bespoke & Certificate Courses

MIME offers specialised short-term upskilling programmes delivered by experienced faculty using advanced simulation labs and high-fidelity manikins.

Upcoming Courses – June/July 2026

- 3rd Max Robotic Prostatectomy Workshop – 25th July 2026
- Certification Course in Infection Control for Nurses – 26th June 2026
- Certification Course in Musculoskeletal Cross-Section Imaging – 5th June 2026
- Certificate in Mammography – 15th June 2026

FMG Clinical Skills Courses

Designed for Foreign Medical Graduates (FMGs), these programmes strengthen clinical competencies and prepare candidates for Foreign Medical Graduate Examination (FMGE)/ National Exit Test (NExT) examinations through practical exposure and hands-on training.

Duration

- Basic Programme – 15 Days
- Advanced Programme – 20 Days

Upcoming Batch

July 2026

MIME Online Courses

Self-paced hybrid online courses designed for doctors, nurses, and paramedical professionals.

Online Fellowship Courses

- Diabetes Management
- Infectious Disease
- Emergency Medicine
- Critical Care
- Clinical Cardiology
- Obstetrics & Gynaecology
- Bariatric Anaesthesia
- Management of Liver Disorders

New Launches – June 2026

- Family Medicine
- Paediatrics

Online Certificate Courses

- Aesthetic Medicine & Surgery
- Healthcare Quality Management
- Public Health
- Clinical Research
- Bariatric Nutrition
- Acute Liver Failure (ALF)
- Geriatric Care
- Difficult Airway Management

Key Highlights

MIME, in partnership with Learna (Diploma MSc) and validated by the University of Buckingham, offers globally aligned healthcare education.

Programme Highlights

- Comprehensive training in sepsis, trauma, respiratory support, and critical care ethics
- Case-based learning with observership opportunities at Max Healthcare
- Mentorship by Dr. Rajesh Pande and Dr. Nick Stallard
- Flexible hybrid learning model for working professionals

For more information, contact us:

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25

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115

Ongoing Clinical Trials

23

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160+

Scientific Publications in
High-Impact Journals

Drug and Device Trials

Max Healthcare continues to strengthen its position as a leading research-driven healthcare institution with over 115 ongoing clinical trials and 25 grant studies across multiple specialities. This quarter also marked the successful completion of the pioneering first-ever human trial in robotic surgery, with the Case Study Report submitted to the Central Drugs Standard Control Organisation (CDSCO).

Publications

During Q4 FY26, Max Healthcare researchers contributed more than 160 scientific publications in high-impact journals, including Nature Medicine, Lancet Neurology, Lancet Global Health, and European Journal of Heart Failure. Over the last 11 years, Max Healthcare has achieved more than 3,300 indexed publications.

Grants and Collaborations

Max Healthcare expanded its global research network through collaborations with Columbia University, USA, adding to the 23 partnerships with national and global academic and industry partners, including Imperial College London, Monash University, National Centre for Biological Sciences (NCBS), Tata Institute for Genetics and Society (TIGS), Deakin University, Indian Institute of Technology (IIT) Bombay, IIT Delhi, Birla Institute of Technology and Science (BITS) Pilani, Ashoka University, Boston University, Rajiv Gandhi Centre for Biotechnology (RGCB), Indraprastha Institute of Information Technology (IIIT) Delhi, Pfizer Inc, and Mazumdar Shaw Medical Foundation (MSMF).

Dr. Bharat Aggarwal and Aniket Aman, along with Prof. Kshitij Jadhav (IIT Bombay), received the India AI & National Cancer Grid (NCG) Cancer AI & Technology Challenges (CATCH) grant for AI-driven healthcare innovation. Dr. Ambrish Mithal, in collaboration with Ashoka University, was awarded the Centre for Advanced Research (CAR) grant for the Centre for Precision Metabolic Health (CPMH) focused on digital twin-enabled precision diabetes care. Dr. Bharat Aggarwal also received support from the Wadhwani Foundation for translational healthcare innovation.

Recent Events

Max Metabolic Summit 2026

The Max Metabolic Summit 2026 brought together leading endocrinologists and clinicians to discuss incretin therapies and metabolic care.

Master of Public Health (MPH) Degree Distribution Ceremony – Batch 2023-2025

The MPH Degree Distribution Ceremony celebrated the graduation of the second batch of Max–Academy of Scientific and Innovative Research (AcSIR) MPH students at Max Healthcare, Saket.

Guest Lecture on Palliative Care by Dr. Sreedevi Warriar

The Office of Research hosted Dr. Sreedevi Warriar from Pallium India for an insightful lecture on holistic palliative care and patient-centred approaches.

New Efforts in Research

This quarter marked important milestones in translational research, including two patent applications in radiomics filed with IIT Bombay and the completion of the first-ever human trial in robotic surgery.

Scope of the Journal

The Max Medical Journal is dedicated to publishing high-quality scientific, clinical, and translational research that contributes to the advancement of healthcare and patient outcomes. The journal provides a platform for clinicians, researchers, academicians, and healthcare professionals to share evidence-based knowledge, innovative practices, and emerging developments across all disciplines of medicine and allied health sciences.

The journal welcomes manuscripts covering clinical, diagnostic, therapeutic, preventive, ethical, and public health aspects of medicine. Submissions involving original investigations, multidisciplinary research, healthcare innovation, and quality improvement initiatives will be considered for publication.

The Max Medical Journal aims to promote the timely dissemination of clinically relevant information that directly enhances patient care, medical education, and healthcare delivery. The journal encourages contributions from both established and emerging researchers worldwide.

The journal publishes original and impactful work in the field of General Medicine and all major medical and surgical specialties.

Article types

- Original Articles
- Review Articles
- Case Studies
- The Images
- Students' Corner

Vision

To become a leading platform for the dissemination of evidence-based medical knowledge and advancement of excellence in patient-centred healthcare.

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- To promote high-quality clinical and scientific research.
- To encourage interdisciplinary academic collaboration.
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- To publish clinically relevant research that improves patient outcomes.
- To foster innovation, education, and continuous advancement in healthcare.

Author Guidelines

Articles submitted to The Max Medical Journal must adhere to the author guidelines mentioned below:

Writing and formatting

The manuscript should be written in clear English using UK spelling and arranged in the following order: Title, Abstract and Keywords, Introduction, Main Heading(s), Discussion, Conclusion, Declarations, and References.

Copyright statement

A copyright statement signed by all the authors must be submitted.

Title

The title should be concise, informative, and specific to the topic of the article. Abbreviations should be avoided in the title.

Author names and affiliations

Provide the first name or initials (if used), middle name or initials (if used), and surname for all authors. Affiliation details should include department, institution/university/organisation, city, state, and country. One author should be designated as the corresponding author with an asterisk (*) against his/her name. Only the corresponding author's email address should be provided.

Abstract and keywords

The abstract should be unstructured, written as a single paragraph, and should not exceed 300 words. Authors should provide 4–6 keywords below the abstract.

Abbreviations

All abbreviations used in the manuscript should be expanded upon first use (acronym in parentheses) in the abstract and text separately, unless they represent standard units of measurement.

Figures and tables

All figures and tables must be cited in the text. Authors should indicate where they should be inserted within the text. Figure legends and table titles should be concise and included in the manuscript file. Footnotes may be used to explain abbreviations. For figures with sub-parts, each part should be clearly labelled using uppercase letters followed by a period (e.g., A., B., C.), along with a brief description for each part.

Example

Figure 1: Renal biopsy: **A.** PAS stain (20X); **B.** Silver stain (20X); **C.** Silver stain (40X).

Word limit

Manuscripts should preferably remain within the following word limits:

- Case Studies – 1500 words
- The Images and Students' Corner submissions – 2000 words
- Original and Review Articles – 3000 words

The word count excludes abstract, references, tables, and figure legends.

References

References should be cited in the text using superscript Arabic numerals in the order of appearance. A complete reference list should be provided at the end of the manuscript and should follow the Vancouver style. Only published or accepted manuscripts should be included in the reference list. Meetings, abstracts, conference presentations, and manuscripts submitted but not yet accepted for publication should not be cited as references.

Example:

Rajput R, Yadav Y, Nanda S, *et al.* Prevalence of gestational diabetes mellitus & associated risk factors at a tertiary care hospital in Haryana. *Indian J Med Res.* 2013;137(4):728–33.

Declarations

Acknowledgements, conflict of interest, funding details, ethical approval, informed consent, and author contributions should be included under a separate "Declarations" section before references, wherever applicable.

Covering Letter

A covering letter signed by all authors must accompany the submission, confirming that the manuscript has not been published previously, is not under consideration elsewhere, and has been approved by all authors for submission.

All the articles to be sent to this email ID:
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About Max Healthcare

Max Healthcare Institute Limited (Max Healthcare) is one of the largest integrated healthcare providers in the country. We own, operate and provide medical services to facilities in Delhi NCR, Mumbai, Punjab, Uttar Pradesh, Uttarakhand, and Odisha. Max Lab supplements our commitment towards patient care by providing accurate testing and diagnostics. We are also revolutionising the care-continuum through Max@Home, ensuring treatment options are available to our patients in the comfort of their homes. Our continued emphasis on patient-centric care accompanied by our patients' trust has strengthened our position to become one of India's top private healthcare providers.

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