Vacuum-Assisted Breast Biopsy: A Comprehensive Overview

Ankit Gupta[1*], Richa Bansal[1], Bharat Aggarwal[1]

[1]Department of Radiology, Max Super Speciality Hospital, Saket

Correspondence:

Ankit Gupta

E-mail: ankitg2221@gmail.com

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Abstract:

Vacuum-assisted breast biopsy (VABB) is a minimally invasive technique for breast cancer diagnostics, offering advantages over traditional biopsies like higher accuracy, reduced discomfort, minimal scarring, and shorter recovery times. This review covers VABB's historical development, procedural methods, and imaging guidance through ultrasound, stereotactic mammography, magnetic resonance imaging (MRI), and tomosynthesis.

It categorises VABB's applications into diagnostic uses for evaluating suspicious microcalcifications and therapeutic interventions for benign lesions such as fibroadenomas. The review also addresses potential risks, post-procedural care, and innovations like artificial intelligence (AI)-assisted imaging and device miniaturisation for enhanced clinical use.

With its ability to obtain larger, more representative tissue samples in a single insertion, VABB has become an essential tool in early breast cancer detection and management. As technology advances, further refinements in VABB may expand its applications, improving patient outcomes and enhancing precision in breast healthcare

Key words: Vacuum-Assisted Breast Biopsy (VABB), Minimally Invasive Breast Procedures and Surgery, Ultrasound-Guided Biopsy, Stereotactic-Guided Biopsy, Digital Breast Tomosynthesis (DBT), Mammotome System, Microcalcifications, Core Needle Biopsy (CNB), Fine Needle Aspiration (FNA), Benign Breast Lesions, BI-RADS Classification, Aesthetic Outcomes in Breast Biopsy, AI in Breast Imaging.

Introduction

In the era of modern diagnostic tools, vacuum-assisted breast biopsy (VABB) has emerged as a revolutionary procedure for the detection and evaluation of breast abnormalities. Known for its precision and minimally invasive nature, VABB is a significant advancement in breast healthcare.[1] This article provides an in-depth exploration of VABB, its methodology, benefits, and considerations.

History of VABB

The development of VABB reflects significant advancements in medical technology and breast cancer diagnostics. The procedure was first introduced in the mid-1990s as a response to the limitations of traditional core needle biopsy techniques.[2] Early designs of the vacuum-assisted device allowed for single-insertion sampling, addressing the need for larger and more representative tissue samples.

In 1995, the Mammotome device, one of the first commercially available VABB systems, was approved for clinical use. Its success led to widespread adoption in the United States and Europe, with subsequent innovations enhancing its precision and usability.[3] Over the years, imaging-guided VABB—integrated with ultrasound, stereotactic mammography, and magnetic resonance imaging (MRI)—has become the gold standard for diagnosing suspicious breast lesions.[4]

Continuous refinements in probe technology, imaging integration, and tissue collection efficiency have made VABB an important tool for minimally invasive breast care. Today, it remains a vital tool in early breast cancer detection and management, offering high diagnostic accuracy with minimal patient discomfort.

What is VABB?

VABB is a minimally invasive procedure used to extract tissue samples from suspicious breast areas.[1,4] It is often recommended when a mammogram, ultrasound, or MRI reveals abnormalities such as lumps, microcalcifications, or architectural distortions.[2,5] Unlike traditional biopsy methods, VABB uses a vacuum-powered probe to remove tissue, allowing for larger and more accurate samples with fewer insertions.[6]

Types of VABB

Several types of VABB are utilised based on the imaging guidance system employed and the specific clinical scenario:[5]

- **Ultrasound-guided VABB:** This type uses ultrasound imaging to locate the lesion. It is ideal for biopsying abnormalities visible on ultrasound, such as solid masses or cysts.[6] The real-time imaging provides precise targeting, making it suitable for lesions located in various parts of the breast.
- **Stereotactic-guided VABB:** Stereotactic guidance involves using mammographic imaging from two angles to pinpoint the lesion.[7] It is commonly used for sampling microcalcifications or non-palpable abnormalities. This method is particularly effective for detecting and diagnosing abnormalities found during routine mammography.
- **MRI-guided VABB:** Magnetic resonance imaging is employed to guide the biopsy in cases where abnormalities are only visible on MRI. This type is often used for high-risk patients or those with dense breast tissue, where other imaging modalities are less effective.[8]
- **Mammotome-assisted VABB:** The Mammotome biopsy system is an effective and safe option for treating benign breast lesions when the targeted lesion is fully excised. Utilising stereotactic, ultrasound, and magnetic resonance guidance, this method allows for larger tissue samples, ensuring high accuracy in diagnosis. Additionally, it offers satisfactory cosmetic outcomes, aligning with patient preferences and the standards of breast surgery.[9-12]

How Does VABB Work?

The procedure typically involves the following steps:

1. **Preparation:** The patient is positioned based on the imaging modality being used (mammogram, ultrasound, or MRI). Local anaesthesia is administered to minimise discomfort.
2. **Imaging guidance:** Real-time imaging helps the clinician locate the targeted area with high precision.
3. **Insertion of the probe:** A small incision is made, and a hollow probe connected to a vacuum device is inserted into the breast.
4. **Tissue sampling:** The vacuum mechanism gently draws tissue into the probe. A rotating cutting device inside the probe separates the tissue, which is then suctioned into a collection chamber. Multiple samples can be obtained through a single insertion.
5. **Completion:** Once sufficient tissue has been collected, the probe is removed, and a small adhesive bandage is applied. In some cases, a tiny marker is left at the biopsy site for future reference.

Advantages of VABB

VABB offers several benefits over traditional biopsy methods:

- **Minimally invasive:** The procedure requires only a small incision, leading to minimal scarring and faster healing[13]
- **High accuracy:** Larger and more representative tissue samples improve diagnostic precision
- **Reduced discomfort:** Local anaesthesia and the minimally invasive nature of the procedure result in less pain and discomfort for patients
- **Efficiency:** Multiple samples can be obtained in one session, reducing the need for repeat procedures[4]
- **Short recovery time:** Patients can typically resume normal activities within 24 hours[14]

Indications for VABB

The use of VABB is categorised into:

1) Diagnostic

2) Therapeutic

Diagnostic indications[12,15-18]

- Palpable or non-palpable American College of Radiology BI-RADS category 3 and 4A lesions
- Lesions smaller than 5 mm, where core needle biopsies may yield false-negative results
- Suspicious microcalcifications requiring further evaluation
- Inflammatory breast cancer, which may present without a distinct lump
- Irregularities in breast tissue structure detected on imaging
- Recurrence of previously treated breast conditions
- Solid masses appearing benign but requiring further evaluation
- Asymmetries or distortions in breast architecture visible on imaging
- Lesions requiring detailed sampling for confirmation of diagnosis
- Monitoring response to neoadjuvant therapy in breast cancer patients

Therapeutic indications

- **Excision of benign breast lesions**[19-22]
  - VABB is frequently employed for the removal of benign breast conditions such as fibroadenomas, intraductal papillomas, and other non-malignant lumps.
  - Why VABB? Unlike traditional surgical excision, which requires general anaesthesia, and may leave visible scars, VABB offers a minimally invasive approach with minimal scarring and shorter recovery time.
- **Management of uncertain palpable lesions**
  - VABB is beneficial for:
    - Cases where imaging and core needle biopsy provide inconclusive results, enabling more adequate tissue sample for detailed histological examination
    - Patients with family history of cancer, with a genetic predisposition to breast cancer (e.g., BRCA mutations), where ambiguous imaging findings benefit from VABB to address and confirm the benign nature of lesions early
    - High-risk cases, with a history of benign conditions turning malignant, where VABB enables a more aggressive yet precise approach to obtain diagnostic clarity
  - **FDA-approved removal of benign lesions**
    - The FDA approved VABB in 2002 for the therapeutic removal of benign lesions.[20,21]
    - Advantages over surgery: Removes the lesion completely without requiring hospitalisation, and allows for tissue marker placement for follow-up imaging.
  - **Triple test validation**
    - The triple test (clinical examination, imaging, and biopsy) has a 95% accuracy rate, but it is not fully reliable.[23,24] When discrepancies arise, VABB allows for a larger and more representative tissue sample to confirm or refine the diagnosis.
    - Use case example: A lesion considered benign via ultrasound and mammography but clinically suspicious can be biopsied more thoroughly using VABB for confirmation.
  - **Alternative to surgical excision**
    - Fibroadenomas: Small-to-moderate fibroadenomas can be effectively treated with VABB, avoiding open surgery.
    - Papillomas: Intraductal papillomas, especially those with atypical features or associated with nipple discharge, can be excised entirely via VABB.

Advantages of Therapeutic VABB

- **Complete lesion removal:** VABB enables complete removal of smaller benign lesions, reducing the need for follow-up surgical interventions.
- **Improved aesthetic outcomes:** As only a tiny incision is required, cosmetic outcomes are significantly better than with traditional surgical methods.
- **Cost-effective:** By reducing the need for surgery and associated hospital stays, VABB is more economical while achieving similar outcomes for select cases.

Potential Risks and Considerations

While VABB is generally safe, it is not without potential risks, including:

- **Bleeding and bruising:** Minor bleeding or bruising at the biopsy site[6]
- **Infection:** Rare but possible at the incision site
- **Discomfort:** Mild soreness or tenderness following the procedure
- **False positives/negatives:** Though rare, there is a slight possibility of inaccurate results[25]

Patients should discuss their medical history, allergies, and any concerns with their healthcare provider before undergoing the procedure.

Post-Procedure Care

After VABB, patients are advised to:

- Keep the biopsy site clean and dry for 24 hours
- Avoid strenuous activities for a day or two
- Take over-the-counter pain relievers if needed
- Follow up with their healthcare provider for results and further management

Potential Future Applications

- **Localised treatment:** Research is exploring VABB for very early-stage ductal carcinoma *in situ* (DCIS) by removing all affected tissue without surgery.
- **Minimising risk in high-risk patients:** In patients with dense breasts or high-risk lesions, VABB could serve as both a diagnostic and therapeutic intervention.

Future Directions of VABB

The field of VABB is poised for several promising advancements:

- **Integration with artificial intelligence:** AI-based imaging analysis is being explored to enhance lesion detection and improve targeting precision during VABB.[26]
- **Miniaturisation of devices:** Efforts are underway to develop smaller biopsy devices that can be used in a wider range of clinical settings, including outpatient and rural healthcare facilities.[27]
- **Real-time diagnostic capabilities:** Advanced probes capable of providing immediate pathological assessment are being researched to reduce the time between biopsy and diagnosis.[28]
- **Improved patient comfort:** Techniques such as automated local anaesthesia delivery and reduced probe sizes aim to further minimize discomfort during the procedure.[29]
- **Expansion of indications:** VABB is being adapted for use in other areas of oncology and tissue sampling, broadening its applicability beyond breast health.
- **Personalised medicine approaches:** Integration with genomic and proteomic studies may enable tailored treatment strategies based on biopsy results.

Conclusion

Vacuum-assisted breast biopsy represents a critical tool in the early detection and diagnosis of breast abnormalities. Its minimally invasive approach, accuracy, and efficiency, make it a preferred choice for both patients and clinicians. By enabling timely and precise diagnoses, VABB plays a vital role in improving breast health outcomes and reducing patient anxiety.

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Image 1: Needle positioning at the lesion. 2 echogenic lines corresponding to the 2 edges of the trough/aperture can be seen.

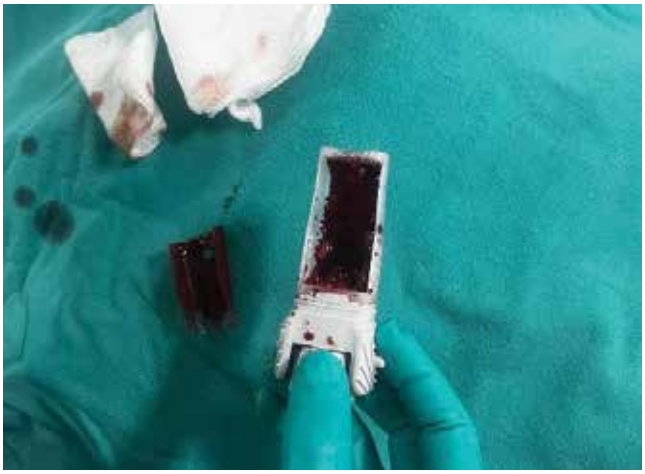

Image 2: Tissue sample extracted from the needle.

Image 3: Vacuum-assisted breast biopsy (VABB) machine.

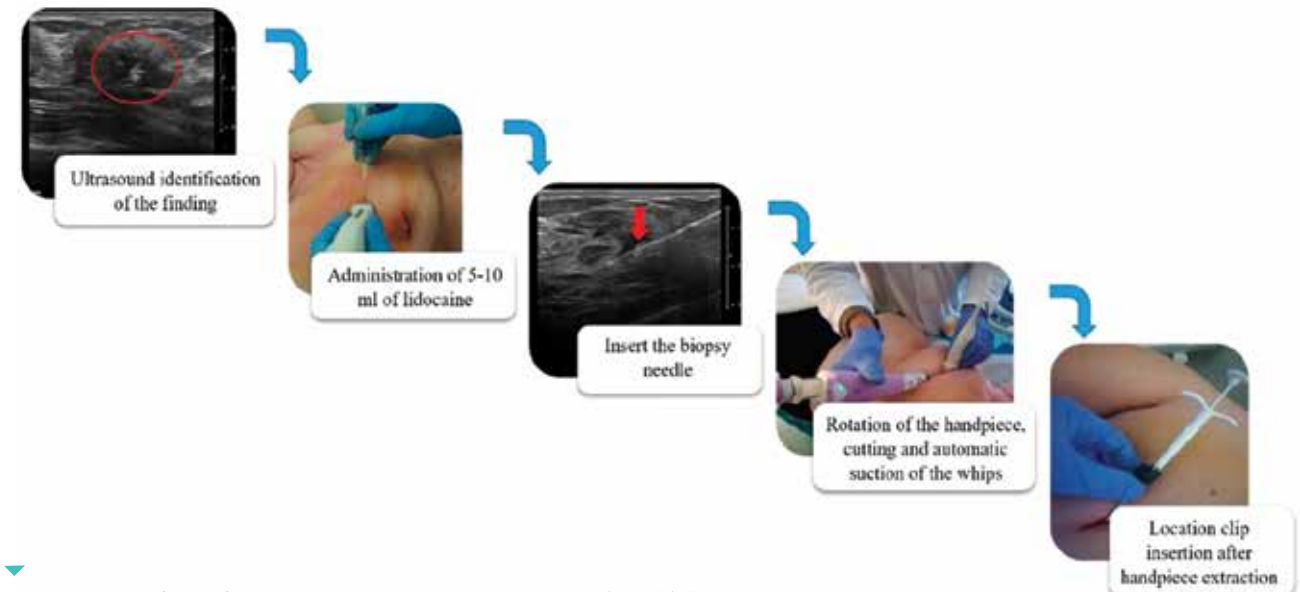

Image 4: Workflow of the vacuum-assisted breast biopsy (VABB) Elite procedure.
Source: La Forgia D, Fausto A, Gatta G, *et al. Diagnostics.* 2020;10(5):291.