Application of Power Doppler Vocal Fremitus Sonography in Breast Lesions

Min Jung Kim, MD, Eun-Kyung Kim, MD, Ji Hyun Youk, MD, Ji Young Lee, MD, Byung Moon Kim, MD, Ki Keun Oh, MD

Objective. The purpose of this study was to illustrate the method and use of power Doppler vocal fremitus (PDVF) sonography in the detection and diagnosis of breast lesions. ***Methods.*** One case was evaluated by various sonographic parameters and equipment to determine how the VF images were affected. Cases illustrative of a broad range of breast conditions were also collected. Each image pair consisted of B-mode and VF images to maintain an identical projection and to illustrate the influence of PDVF sonography. ***Results.*** With B-mode and PDVF sonography, we evaluated and compared various breast conditions, including normal anatomic structures and abnormal lesions. We found that PDVF sonography is useful for distinguishing abnormal masses from normal tissue, such as differentiating between isoechoic tumors and isoechoic glandular tissues, and discriminating entrapped fat lobules from isoechoic tumors. Furthermore, PDVF sonography was useful for determining whether intracystic echoes are attached to the cyst wall. ***Conclusions.*** Power Doppler VF imaging is a valuable adjunct tool to B-mode sonography in the evaluation of breast lesions. ***Key words:*** breast sonography; Doppler sonography; ultrasound technology.

Abbreviations
PDVF, power Doppler vocal fremitus; PRF, pulse repetition frequency

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Address correspondence to Eun-Kyung Kim, MD, Department of Diagnostic Radiology, Yonsei University College of Medicine, Seodaemun-ku Shinchon-dong 134, Seoul 120-752, Korea.

E-mail: ekkim@yumc.yonsei.ac.kr

Power Doppler vocal fremitus (PDVF) sonography is the controlled manipulation of power Doppler artifacts during the oscillation of a patient's chest wall through vocalized sound. Sohn et al[1–3] first described PDVF imaging, finding that when a patient spoke during color Doppler examination, vibrations from the chest wall created color artifacts in normal tissue but not within tumors. They also found that benign and malignant masses could be distinguished in the filling defect pattern of the color artifact; however, Stavros[4] reported that the vibratory artifact cannot distinguish benign from malignant masses and suggested that the artifact defect could be useful in differentiating abnormal lesions from normal tissue.

The intent of this study was to show the usefulness of PDVF sonography in various breast conditions.

Materials and Methods

This study included 87 patients and was performed in the Ultrasound Division of the Department of Radiology, Severance Hospital (Seoul, Korea), between April and May 2005 with an HDI 5000 system (Philips Medical Systems, Bothell, WA) and an IU-22 system (Philips Medical Systems) with a broad-bandwidth L12-5 linear scan head. In our institution during that period, before a biopsy was performed, all breast masses or masslike lesions were scanned first by gray scale imaging and then by power Doppler imaging with the VF technique. After the patient was scanned with B-mode imaging, the patient was then instructed to sound the vowel "eeee" or "arr" for 5 to 10 seconds while the breast was examined with power Doppler sonography. The parenchymal vibrations due to the fremitus were shown by placing a Doppler box around the region of interest. A VF image was usually obtained with the preferred parameters used by Schultz et al[5] (a pulse repetition frequency [PRF] of approximately 1000, a default gain, a low wall filter, and a default focal zone). To optimize the contrast of a lesion versus surrounding tissues, varied parameters of sonographic equipment that could influence the effect of PDVF imaging were applied in terms of power Doppler PRF (500–1000), gain (increased or default), wall filter (low to maximum variation), focal zone movement, and size of the sampling box (small or large).

Results

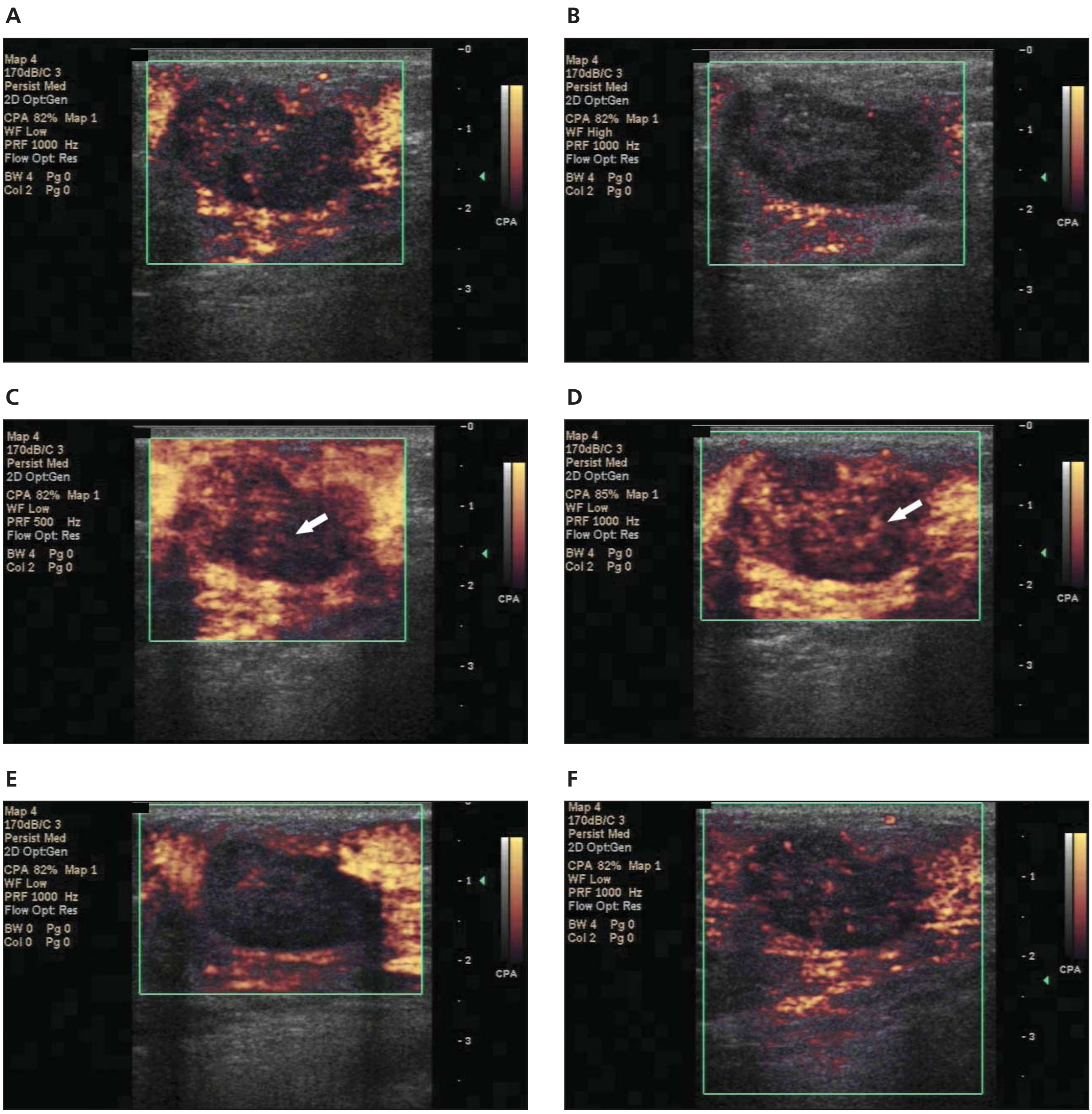
The influence of various parameters in terms of gain, wall filter, PRF, focal zone movement, and sampling box size on VF images is shown in Figure 1. Representative examples of various breast conditions, including fat lobules and benign and malignant breast lesions, are shown in Figures 2–13 and show the influence of PDVF sonography.

Discussion

Sohn et al[1–3] suggested that color PDVF sonography could differentiate between benign and malignant masses and could also characterize breast lesions. In addition, their study reported that the differential diagnosis was in agreement with the histologic results in 91% of the cases; however, we found few reports in the literature supporting these findings. Recently, Stavros[4] reported that PDVF sonography could not distinguish benign from malignant masses. His investigation suggested that power Doppler imaging was more sensitive than color Doppler imaging for VF. Furthermore, his study found that power Doppler imaging is more useful for distinguishing abnormal masses from normal tissues than for differentiating between benign and malignant masses. In the current study, our results are in keeping with those reported by Stavros.[4] We found that any solid mass, whether benign or malignant, including those masses with calcifications, prominent vascularity, dense fibrosis, hyalinization, or mural nodules within cystic portions, showed internal vibrational artifacts in the middle of the tumor during PDVF imaging, which can result in false-negative PDVF results (Figures 8–11). Garra et al[6] and Lin et al[7] suggested that malignant breast lesions could be distinguished from benign masses by using the size difference in vibrational imaging; however, in contrast to the work of Garra et al[6] and Lin et al,[7] we found that their assertion was not applicable for all breast cancers but only for spiculated ones with an echogenic halo (Figures 1 and 2). (Note that circumscribed malignant lesions, such as benign lesions, have fremitus defects the same size as the lesions on gray scale imaging.)

We also found that the defect of a vibrational artifact during PDVF sonography only indicated that those areas showing no vibrational artifact had tissue components that were different from surrounding tissues at the same depth and had different susceptibility for vibration as well (Figure 13). We believed that the artifact in the middle of the malignant mass reported by Sohn et al[2] was likely to result from a microcalcification or a fibrotic cord that was susceptible to vibration (Figures 8–10). Moreover, we found that vibrational Doppler imaging was helpful for the detection of lesions in some cases. These results are similar to the findings reported by Stavros.[4] We suggest that the most applicable use for VF imaging is to distinguish isoechoic tumors from fatty tissue or to differentiate between isoechoic glandular tissues and fat lobules (Figures 5–7). Vocal fremitus imaging was helpful for detecting multifocal disease as well (Figure 5). Another use for VF imaging would be to identify intracystic lesions. The intracystic solid portion, which was attached to the cystic wall, showed the same vibrational artifact as the artifacts caused by the wall, where-

Figure 1. Invasive papilloma in a 73-year-old woman that was confirmed by a 14-gauge core needle biopsy. This case illustrates the influence of the wall filter on PDVF imaging by various parameters. **A**, Vocal fremitus image with the preferred parameters used by Schultz et al[5] (a PRF of ≈1000, a default gain, a low wall filter, and a default focal zone) shows prominent parenchymal enhancement, which improved the contrast between the lesion and the surrounding parenchyma. **B**, Vocal fremitus image with a high wall filter shows minimal parenchymal enhancement and diminishes the fremitus effect. Schultz et al[5] stressed that the low wall filter gave the strongest fremitus effect. Note the difference between **A** and **B**. **C**, Vocal fremitus image with a PRF of approximately 500 augments the enhancement of surrounding tissues but lessens the fremitus effect by showing vibratory artifacts (arrow) in the middle of the lesion. Nevertheless, we used a PRF of approximately 700 or 500 when the region of interest was superficially located or was surrounded by fat tissue. **D**, Vocal fremitus image with increased gain also shows further vibratory artifacts (arrow) in the lesion and decreased differentiation between the lesion and the surrounding parenchyma. **E**, Vocal fremitus image with the focal zone on the exact center of the mass amplifies the Doppler artifact difference between the lesion and the surrounding parenchyma. Note that placement of the focal zone in the center of the mass increases the enhancement of the surrounding parenchyma without the effect of the artifact in the lesion. **F**, Vocal fremitus image with the large Doppler box shows no difference in VF effect when compared with an image with the small Doppler box shown in **A**. Note that the most effective and strongest fremitus effect was shown by the parameter combination in **E**.



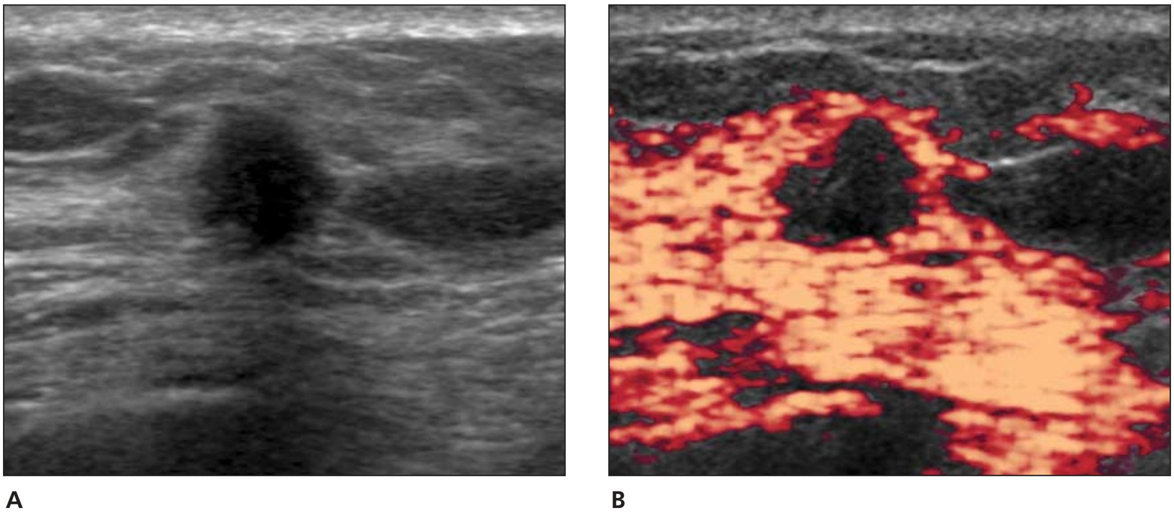
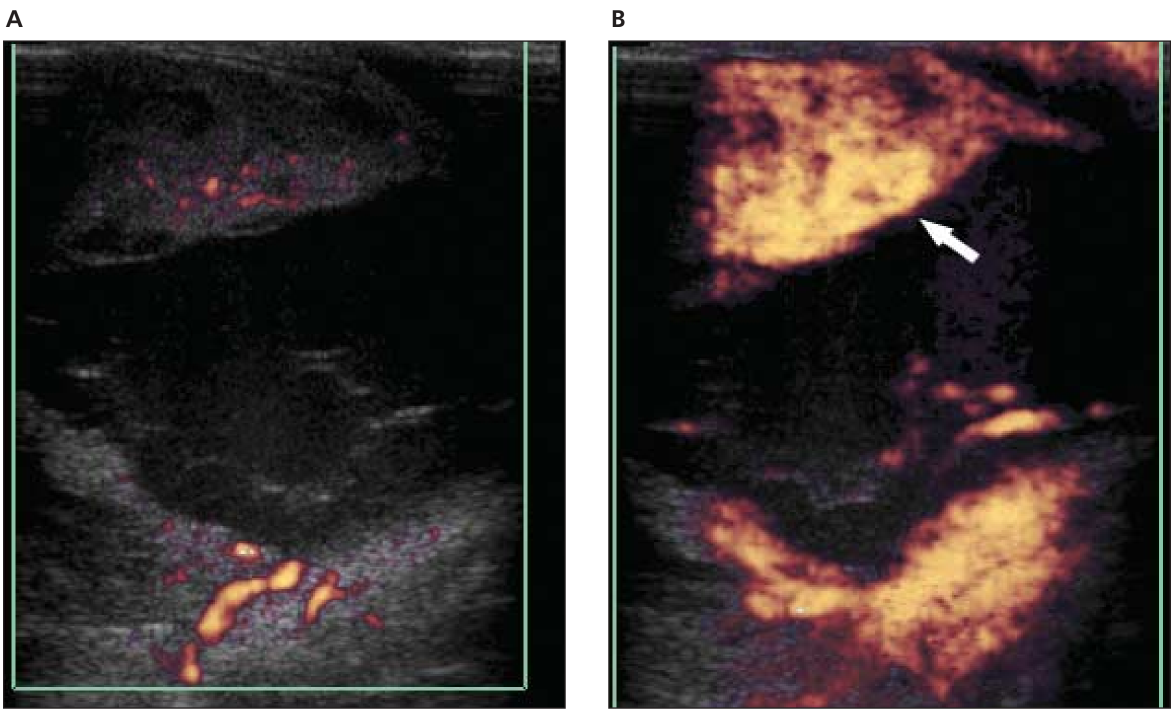


Figure 2. Infiltrating ductal carcinoma in a 61-year-old woman that was confirmed by 14-gauge core needle biopsy. **A**, B-mode image shows spiculated margins, a hypoechoic internal echo texture, and a thick echogenic halo. **B**, Vocal fremitus image shows a larger acoustic vibratory defect size than the corresponding hypoechoic area of the B-mode image. The extent of the defect includes the echogenic boundary, suggestive of fine spiculations, as well as the hypoechoic area.

as the debris or lipid cyst with fat-fluid levels arising from chronic hematomas, which were detached from the cystic wall, showed the artifact defect (Figures 3 and 4). Furthermore, the cystic fluid seemed to amplify the vibrational effect of the intracystic solid portion. Although gray scale imaging alone can show movement of debris or lipid levels, the debris levels and lipid levels are so viscous that it can take approximately 5 minutes for the shift from one position to

Figure 3. Intraductal papilloma in a 31-year-old woman that was confirmed by a 14-gauge core needle biopsy and a subsequent excision. **A**, Power Doppler image shows the vascularity of the intracystic mural nodule. **B**, Vocal fremitus image shows an intensive vibratory artifact in the mural nodule (arrow) and absence of the artifact in the cystic portion.



another to occur. In women with florid fibrocystic changes, there may be as many as a dozen cysts with fat-fluid levels, fluid-debris levels, or both on each side; 5 minutes is too long to wait for each of these to shift. Thus, PDVF sonography becomes a shortcut to distinguish an attached mural nodule from unattached debris or a floating lipid layer and takes much less time than changing the patient position and waiting for interfaces to change alignment.

We acknowledge that VF imaging is limited by interobserver and intraobserver variability in interpretation and performance. Another limitation is the intersubject variability caused by the patient's condition, such as body habitus and lung disease. The patient could have various degrees of the ability to vibrate her chest wall by vocal sound. If she has chronic lung disease, the ability will be decreased. Therefore, the standardization of parameters for VF imaging is very important for decreasing these variables in practical applications. Schultz et al[5] preferred to use a power Doppler PRF of approximately 1000, a default gain, a low wall filter, and an appropriate focal zone, and write priority settings. Our preferences were similar to those of Schultz et al.[5] In addition, rather than increase the gain, we used a lower PRF, such as approximately 700 or 500, when the region of interest was superficially located or surrounded by fat tissue. Otherwise, we would have used a PRF of 1000. We also preferred placing the focal zone arrow on the exact anteroposterior center of the lesion rather than elsewhere in the lesions (Figure 1). Schultz et al[5] stressed that parameter optimization was very important in VF imaging, and the low wall filter gave the strongest fremitus effect.

A

B

C

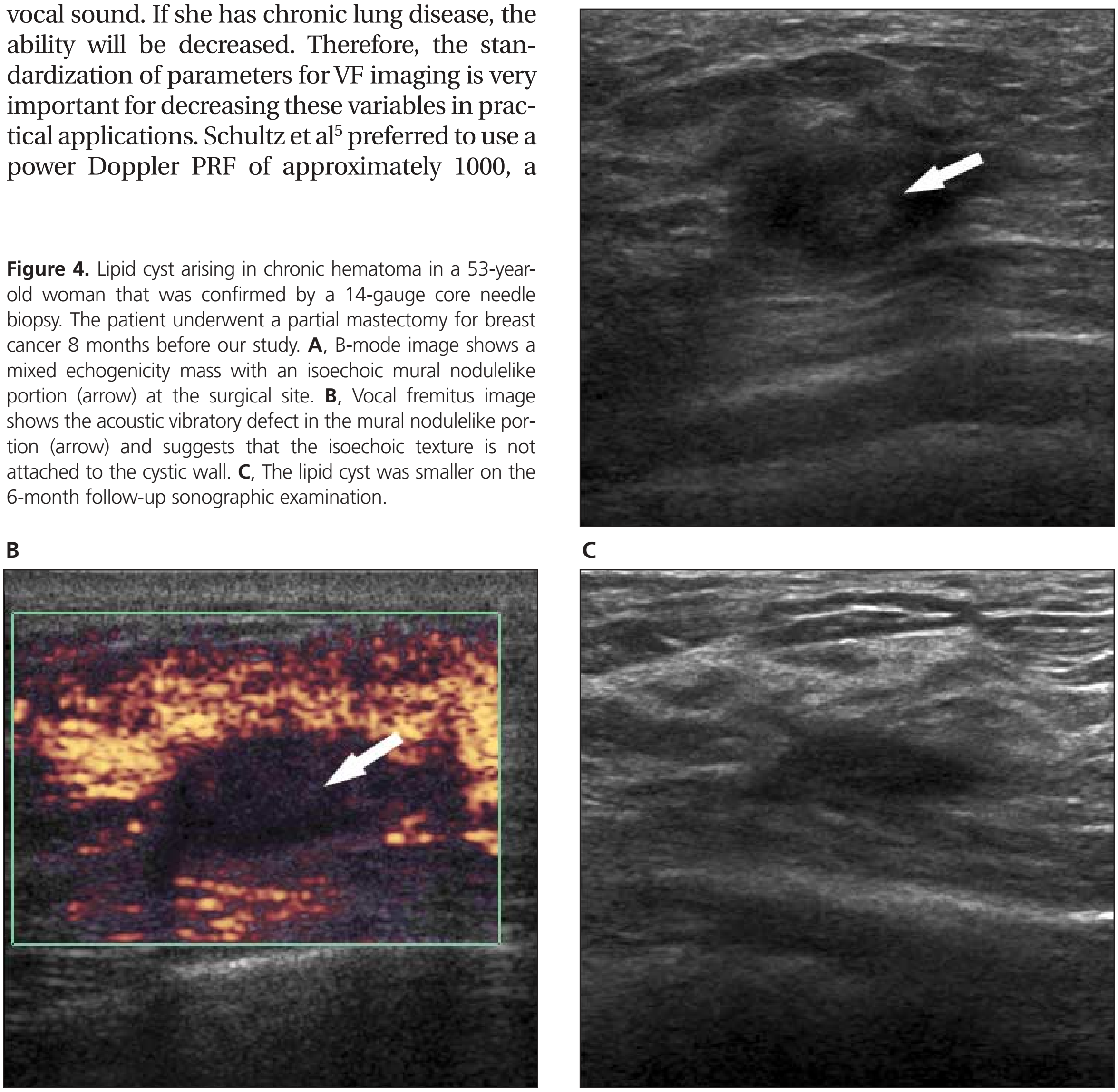
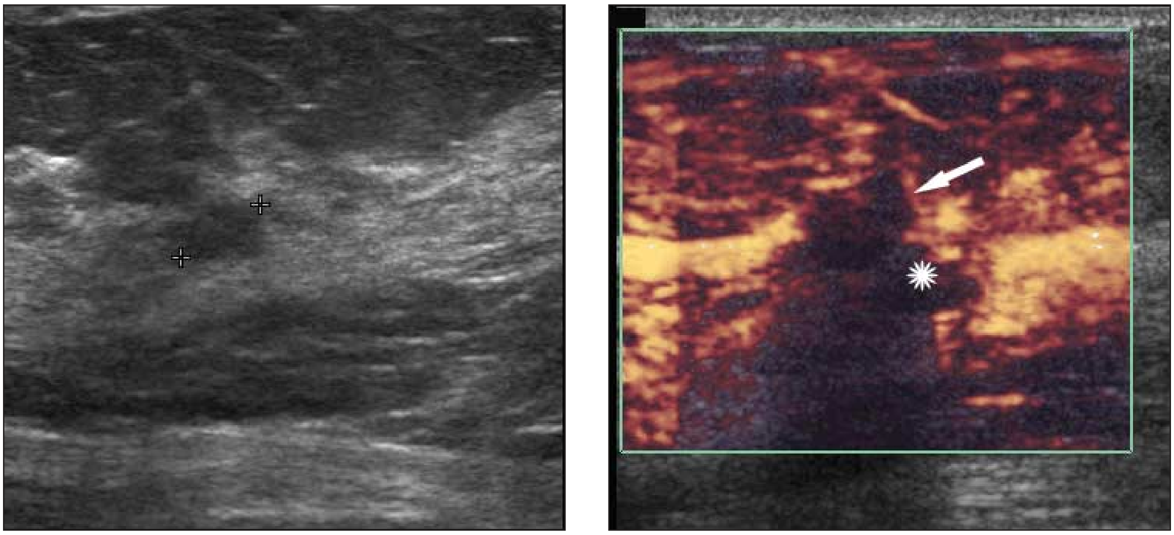


Figure 4. Lipid cyst arising in chronic hematoma in a 53-year-old woman that was confirmed by a 14-gauge core needle biopsy. The patient underwent a partial mastectomy for breast cancer 8 months before our study. **A**, B-mode image shows a mixed echogenicity mass with an isoechoic mural nodulelike portion (arrow) at the surgical site. **B**, Vocal fremitus image shows the acoustic vibratory defect in the mural nodulelike portion (arrow) and suggests that the isoechoic texture is not attached to the cystic wall. **C**, The lipid cyst was smaller on the 6-month follow-up sonographic examination.



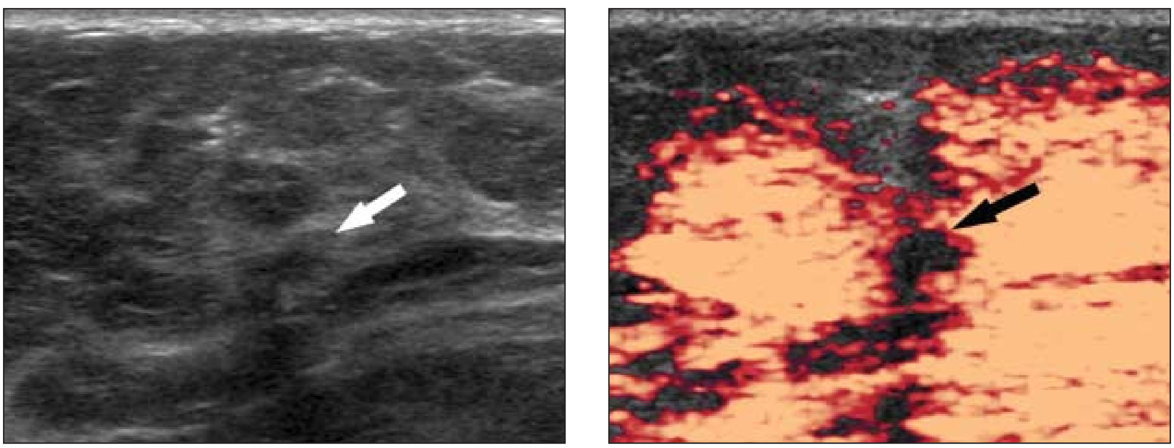
A B

Figure 5. Fibroadenoma in a 58-year-old woman. **A**, B-mode image shows an isoechoic nodule (calipers) at the mammary zone. **B**, Vocal fremitus image shows an additional acoustic vibratory defect (arrow) at the superficial aspect of the previous nodule (asterisk). The additional lesion was initially missed on real-time imaging. The 2 nodules were shown to be fibroadenomas by 14-gauge core needle biopsies. A VF image may be helpful for detecting multifocal disease.

In summary, PDVF sonography is useful in practical applications for the following cases: identification of isoechoic tumors in isoechoic glandular tissue or fat tissue, differentiation of isoechoic tumors versus entrapped fat lobules, detection of multifocality of lesions, and determination of a wall attachment for intracystic echoes. Therefore, although VF imaging has several limitations, this technique enables us to obtain useful information in detecting and characterizing lesions. Furthermore, VF imaging is a valuable adjunctive tool to B-mode sonography in the evaluation of breast lesions.

Figure 6. Infiltrating ductal carcinoma in a 53-year-old woman that was confirmed by a 14-gauge core needle biopsy. **A**, B-mode image shows a questionable isoechoic distortion (arrow). **B**, Vocal fremitus image shows a corresponding vibratory artifact defect (arrow) that was identical in size and shape to the finding noted on the B-mode image. The VF image was helpful in confirming the presence of the subtle distortion.

A B



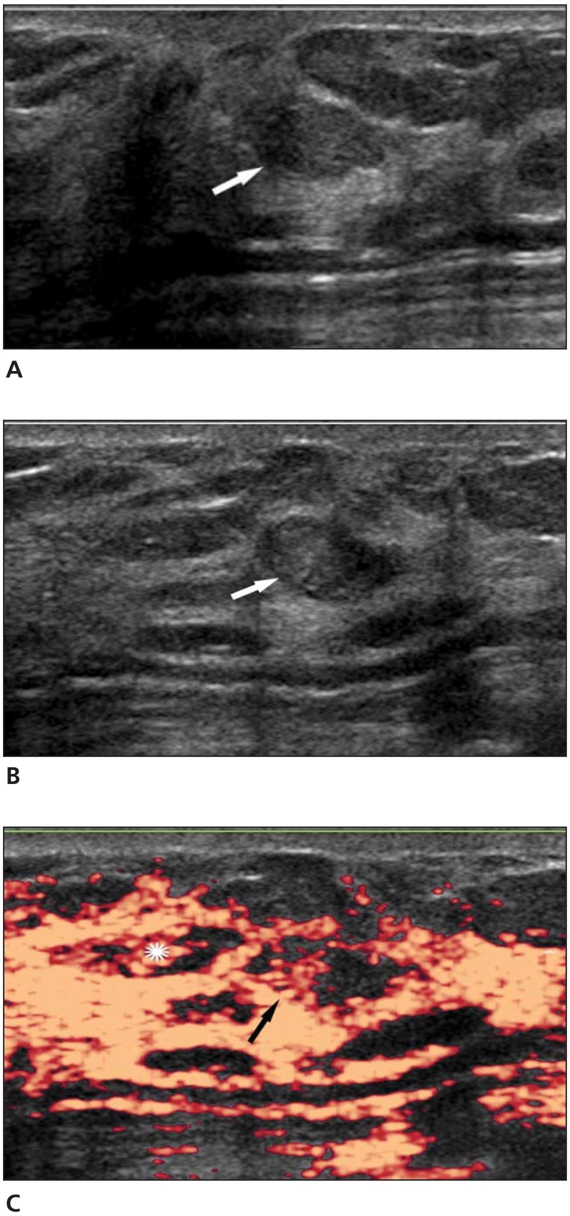


Figure 7. Isolated fat lobule in a 29-year-old woman that was confirmed by a 14-gauge core needle biopsy. **A** and **B**, B-mode images show a lobulated, circumscribed, isoechoic lesion (arrows). The differentiation between a fat lobule and an isoechoic tumor is not possible with B-mode scans. **C**, Vocal fremitus image shows normal vibrational artifacts (arrow), indicating that the finding was a fat lobule. The lesion vibrated identically to the surrounding fat (asterisk) at a similar depth.

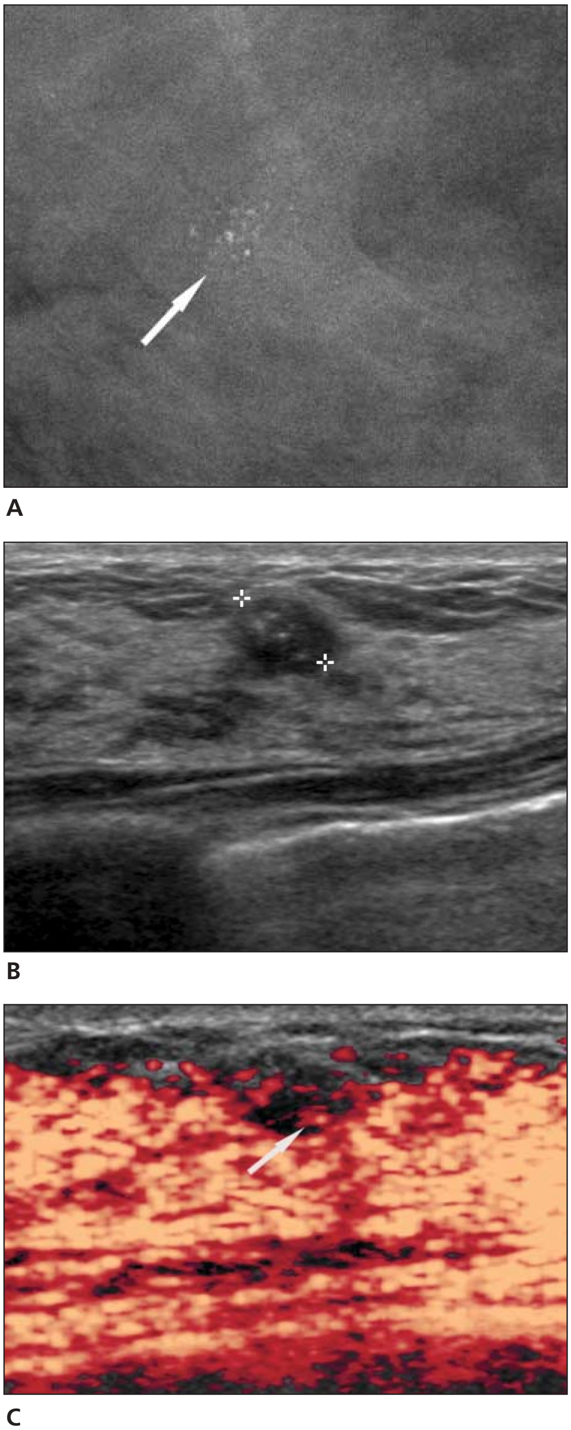


Figure 8. Intraductal papilloma with microcalcifications in a 34-year-old woman that was confirmed by a 14-gauge core needle biopsy. **A**, Clustered amorphous microcalcifications (arrow) are shown on the mediolateral oblique view of the right breast. **B**, B-mode image shows a hypoechoic mass (calipers) with several echogenic foci indicating microcalcifications. **C**, Vocal fremitus image shows the internal vibratory artifact (arrow) in the lesion. The lesion, which contains numerous calcifications, might be obscured by the vibration of internal calcifications.

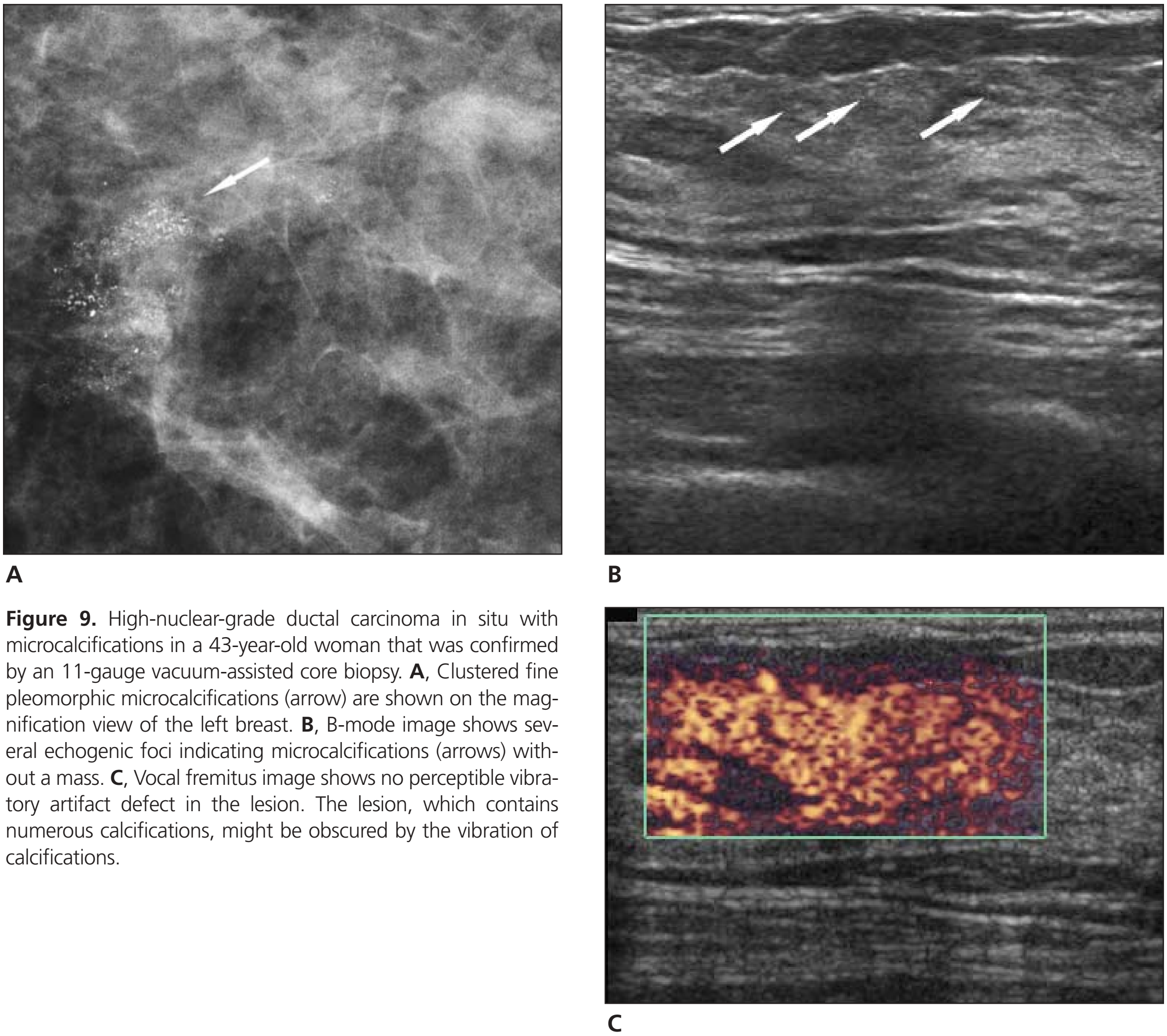
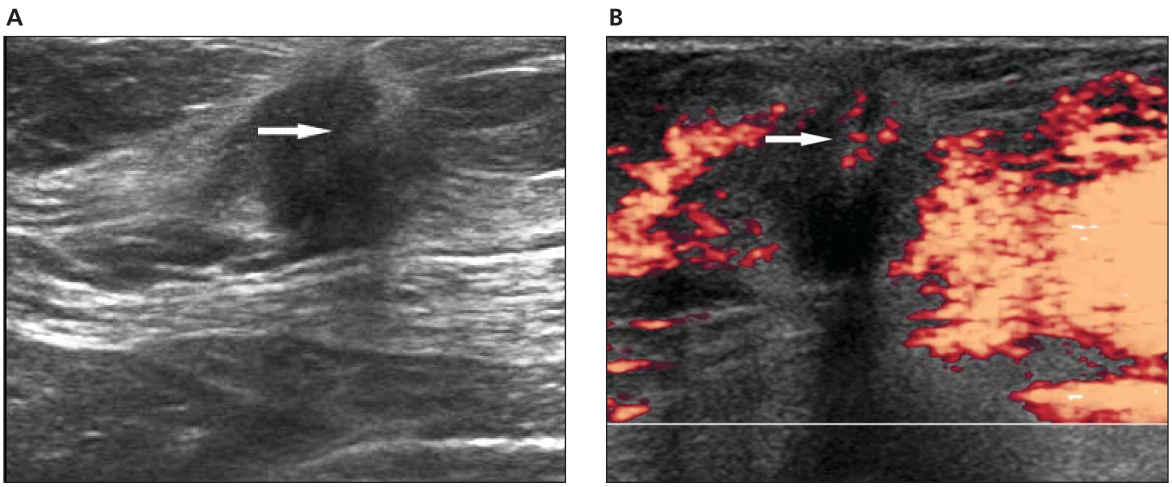
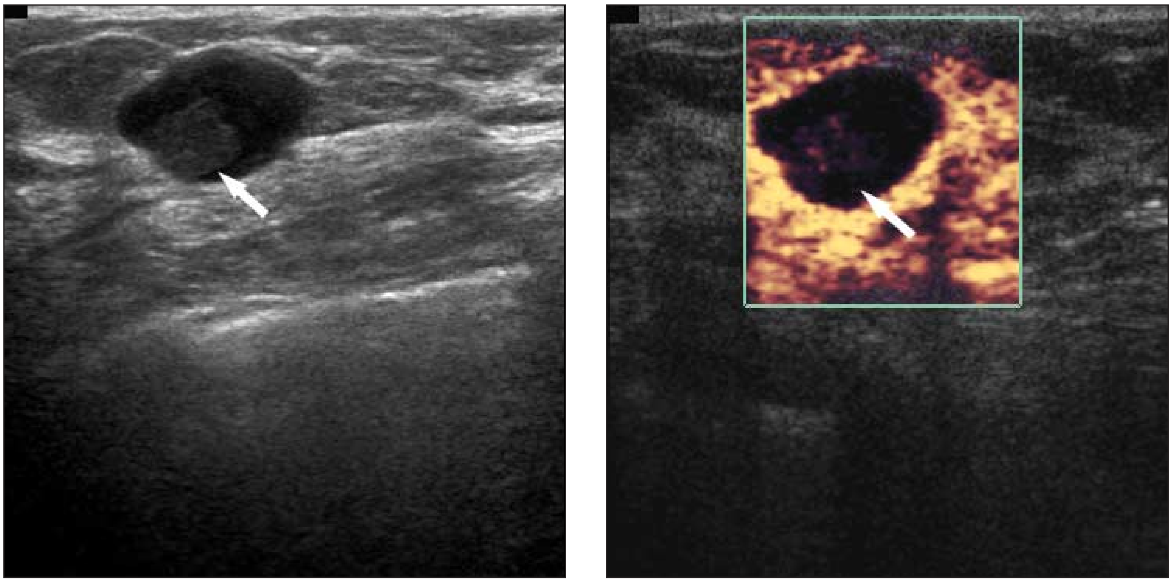


Figure 9. High-nuclear-grade ductal carcinoma in situ with microcalcifications in a 43-year-old woman that was confirmed by an 11-gauge vacuum-assisted core biopsy. **A**, Clustered fine pleomorphic microcalcifications (arrow) are shown on the magnification view of the left breast. **B**, B-mode image shows several echogenic foci indicating microcalcifications (arrows) without a mass. **C**, Vocal fremitus image shows no perceptible vibratory artifact defect in the lesion. The lesion, which contains numerous calcifications, might be obscured by the vibration of calcifications.

Figure 10. Infiltrating ductal carcinoma in a 50-year-old woman that was confirmed by a 14-gauge core needle biopsy. **A**, B-mode image shows a spiculated margin and an internal echogenic focus (arrow). **B**, Vocal fremitus image shows the artifactual defect, including a thick echogenic boundary and the internal vibratory artifact corresponding to the internal echogenic foci (arrow) on the B-mode image. The echogenic focus was a fibrotic central scar in the specimen.



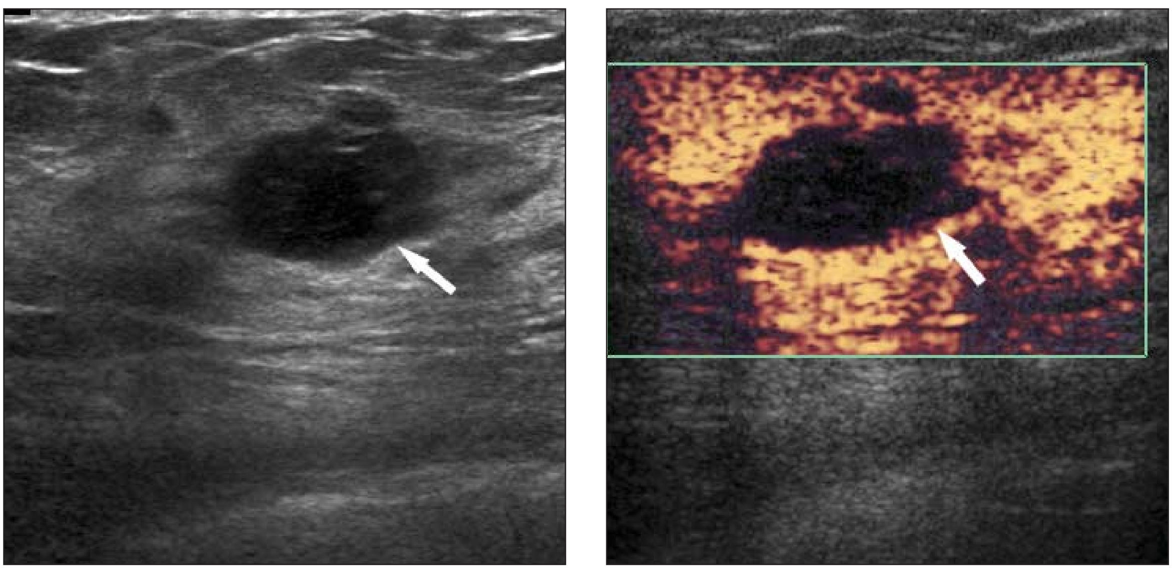


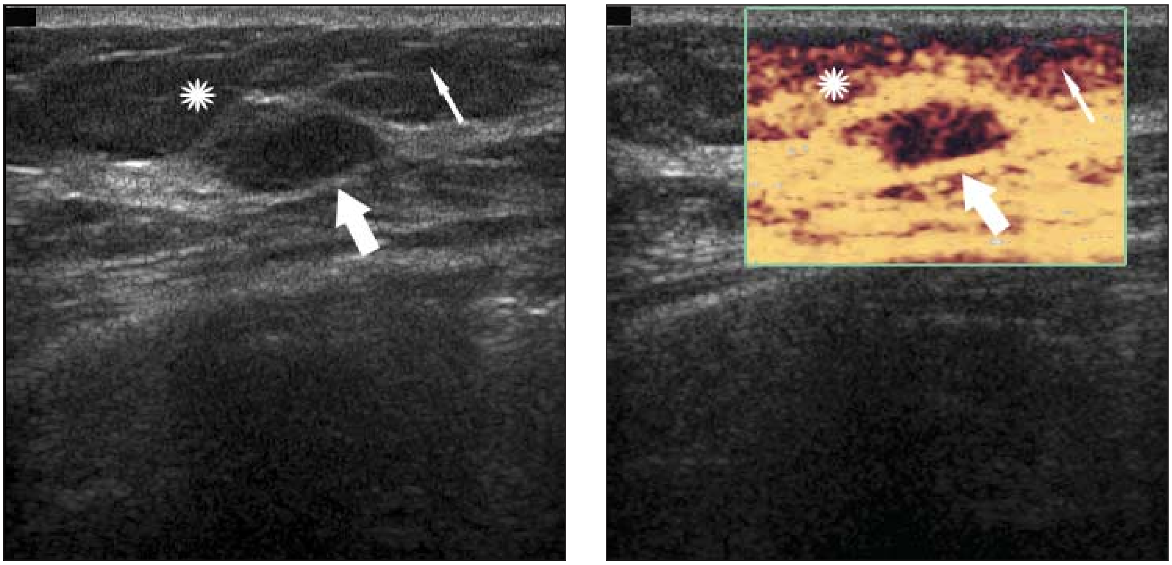
A B

Figure 11. Mucocelelike tumor in a 58-year-old woman that was confirmed by a 14-gauge core needle biopsy and excision. **A**, B-mode image shows a mixed echogenicity mass with a mural nodule (arrow). **B**, Vocal fremitus image shows a minimal vibratory artifact corresponding to the mural nodule (arrow). This mural nodule shrank after the core biopsy. We suggest that the thick mucinous material could have transmitted fremitus because of its semisolid nature and could result in false-negative PDVF results.

Figure 12. Abscess in a 36-year-old woman that was confirmed by a 23-gauge fine-needle aspiration biopsy. **A**, B-mode image shows slight posterior acoustic enhancement and an indistinct marginated lesion (arrow). **B**, Vocal fremitus image shows the complete artifactual defect (arrow).

A B





A B

Figure 13. Fibroadenoma in a 50-year-old woman that was confirmed by a 14-gauge core needle biopsy. **A**, B-mode image shows a well-circumscribed, isoechoic, masslike lesion (thick arrow) that may be difficult to differentiate from an isolated fat lobule. Asterisk indicates the fat tissue at a depth similar to the masslike lesion; thin arrow, subcutaneous fatty tissue; and thick arrow, fibroadenoma. **B**, Vocal fremitus image shows the artifact defect, suggestive of a tumor (thick arrow) rather than an isolated fat lobule. Note the artifacts found in fat tissue (asterisk) at a similar depth in the breast tissue and sparse artifacts in the subcutaneous fatty tissue (thin arrow).

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