



Diagnostic Accuracy of Doppler Ultrasound in the Detection of Malignant Breast Lesions and Differentiating Them from Benign Breast Masses Taking Histopathology as Gold Standard

Suman Baig¹, Abdus Sami Qazi¹, Muhammad Mehtab Baig², Muhammad Ahsan Baig³, Ayesha Ijaz Sandhu¹

¹Ali Fatima Hospital, Lahore, Punjab, Pakistan.

²Maryam Nawaz Health Clinic, Lahore, Punjab, Pakistan.

³Civil Hospital Daska, Sialkot, Punjab, Pakistan.

ARTICLE INFO

Keywords: Breast Neoplasms, Diagnostic Imaging, Histopathology, Ultrasonography.

Correspondence to: Suman Baig, Ali Fatima Hospital, Lahore, Punjab, Pakistan.

Email: drsumanbaig32@gmail.com

Declaration

Authors' Contribution

All authors equally contributed to the study and approved the final manuscript

Conflict of Interest: No conflict of interest.

Funding: No funding received by the authors.

Article History

Received: 10-03-2025 Revised: 12-05-2025

Accepted: 24-05-2025 Published: 30-05-2025

ABSTRACT

Background: Breast cancer constitutes one of the main sources of morbidity and mortality in women across the globe. For increased rates of survival, it is imperative that diagnosis is carried out early and accurately. While it is true that a biopsy is considered imperative in determining malignancy, it is also true that non-invasive diagnostic techniques have played a crucial role in its diagnosis. **Objective:** To determine the diagnostic accuracy of Doppler ultrasound in detecting malignant breast lesions using histopathology as the gold standard. **Study Design:** Cross Sectional validation study. **Duration and Place of Study:** This study was conducted from September 2024 to February 2025 in the Department of Diagnostic Radiology, Ali Fatima Hospital, Lahore. **Methodology:** A total of 154 female patients aged 30–60 years presenting with palpable solid breast lumps were included. Doppler ultrasound was performed by an experienced radiologist to evaluate internal vascularity and vessel patterns. Lesions showing multiple central or penetrating vessels were classified as malignant. Histopathological examination of tru-cut biopsy specimens served as the reference standard. **Results:** The mean age of participants was 43.95 years. Doppler ultrasound demonstrated sensitivity of 84.20%, specificity of 62.50%, positive predictive value of 86.50%, negative predictive value of 58.10%, and overall diagnostic accuracy of 78.60% ($p = 0.001$). **Conclusion:** Doppler ultrasound is a reliable and cost-effective imaging tool for detecting malignant breast lesions. It shows good sensitivity for identifying tumor vascularity and can assist in differentiating malignant from benign breast masses.

INTRODUCTION

Malignant breast lesions are cancer growth that start in ducts or lobules and then invade nearby tissue and blood or lymph channels.¹ The common types are invasive ductal carcinoma and invasive lobular carcinoma, and less common types include medullary, mucinous, and tubular tumors.² These tumors grow with abnormal cells that divide fast, form a hard mass, and induce new blood vessels that feed the mass.³ They often show irregular shape, spiculated edges, and gritty feel, and they fix to skin or chest wall when large.⁴ Nipple may retract, ulcer may form, and skin can show edema with peau d'orange.⁴ Risk rises with age, family history, BRCA1 or BRCA2 mutation, long estrogen exposure, obesity after menopause, alcohol, and prior chest radiation.⁵ Spread goes to axillary nodes first, then bone, lung, liver, and brain.⁶ Prognosis depends on tumor size, nodal spread, hormone receptor status, HER2 status, grade, and margin after surgery, and early find gives better survival and easier treatment.⁷

Diagnosis of breast masses follows a clear pathway that aims to detect cancer early and to classify it well. First step is clinical breast exam with careful palpation of both breasts and nodes.⁸ Imaging then starts with mammography for women over 40 or high risk, which shows masses, calcifications, and distortion, and uses BI-RADS for category.⁹ Ultrasound follows to tell cyst from solid and to describe shape, edge, echo pattern, and posterior features, and it helps in dense breasts and in young women.¹⁰ MRI with contrast is used in high risk screen, staging, implant evaluation, and when mammogram and ultrasound do not agree, because it shows enhancement pattern and extent.¹¹ Tissue diagnosis remains the gold standard: fine-needle aspiration gives cells, core-needle biopsy gives tissue and receptors, and vacuum-assisted biopsy helps small or microcalcification targets.¹²

Ultrasound gives special help in this work, and Doppler ultrasound adds blood flow study that improves

the power to tell malignant from benign masses. On grayscale, malignant masses tend to be taller-than-wide, have irregular or spiculated edge, hypoechoic center, posterior shadow, and sometimes duct extension; benign masses like fibroadenoma more often are oval, wider-than-tall, have smooth edge, gentle lobule, and posterior enhancement.¹³ Color and power Doppler then show internal and peripheral vessels, branching vessels, and penetrating feeders in many cancers, while benign masses show less flow or only peripheral small flow.¹⁴ Spectral Doppler can show higher peak velocity and altered waveforms in malignant vessels due to new fragile vessels and low resistance bed, while benign lesions often have lower velocity and different resistance pattern; these features support the grayscale impression but do not replace it.¹⁵ When sonographer combines grayscale with Doppler, the sensitivity for cancer detection goes up and the false positive rate can go down, especially in dense breast where mammography is less clear; adding elastography can further raise accuracy by showing stiff core that is common in cancer.¹⁵

In a study by Nadeem et al., Doppler ultrasound showed a malignancy prevalence of 55%, with sensitivity 88.9%, specificity 77.3%, diagnostic accuracy 84.7%, positive predictive value 86.9%, and negative predictive value 80.6%.¹⁶

There is need to do this study in Lahore because many women here come with breast lumps and not all can afford biopsy early. Doppler ultrasound is easy and safe method which can help to know which lesion is cancer or not. In local hospitals of Lahore still less work done on this topic, so this study will help to improve early finding and right treatment for breast cancer patients.

METHODOLOGY

This was a cross-sectional study done in the Department of Diagnostic Radiology, Ali Fatima Hospital, Lahore, from September 2024 to February 2025. Permission for the study was taken from the ethical committee of the hospital before starting. The study included 154 patients. The number of participants was calculated by using WHO sample size calculator, keeping the expected sensitivity of Doppler ultrasound as 88% and specificity as 77.33% for detecting breast cancer,¹⁶ with 95% confidence and 10% precision. Women between 30 and 60 years old who had a solid lump in the breast that can be felt by hand and were referred for ultrasound were included. Those having cystic lumps, or any previous breast surgery, or already treated with hormones or chemotherapy for breast problems were not part of this study. After taking approval, written consent was taken from each participant before collecting any data. Patients were explained the purpose of study and the simple steps of the procedure before giving agreement.

Patient information like name, age, and how long the lump was present were recorded. Short clinical history and local examination of the breast were done to locate the lump and note its size and side. Then, color Doppler ultrasound of breast was done by an experienced radiologist with more than five years of work in breast imaging. A lump on Doppler ultrasound was taken as cancer when it showed many blood vessels inside, more than two arteries in the mass, or a main artery entering the

center of lump. Lumps with only one or two vessels, poor flow, or blood supply only at the edges were taken as non-cancer. After that, a tru-cut biopsy of the same lump was performed with an 18G needle by the same radiologist. The tissue was sent to the pathology lab where senior histopathologists examined it under microscope and gave final report whether it was cancer or not. On tissue report, a lump was taken as cancer when it showed cells growing fast and irregular, loss of normal outer cell layer, and presence of abnormal shapes or dead tissue under microscope. Cases where both Doppler and tissue showed cancer were taken as true positive. If both were non-cancer, they were true negative. If Doppler showed cancer but tissue was non-cancer, it was false positive. If Doppler showed non-cancer but tissue showed cancer, it was false negative. Breast cancer was the main outcome of this research.

All collected data were analyzed using SPSS version 27. The values like age and time of lump were shown as mean and standard deviation. Results like side of breast, Doppler result, and biopsy result were given in frequencies and percentages. The results were divided into true and false categories as described. A 2x2 table was made to find sensitivity, specificity, positive predictive value, negative predictive value, and total accuracy of Doppler ultrasound while keeping biopsy report as the final comparison.

RESULTS

The study included patients with a mean age of 43.95 ± 6.43 years and the duration of breast mass was 5.77 ± 5.23 months (as shown in Table-I). Regarding lesion quadrant distribution, upper right quadrant was found in 42 patients (27.3%), lower right quadrant in 28 patients (18.2%), upper left quadrant in 43 patients (27.9%), and lower left quadrant in 41 patients (26.6%) (as shown in Table-I).

Table I

Patient Demographics and Clinical Characteristics

Demographics	Mean \pm SD / n (%)
Age (Years)	43.95 \pm 6.43
Duration of Breast Mass (Months)	5.77 \pm 5.23
Lesion Quadrant	
Upper Right n (%)	42 (27.3%)
Lower Right n (%)	28 (18.2%)
Upper Left n (%)	43 (27.9%)
Lower Left n (%)	41 (26.6%)

The overall results showed that on Doppler ultrasound, benign lesions were 111 (72.1%) and malignant lesions were 43 (27.9%), while on histopathology, benign lesions were 114 (74.0%) and malignant lesions were 40 (26.0%) out of total 154 cases (as shown in Table-II).

Table II

Overall Results of Doppler Ultrasound and Histopathology in Diagnosis of Breast Lesions

Breast Lesion Classification	Doppler Ultrasound	Histopathology
Benign	111 (72.1%)	114 (74.0%)
Malignant	43 (27.9%)	40 (26.0%)
Total	154 (100%)	154 (100%)

When comparing Doppler ultrasound versus histopathology for diagnosis of malignant breast lesions,

true positive cases were 96, false positive cases were 15, false negative cases were 18, and true negative cases were 25, with chi square value of 11.35 and p value of 0.001 which was statistically significant (as shown in Table-III).

Table III
Comparison of Doppler Ultrasound versus Histopathology in Diagnosis of Malignant Breast Lesions

Doppler Ultrasound	Histopathology		Total
	Malignant	Benign	
Malignant	96 (TP)	15 (FP)	111
Benign	18 (FN)	25 (TN)	43
Total	114	40	154

Chi square = 11.35

P value = 0.001

Key:

TP = True positive

FP = False positive

FN = False negative

TN = True negative

The diagnostic parameters of Doppler ultrasound showed sensitivity was 84.20%, specificity was 62.50%, diagnostic accuracy was 78.60%, positive predictive value was 86.50%, and negative predictive value was 58.10% for diagnosis of malignant breast lesions (as shown in Table-IV).

Table IV
Sensitivity, Specificity, Diagnostic Accuracy, PPV and NPV of Doppler Ultrasound in Diagnosis of Malignant Breast Lesions

Diagnostic Parameter	Result
Sensitivity	84.20%
Specificity	62.50%
Diagnostic Accuracy	78.60%
PPV	86.50%
NPV	58.10%

DISCUSSION

The mean age of patient in this study was 43.95 ± 6.43 years which is consistent with peak incidence of breast pathology occurring in middle aged woman because hormonal fluctuations and cumulative exposure to estrogen over reproductive years increases risk of both benign and malignant breast diseases in this age group. The mean duration of breasts mass was 5.77 ± 5.23 months which shows that most patients presented with relatively recent onset of symptoms, this can be attributed to increased awareness about breast diseases and early presentation to healthcare facilities for evaluation. The distribution of lesion across all four quadrants was fairly equal, with upper left quadrant showing slightly higher frequency at 27.9% and lower right quadrant showing lowest at 18.2%, this distribution patterns occurs because upper outer quadrants contains more glandular tissue and has greater volume of breast parenchyma where majority of both benign and malignant lesions develops. The Doppler ultrasound identified 111 benign lesions and 43 malignant lesions while histopathology confirmed 114 benign and 40 malignant lesions, this slight discrepancy demonstrates that ultrasound can sometimes overestimate malignancy due to increased vascularity which can be present in inflammatory conditions and rapidly growing benign lesions as well. The sensitivity of

Doppler ultrasound was 84.20% which indicates that technique successfully detected majority of malignant lesions, this high sensitivity occurs because malignant tumors exhibit neoangiogenesis with formation of irregular vessels having abnormal blood flow patterns that are easily detected on color Doppler imaging. The specificity was 62.50% which is relatively lower, this happens because benign conditions like fibroadenomas and inflammatory lesions also shows increased vascularity and can mimic malignant patterns on Doppler examination leading to false positive results. The positive predictive value was 86.50% suggesting that when Doppler ultrasound diagnoses lesion as malignant, it is correct in most cases, this occurs due to characteristic vascular features of malignant tumors including high peak systolic velocity and low resistance index. The negative predictive value was 58.10% which is lower, indicating that benign diagnosis on Doppler should be interpreted with caution because some malignant lesions particularly small or well-differentiated tumors may not show prominent vascular changes in early stages. The overall diagnostic accuracy was 78.60% with statistically significant p value of 0.001, this demonstrates that Doppler ultrasound is valuable diagnostic tool but should be combined with other imaging modalities and clinical findings for comprehensive evaluation of breast lesions.

The present study demonstrated sensitivity of 84.20% which is comparable to findings reported by Arshad B, et al. who found sensitivity of 84.8% [16], however it is slightly lower than sensitivity reported by Parveen I, et al. at 92.4%¹⁷ and Nadeem F, et al. at 88.97%¹⁸, this variation in sensitivity values can be attributed to differences in patient selection criteria and cut-off values used for resistance index in different studies where higher cut-off values may reduce sensitivity but improve specificity. The specificity of 62.50% in current study is considerably lower compared to other studies, for instance Arshad B, et al. reported specificity of 95%¹⁶, Parveen I, et al. found 88.77%¹⁷, and Nadeem F, et al. demonstrated 77.33%¹⁸, this lower specificity in present study indicates higher false positive rate which occurs because inflammatory and benign proliferative lesions also shows increased vascularity mimicking malignant patterns and strict criteria for malignancy detection may not have been applied uniformly across all examinations. Also, the diagnostic performance of 78.60% in current study is less sensitive than in most of similar studies as Arshad B, et al. recorded 92% diagnostic performance¹⁶, Parveen I, et al. showed 90.67%¹⁷, Quratulain S, et al. recorded 88.11%¹⁹, Tabassum M, et al. demonstrated 88.48% diagnostic performance²⁰, Khan ZG, et al. recorded 88.57% diagnostic performance²¹, and Nadeem F, et al. recorded 84.65% diagnostic performance¹⁸, which could be because of varied specifications of ultrasonic machines, varied expertise of operators, and less stringent criteria of malignancy in vascular division. The positive predictive value of 86.50% in current study is consistent with findings by Nadeem F, et al. who reported 86.92%¹⁸ and Parveen I, et al. with 90.12%¹⁷, this similarity suggests that when Doppler ultrasound identifies malignant features, it is reliable across different settings regardless of variations in other diagnostic parameters. The negative

predictive value of 58.10% is markedly lower than other studies where Parveen I, et al. found 91.3%¹⁷, Arshad B, et al. reported 93%¹⁶, and Tabassum M, et al. showed 87.5%²⁰, this discrepancy indicates that benign classification on Doppler in present study is less reliable and may result in missed malignancies particularly in early stage tumors without prominent neovascularization. The mean age of patients at 43.95±6.43 years in present study is similar to age groups studied by Parveen I, et al. with mean age of 40.23±5.75 years¹⁷ and Arshad B, et al. with mean age of 42.97±7.66 years¹⁶, this consistency across studies confirms that breast pathologies predominantly affect women in fourth and fifth decades when cumulative hormonal exposure and glandular tissue changes are maximal. Studies done using strain elastography together with Doppler as in Prabakaran L, et al. showed a higher degree of accuracy of 96%²², which indicates that a combination of various methods of ultrasonography performs better than individual Doppler ultrasonography, this is because while one measures stiffness of tissues, the other measures vascularity thus offering a complementary aspect of lesion qualities. Statistical significance with a p-value of 0.001 in this study clearly depicts that a positive relationship exists between histopathology and findings of Doppler ultrasonography, as was seen in studies done by Waqar S, et al., where differences in vascularity measures were seen in malignant and benign lesions as significant.²³

There are a number of limitations in the current study that need to be considered. Firstly, it is a single center study, which could lead to limitations in the

generalisability of results in a different population. Secondly, it is a study of 154 patients that may not be a fair representation of all types of breast pathologies that are common in a real situation. Finally, it is a study that may not have provided stratified data based upon lesion sizes or histological types or patient's risk factors that could have been helpful in understanding its performance in a particular type of situation. Fourth, interobserver variability was not assessed and different operators may interpret Doppler findings differently affecting diagnostic accuracy particularly in borderline cases.

CONCLUSION

Our study has concluded that Doppler ultrasound is effective diagnostic tool for detection of malignant breast lesions when histopathology is taken as gold standard. The technique demonstrates good sensitivity in identifying malignant lesions through assessment of vascularity patterns and blood flow characteristics which are typical features of tumor neoangiogenesis. However, the specificity is moderate indicating that some benign lesions also shows increased vascularity leading to false positive results.

Acknowledgments

We express our gratitude towards the dedicated efforts of healthcare professionals working in our unit whose meticulous approach in documenting clinical information and systematic handling of patient records has contributed significantly to this research endeavor.

REFERENCES

- Kuhn, E., Gambini, D., Despini, L., Asnaghi, D., Runza, L., & Ferrero, S. (2023). Updates on Lymphovascular invasion in breast cancer. *Biomedicines*, 11(3), 968. <https://doi.org/10.3390/biomedicines11030968>
- Jenkins, S., Kachur, M. E., Rechache, K., Wells, J. M., & Lipkowitz, S. (2021). Rare breast cancer subtypes. *Current Oncology Reports*, 23(5). <https://doi.org/10.1007/s11912-021-01048-4>
- Torland, L. A., Lai, X., Kumar, S., Riis, M. H., Geisler, J., Lüders, T., Tekpli, X., Kristensen, V., Sahlberg, K., & Tahiri, A. (2023). Author response for "Benign breast tumors may arise on different immunological backgrounds". <https://doi.org/10.1002/1878-0261.13655/v2/response1>
- Al-Khalili, R., Alzeer, A., Nguyen, G., Crane, E. P., Song, J. H., Jeon, J. L., Nellamattathil, M., Makariou, E. V., & Mango, V. L. (2021). Palpable lumps after mastectomy: Radiologic-pathologic review of benign and malignant masses. *RadioGraphics*, 41(4), E967-E989. <https://doi.org/10.1148/rg.2021200161>
- Obeagu, E. I., & Obeagu, G. U. (2024). Breast cancer: A review of risk factors and diagnosis. *Medicine*, 103(3), e36905. <https://doi.org/10.1097/md.00000000000036905>
- Ibragimova, M. K., Tsyganov, M. M., Kravtsova, E. A., Tsydenova, I. A., & Litviakov, N. V. (2023). Organ-specificity of breast cancer metastasis. *International Journal of Molecular Sciences*, 24(21), 15625. <https://doi.org/10.3390/ijms242115625>
- Yousef, E. M., Alswilem, A. M., Alfaraj, Z. S., Alhamood, D. J., Ghashi, G. K., Alruwaily, H. S., Al Yahya, S. S., & Alsaeed, E. (2025). Incidence and prognostic significance of hormonal receptors and HER2 status conversion in recurrent breast cancer: A retrospective study in a single institute. *Medicina*, 61(4), 563. <https://doi.org/10.3390/medicina61040563>
- Health Commission of the People's Republic of China N. National guidelines for diagnosis and treatment of breast cancer 2022 in China (English version). *Chin J Cancer Res*. 2022;34(3):151-175. <https://doi.org/10.21147/j.issn.1000-9604.2022.03.02>
- Grimm, L. J., Avery, C. S., Hendrick, E., & Baker, J. A. (2022). Benefits and risks of mammography screening in women ages 40 to 49 Years. *Journal of Primary Care & Community Health*, 13. <https://doi.org/10.1177/21501327211058322>
- Al Jahed, D., Dekeyzer, S., Vanwambeke, K., Antic, M., Vanhoenacker, C., & Vanhoenacker, F. (2022). Automated breast ultrasound (ABUS): A pictorial essay of common artifacts and benign and malignant pathology. *Journal of Ultrasonography*, 22(91), 222-235. <https://doi.org/10.15557/jou.2022.0037>
- Taylor, D. B., Burrows, S., Saunders, C. M., Parizel, P. M., & Ives, A. (2023). Contrast-enhanced mammography (CEM) versus MRI for breast cancer staging: Detection of additional malignant lesions not seen on conventional imaging. *European Radiology Experimental*, 7(1). <https://doi.org/10.1186/s41747-022-00318-5>
- Khan, A. Q., Touseeq, M., Rehman, S., Tahir, M., Ashfaq, M., Jaffar, E., & Abbasi, S. F. (2025). Advances in breast cancer diagnosis: A comprehensive review of imaging, biosensors, and emerging wearable technologies. *Frontiers in Oncology*, 15. <https://doi.org/10.3389/fonc.2025.1587517>
- Park, S. Y., Park, J. Y., Park, J. W., Kim, W. H., Park, J. Y., & Kim, H. J. (2022). Unexpected hyperechoic lesions of the

- breast and their correlations with pathology: A pictorial essay. *Ultrasonography*, 41(3), 597-609.
<https://doi.org/10.14366/usg.21243>
14. Park, A. Y., Seo, B. K., & Han, M. (2021). Breast ultrasound Microvascular imaging and Radiogenomics. *Korean Journal of Radiology*, 22(5), 677.
<https://doi.org/10.3348/kjr.2020.1166>
 15. Park, A. Y., & Seo, B. K. (2018). Up-to-date Doppler techniques for breast tumor vascularity: Superb microvascular imaging and contrast-enhanced ultrasound. *Ultrasonography*, 37(2), 98-106.
<https://doi.org/10.14366/usg.17043>
 16. Arshad B, et al. Diagnostic accuracy of spectral Doppler ultrasound in predicting malignancy in solid breast lesions. *KRL Hosp J Radiol*. 2022;(accepted).
 17. Parveen, I., Javed, K., Elahi, B., Nasrullah, F., Mahmood, R., & Aamir, M. O. (2020). Evaluation of breast lesions with Doppler ultrasound: Diagnostic accuracy of resistive index as a predictor of malignancy. *The Professional Medical Journal*, 27(04), 825-830.
<https://doi.org/10.29309/tpmj/2020.27.04.3947>
 18. Nadeem F, et al. (2020). Diagnostic accuracy of power Doppler ultrasonography in evaluation of solid breast mass lesions for malignancy. *Pak Armed Forces Med J*. 2020;70(2).
<https://www.pakjr.com/index.php/PIR/article/view/1259>
 19. Quratulain, S., Bibi, S., Gul, S., Khatoon, S., Mujeeb, Z., & Akram, S. (2024). The diagnostic accuracy of conventional breast ultrasound in diagnosing malignant breast lesions taking histopathology as gold standard. *Pakistan Journal of Health Sciences*, 36-41.
<https://doi.org/10.54393/pjhs.v5i06.1657>
 20. Tabassum, M., Waseem, R., Niazi, M., Riaz, Z., Shakil, H., & Anam, W. (2024). Diagnostic accuracy of spectral Doppler ultrasound in diagnosis of malignant breast lesions taking histopathology as gold standard. *Journal of Rawalpindi Medical College*, 28(3).
<https://doi.org/10.37939/jrmc.v28i3.2345>
 21. Khan, Z., Saleem, M., Bhutta, M., Ullah, N., Fatima, U., & Yousuf, M. (2023). Diagnostic Accuracy of Ultrasonography in the Diagnosis of Breast Carcinoma in Mammographically Dense Breasts: Histopathology as the Gold Standard. *Journal of The Society of Obstetricians and Gynaecologists of Pakistan*, 13(4), 398-402.
<https://jsogp.net/index.php/jsogp/article/view/700>
 22. Prabakaran, L., Aiyappan, S. K., Ramesh, S., Ramesh, R., & Kumaran, S. (2024). Diagnostic Accuracy of Spectral Doppler Indices and Sonoelastography in Predicting Malignancy in Breast Imaging Reporting and Database System 3 Breast Lesions With Histopathology as the Reference Standard. *Cureus*, 16(11).
<https://doi.org/10.7759/cureus.73481>
 23. Waqar, S., Ameer, S., Bajwa, M. A., Bajwa, S. M., Bajwa, G. R., & Tahir, S. (2021). SIGNIFICANCE OF DOPPLER RI AND SYSTOLIC PEAK OF BREAST CARCINOMA LESIONS SEEN ON MAMMOGRAPHY. *DOAJ (DOAJ: Directory of Open Access Journals)*, 71(1), 319-322.