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AUTOMATED 3D BREAST ULTRASOUND (ABUS) FOR BREAST CANCER SCREENING

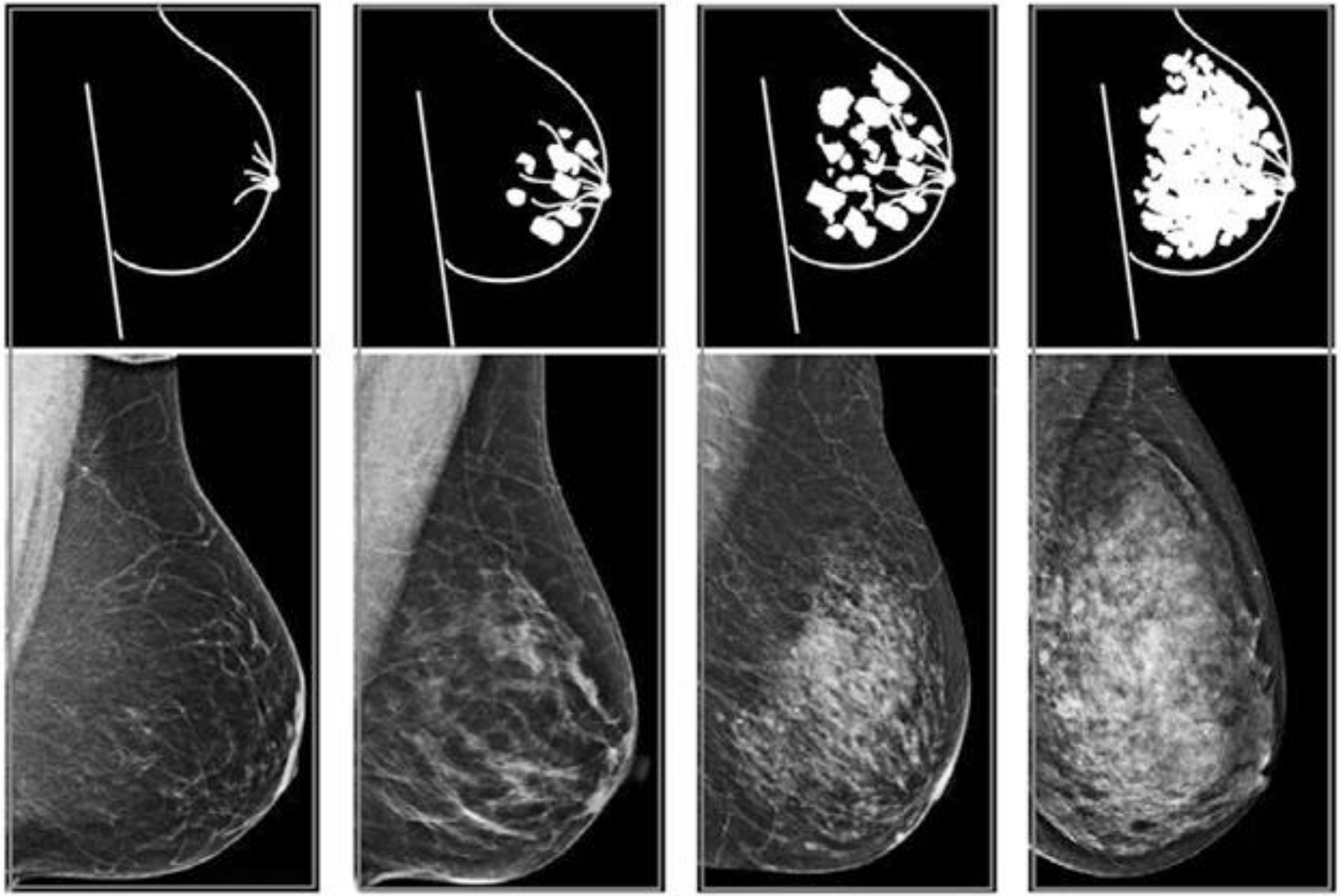
OUTLINE:

1. Introduction
2. Differences between 2D and 3D ultrasound
3. Technique
4. Artefacts

- Mammographic screening programs have reduced breast cancer-related mortality by up to 38%.
- The success of mammographic screening programs attributed to the detection of breast cancer at an early stage.
- However, in women with mammographically dense breasts, the sensitivity is as low as 61%.

HOW BREAST DENSITY AFFECTS ASSESSMENT

- Breast density varies widely; no two breasts are the same.
- A denser breast contains more glandular and connective tissue, and according to BreastCancer.org, the cancer rate is 6 times greater in extremely dense breasts than it is in less-dense breasts.
- Small cancers are masked by the normal fibroglandular tissue and therefore cannot be detected.



A B C D

Combining 3D automated breast ultrasound for breast cancer screening would be more effective than using mammography alone for this kind of patient, reducing the amount of missed breast cancer diagnoses.

According to the European Journal of Radiology, adding 3D ABUS to mammography screening in dense breasts increases cancer detection without increasing the radiation dose and with an acceptable recall rate.

THREE-DIMENSIONAL (3D) ULTRASOUND

Pros:

- Standardization of the images acquired that can be stored and post processed.
- Coronal view gives slice-by-slice visualization of the entire breast, from skin to chest wall. It also facilitate detection of architectural distortion.
- Allow full-volume view with lesion localization.
- Easy correlation with other imaging modalities for cross-referencing
- Single-touch locking mechanism reduce repetitive stress injuries for patient, with minimum compression.

Cons:

- The design of AB US systems does not allow correction of the transducer angle. Hence, wander artifacts are more common to occur.

CONVENTIONAL 2D ULTRASOUND

Pros:

- improves diagnostic accuracy with color and power Doppler.

- evaluate the elasticity by elastogram.

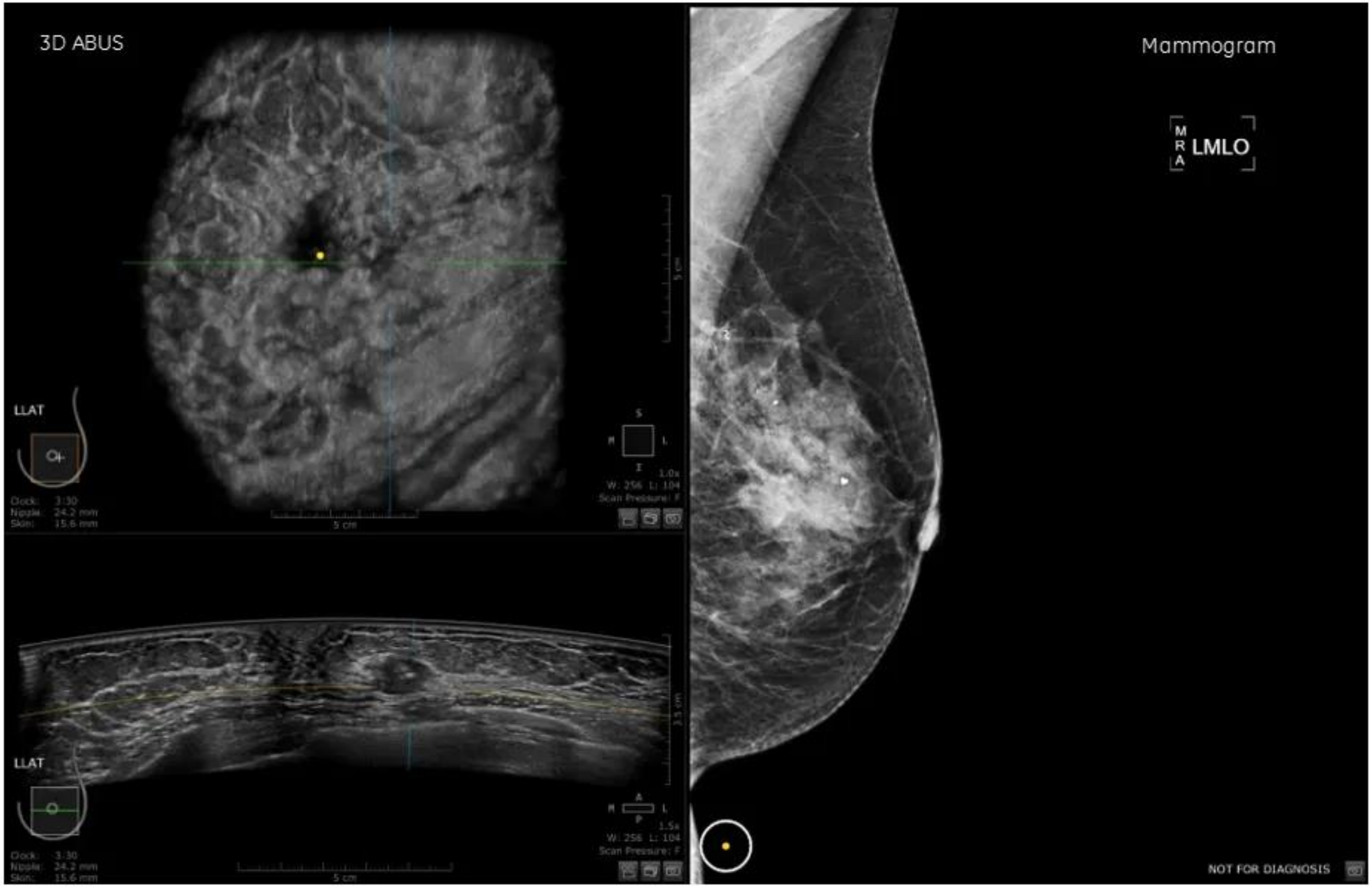
- Excellent detail and contrast resolution.

- wander artifact can be avoided/reduced by adjusting the angle of transducer.

Cons:

- operator dependent. Results are affected by the operator skills and experience with consequent loss of standardization.

- breast lesion has to be immediately characterized during the examination (real time examination).


3D ABUS
LLAT
5 cm
LLAT
5 cm
Mammogram
LMLO
NOT FOR DIAGNOSIS

TECHNIQUE OF AB US

To ensure coverage of the whole breast, AB US systems acquire at least three, overlapping B-mode US volumes per breast with a wide high-frequency linear-array transducer.

The transducer is automatically driven by a mechanical arm and acquires more than 300 sections with a minimal section thickness of 0.5 mm per volume.

By acquiring overlapping volumes, we can image the anatomic breast area between the midsternal line and the midaxillary line.

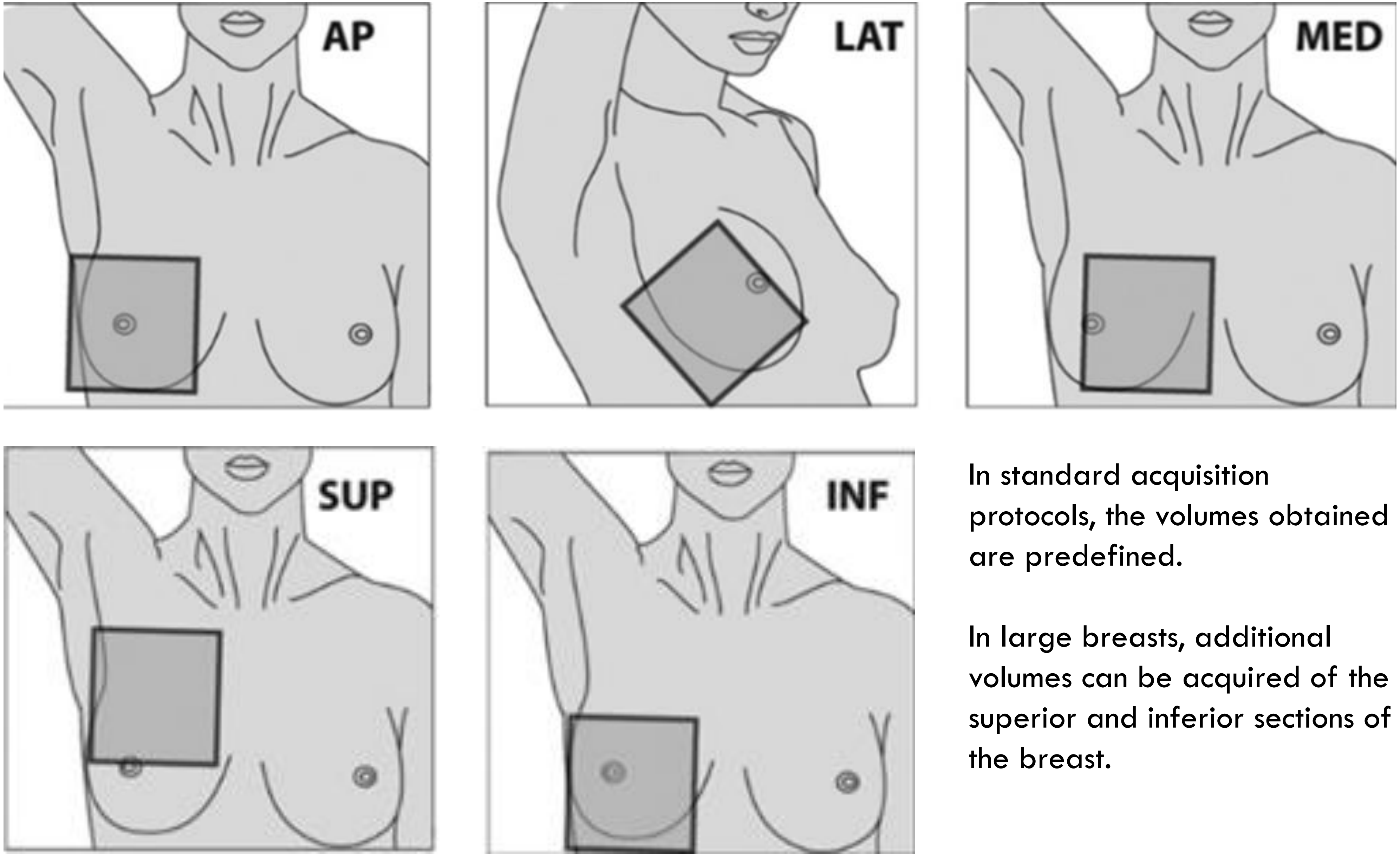
Transducer must be placed on the breast accordingly optimize contact with the skin of the breast.

For average-size and smaller breasts, three acquisitions are sufficient to cover the entire breast with AB US:

- anteroposterior (AP)
- lateral (LAT)
- medial (MED).

For larger breasts, the AB US we might need to perform additional scans:

- superior (SUP)
- inferior (INF) parts of the breast.



In standard acquisition protocols, the volumes obtained are predefined.

In large breasts, additional volumes can be acquired of the superior and inferior sections of the breast.

- To obtain good-quality images, abundant use of water-based gels or lotion on the skin of the breast is mandatory.
- This prevents poor contact between the transducer and the skin and allows the ultrasonic wave to pass into the breast.
- The acquisition depth of the transducer is adjustable to up to 6 cm, depending on breast size.
- We can adjust the time-gain function and focus region of the transducer to improve the image quality.

POST-PROCESSING, MULTIPLANAR REFORMATION, AND IMAGE INTERPRETATION

The original transverse images will be reformats into coronal and sagittal images.

The time needed to evaluate AB US examinations is reported to be 3–5 minutes for a full normal case.

In general, interpretation of AB US images using the Breast Imaging Reporting and Data System (BI-RADS) US lexicon is sufficient for screening and diagnostic purposes.

The coronal and sagittal reformatted images contain additional information that can aid in differentiation of breast lesions.

INCORRECT TRANSDUCER PLACEMENT

The **anteroposterior acquisition** should be performed with the nipple in the center of the AB US image.

The **lateral acquisition** should have some overlap with the anteroposterior acquisition; the lateral boundary of the transducer should be aligned with the midaxillary line to image even the most lateral breast sections.

The medial boundary of the transducer should be aligned with the midsternal line for a **medial acquisition.**

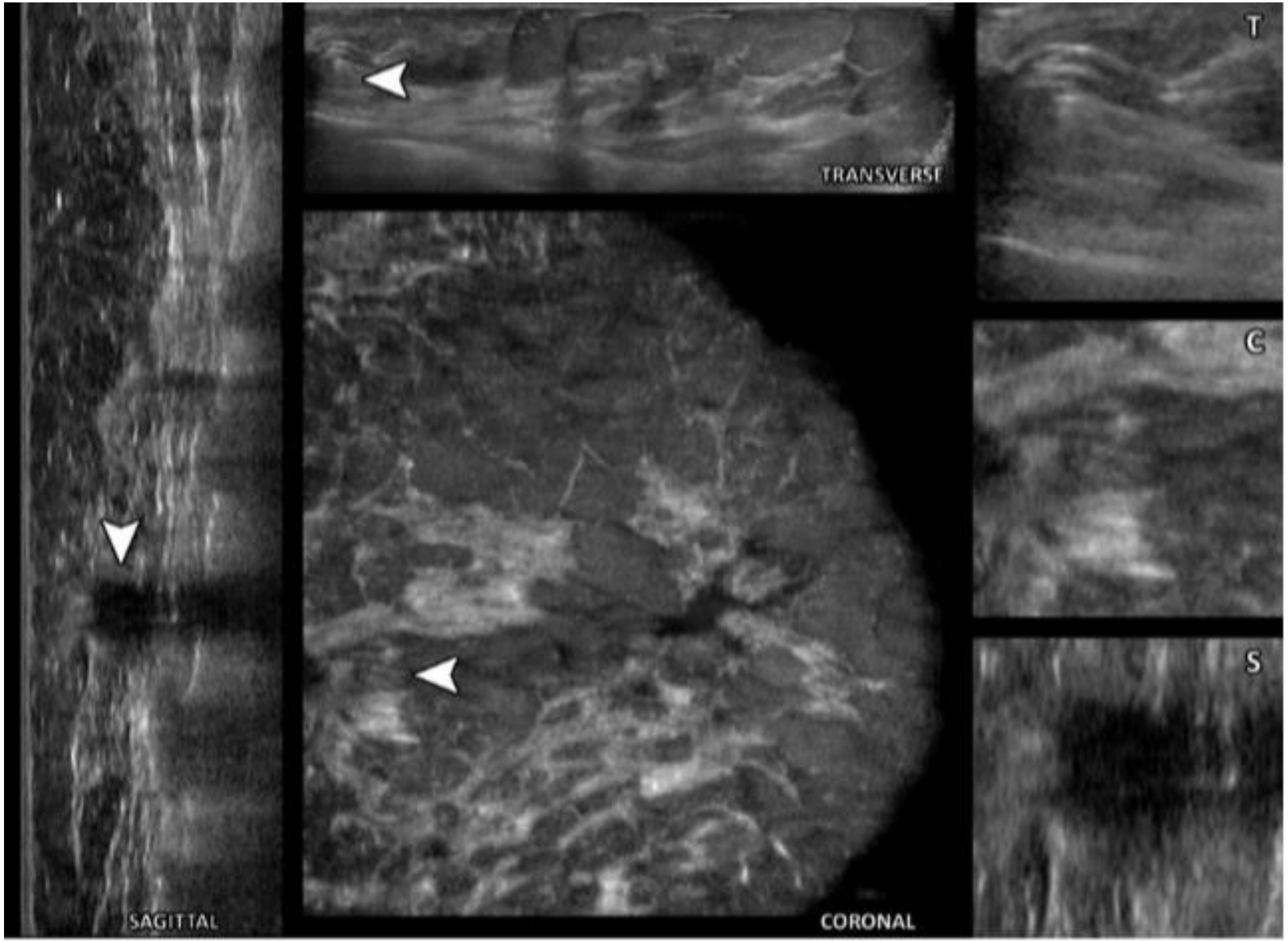


Figure 2. Malignant mass in a 66-year-old woman with a spiculated mass on her heterogeneously dense screening mammograms.

The mass was not seen at supplemental AB US.

In retrospect, AB US images show that the transducer did not fully image the lateral section of the right breast.

The mass is visible along the outer left boundary of the images (arrowheads). More laterally oriented AB US images were not acquired.

AIR CONTACT ARTIFACT

Application of water-based media to the whole breast is vital to avoid air contact artifact.

This artifact is caused by entrapment of sound waves in an enclosed space between the transducer and the skin.

This creates a typical reverberation pattern from the skin and total loss of signal underneath the air bubble.

Air contact artifact prevents reliable evaluation of the underlying breast tissue.

Artifacts larger than 10–15 mm can potentially obscure breast cancers.

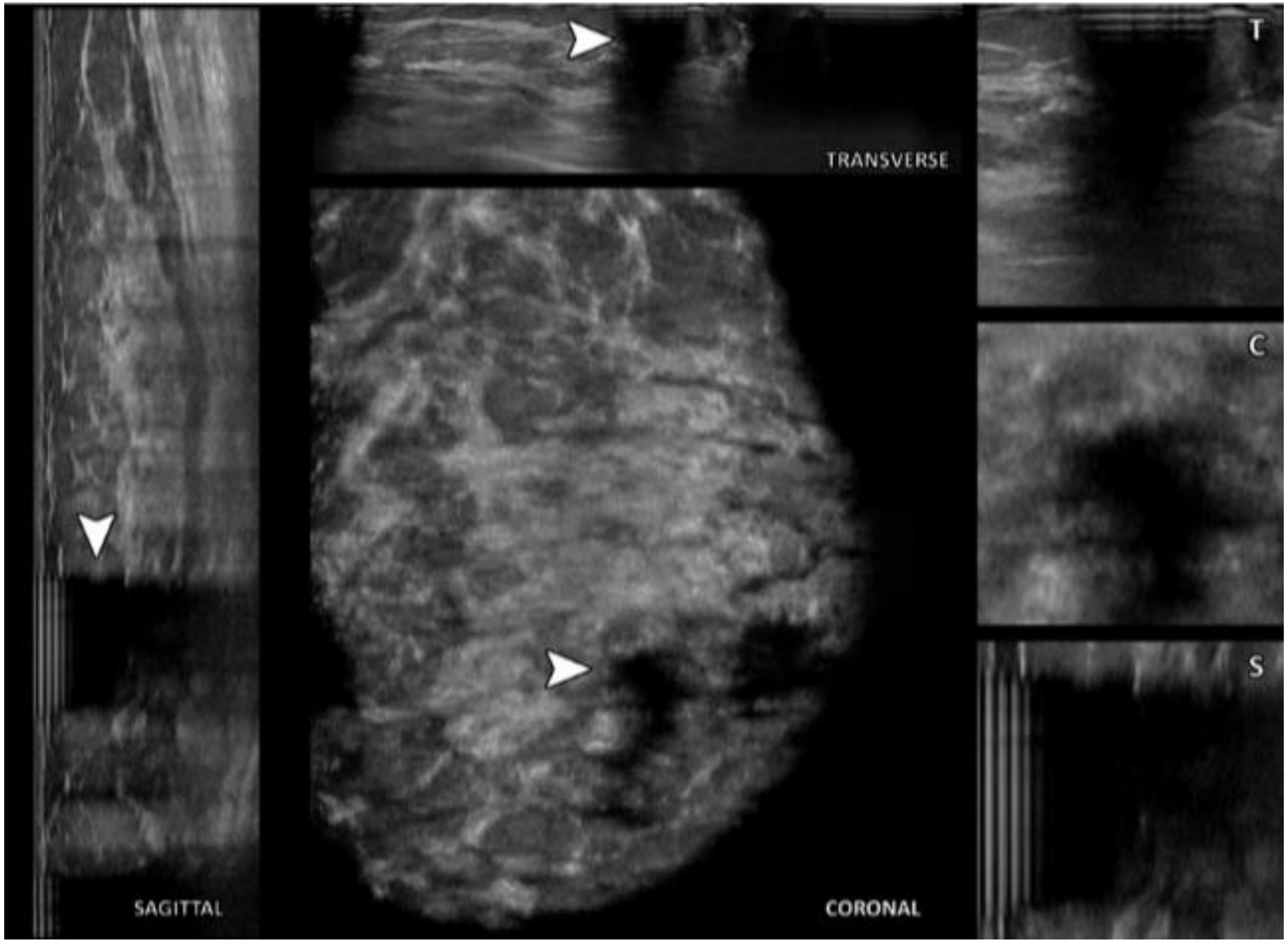


Figure 3. Air contact artifact in a 54-year-old woman with negative results at screening mammography and AB US.

Images from a left medial AB US acquisition show a large air contact artifact on the medial side of the nipple (arrowheads).

A typical reverberation pattern is seen (multiple white lines parallel to the skin).

No reliable diagnosis can be made in the area behind the artifact.

NIPPLE SHADOWING

Heavy shadowing artifacts in the area behind the nipple and areola make it difficult to detect lesion.

Nipple shadowing can be reduced by applying an abundance of water-based medium on the nipple area.

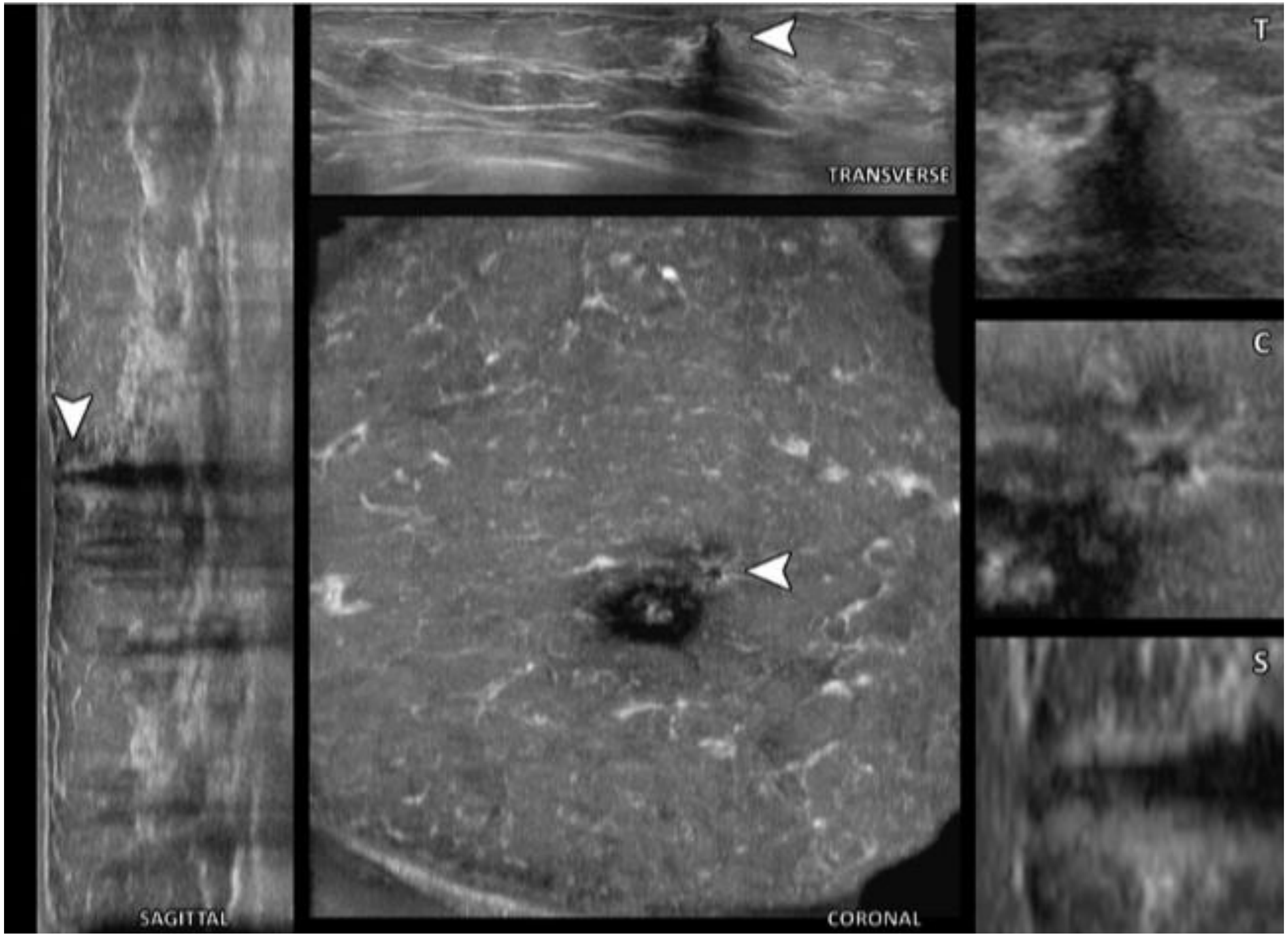


Figure 4a. Invasive ductal carcinoma (IDC) in a 64-year-old woman with negative results at mammographic screening of the left breast.

Left anteroposterior images show an IDC (arrowheads) in the retroareolar area of the left breast.

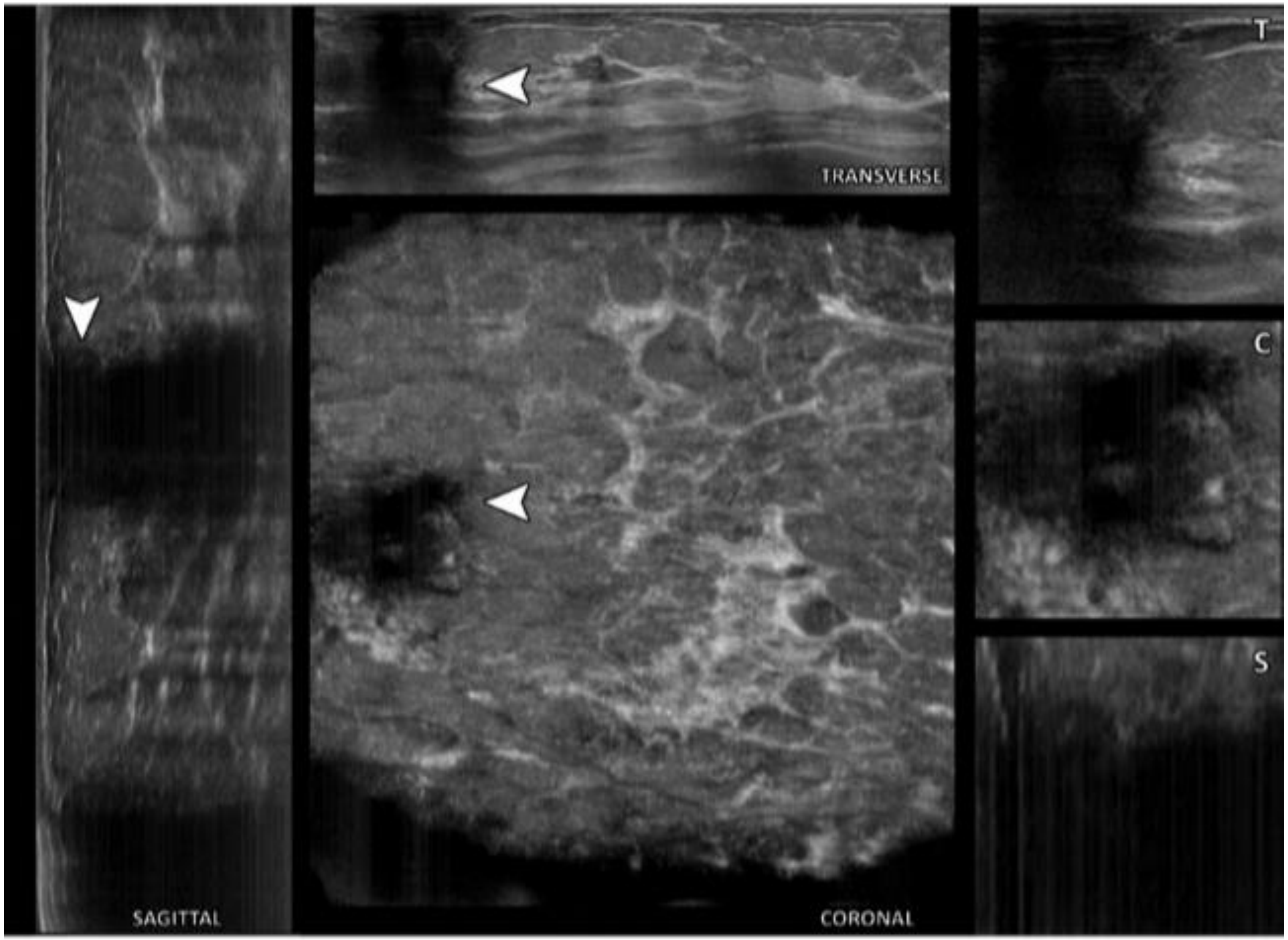
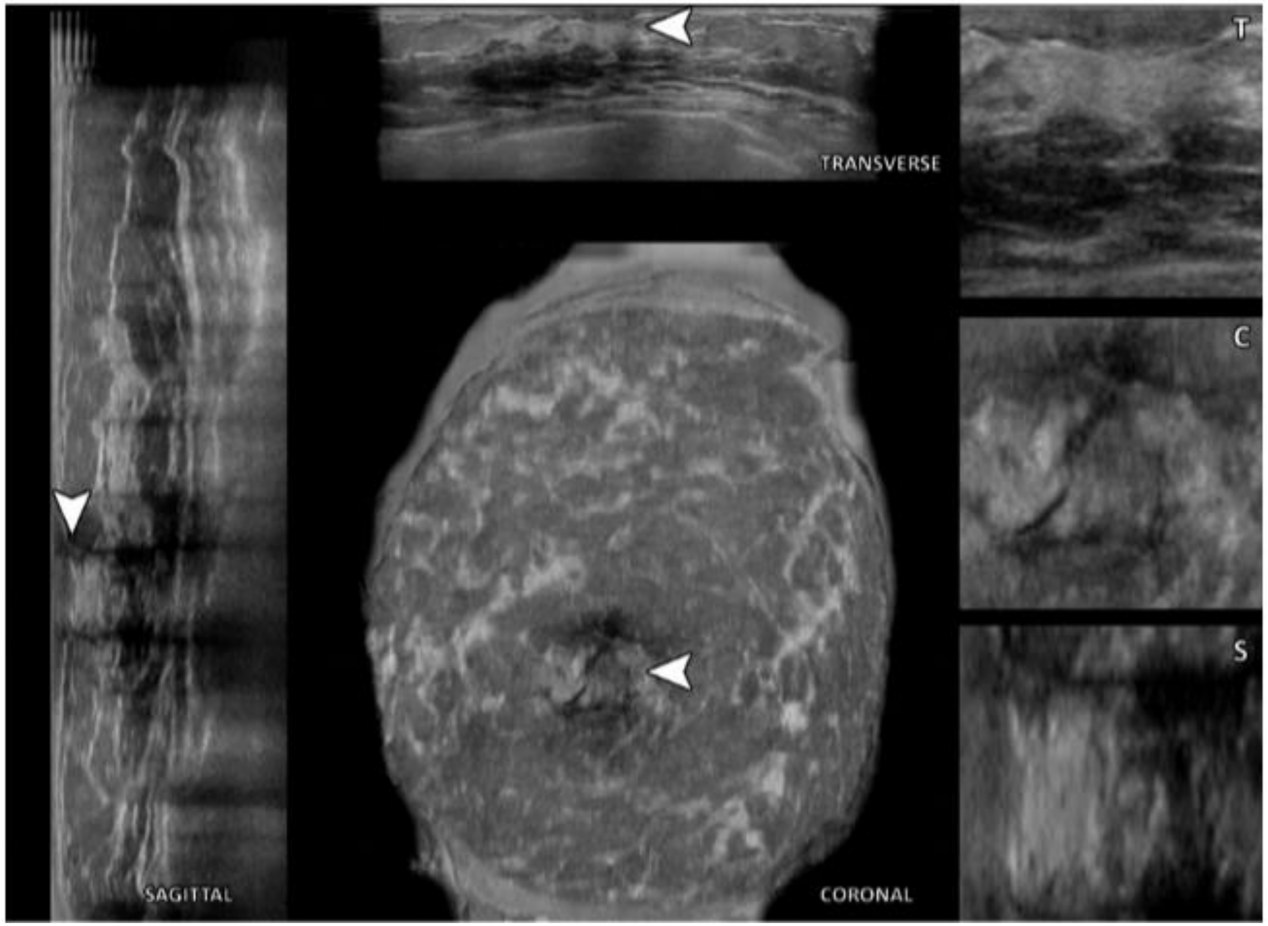


Figure 4(b) On left lateral AB US images, nipple shadowing (arrowheads) obscures the cancer completely.

(Case courtesy of Matthieu J. C. M. Rutten, MD, PhD, Jeroen Bosch Hospital, 's-Hertogenbosch, the Netherlands.)



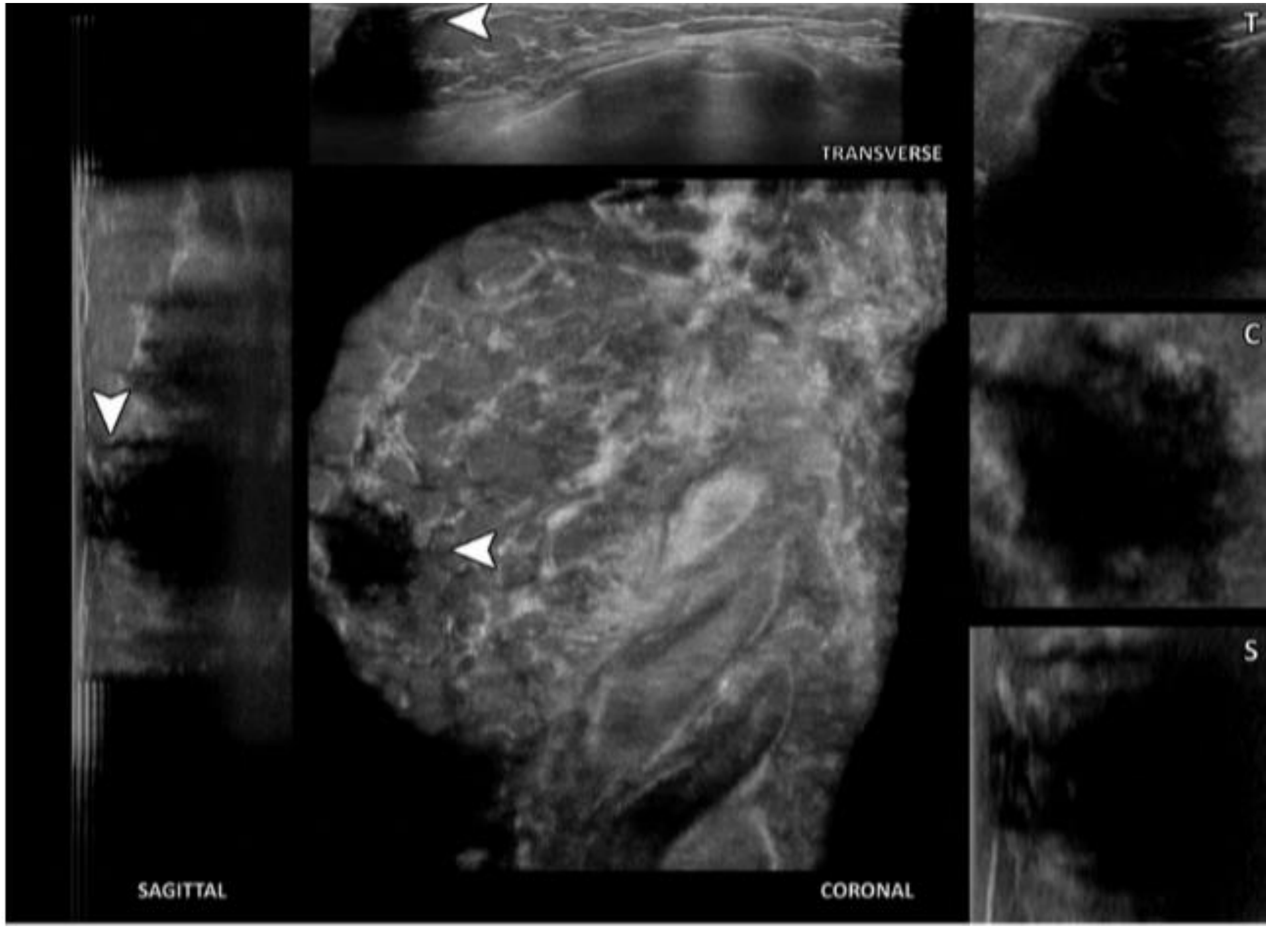


Figure 5. Normal AB US results in a 54-year-old woman. (a) Left anteroposterior AB US images show relatively mild nipple shadowing (arrowheads).

(b) Left lateral AB US images show heavy nipple shadowing (arrowheads).

WANDERING SHADOWS

Wandering shadows are observed in virtually all AB US acquisitions.

The shadows are caused by Cooper ligaments in the breast.

Ultrasonic waves encounter the curved surface of ligaments at a tangential angle and are scattered and refracted, leading to loss of signal and thus acoustic shadowing.

The effect is similar to when ultrasonic waves encounter other curved structures in the breast, such as cysts.

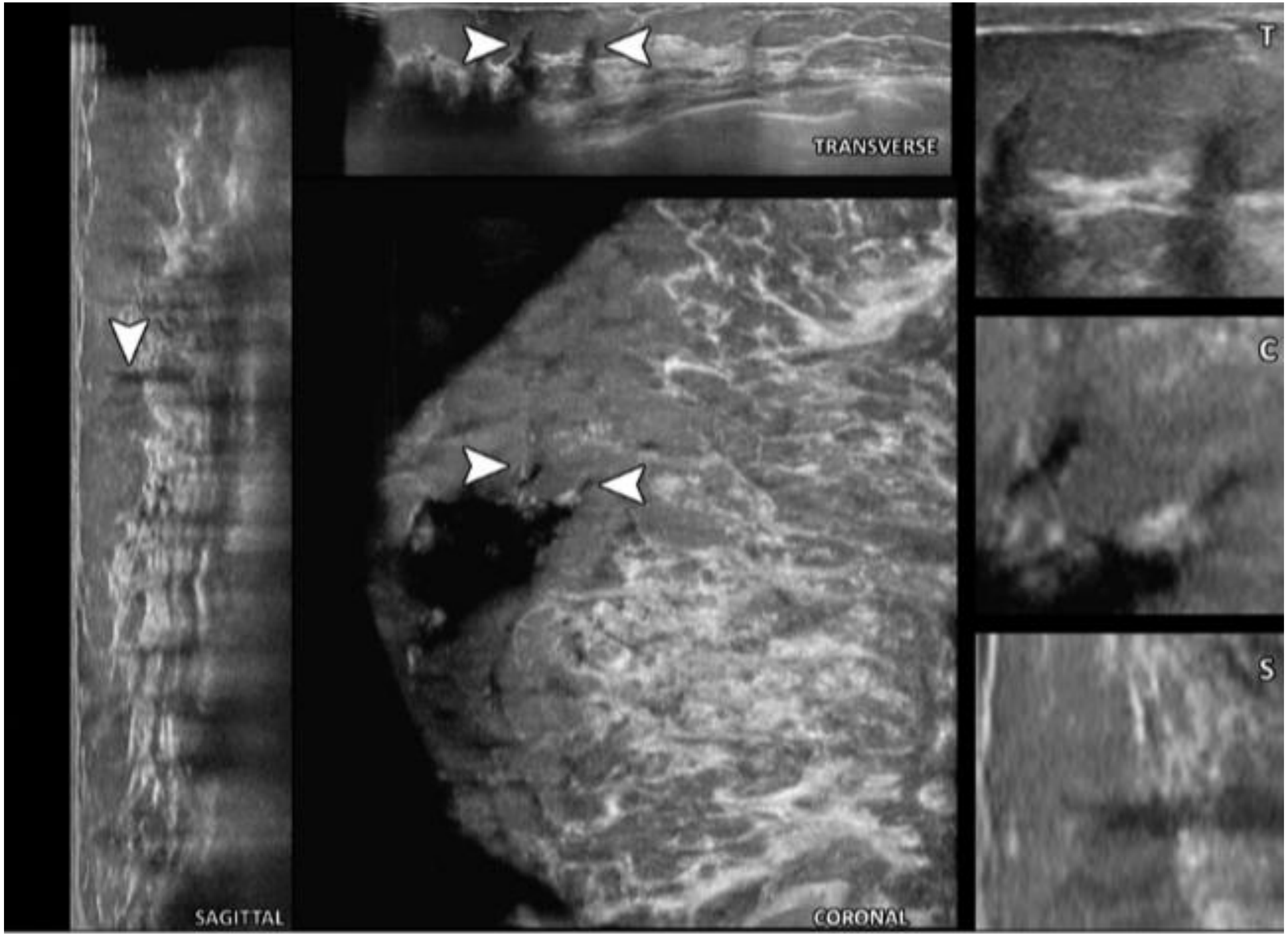


Figure 6. Wandering shadows in a 50-year-old woman with heterogeneously dense breasts.

Images from a normal AB US examination show multiple dark areas (arrowheads).

These are caused by sound waves that refract and scatter from the curved surface of Cooper ligaments, causing wandering shadows in the breast

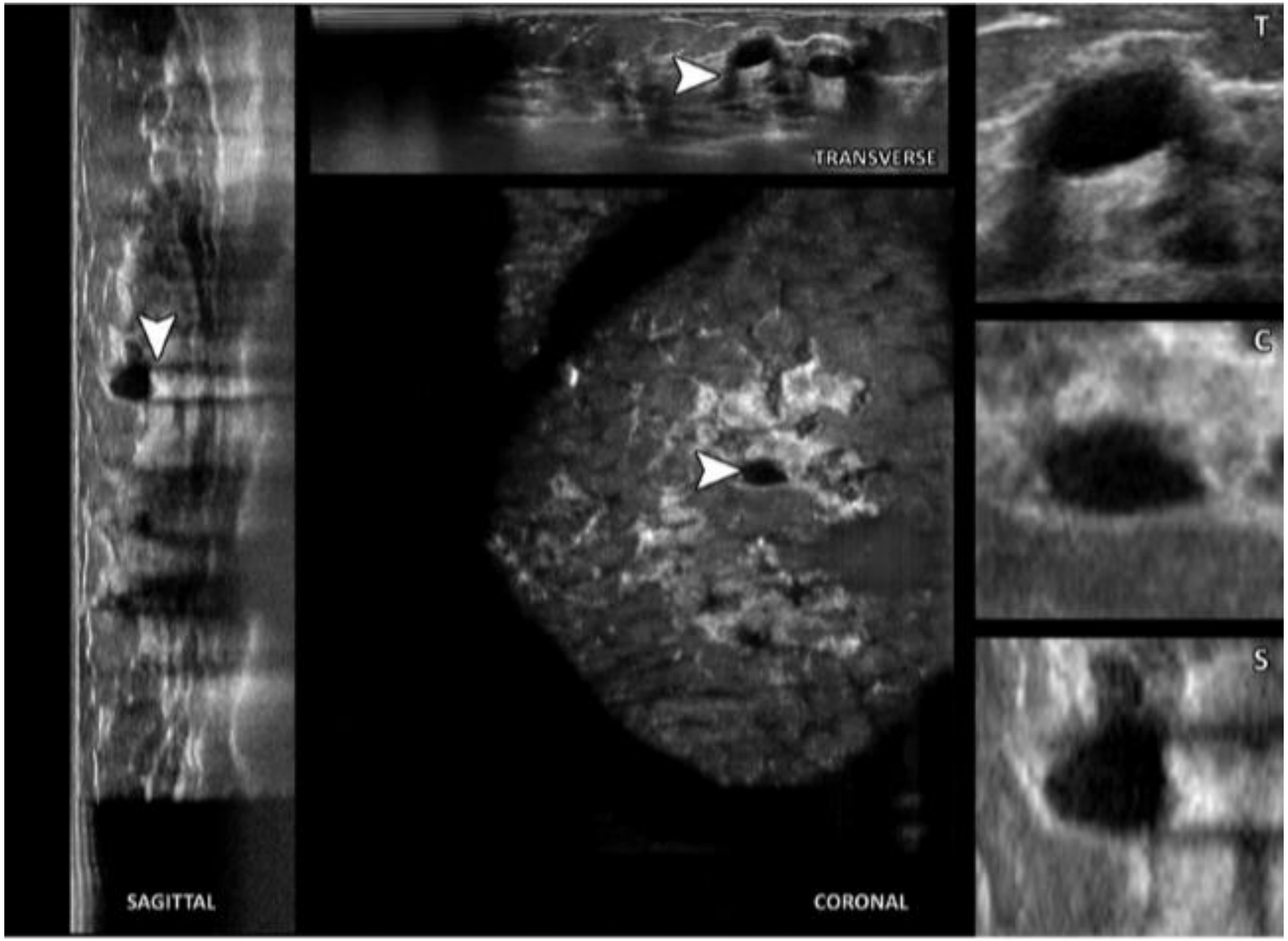


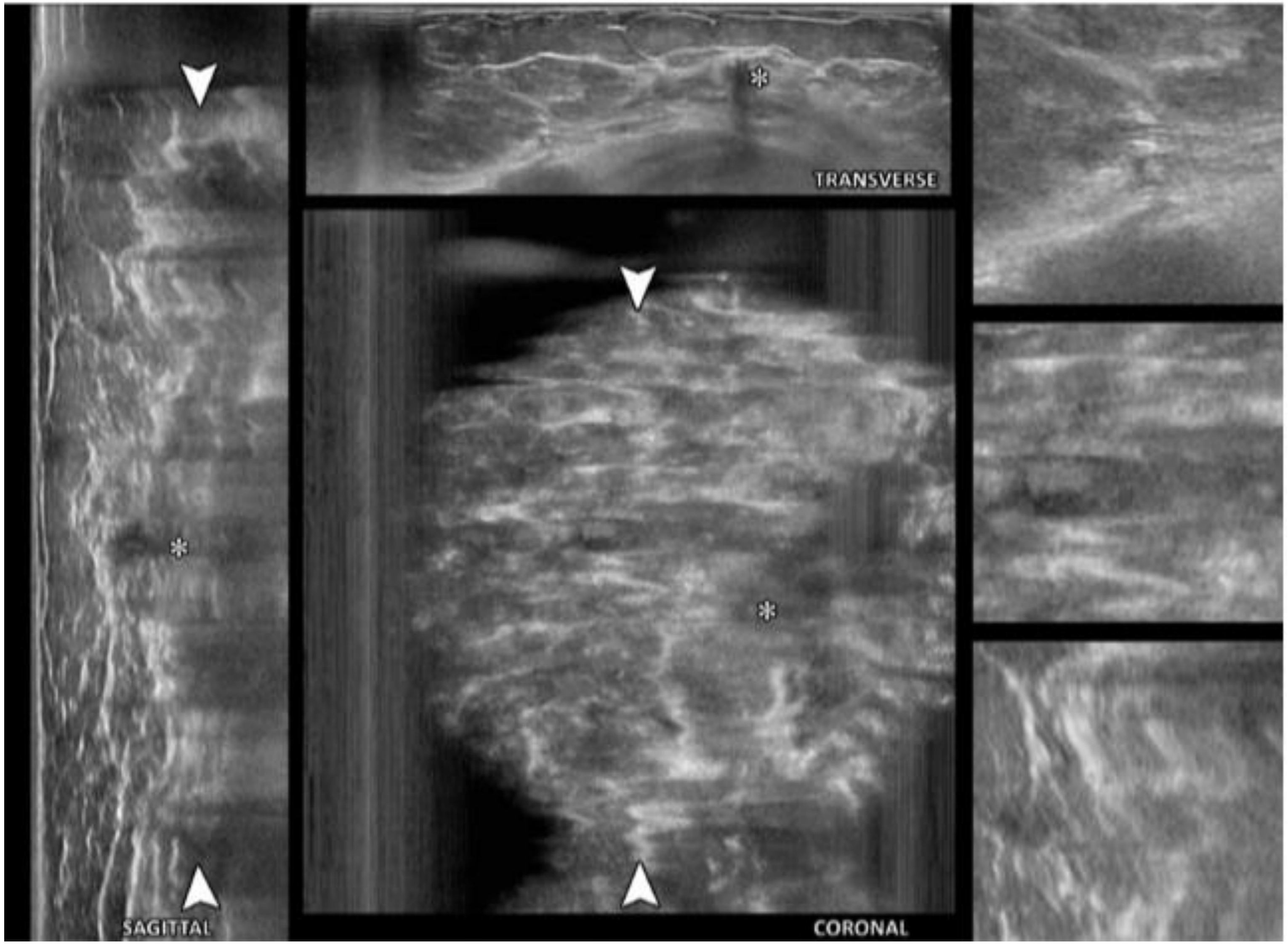
Figure 7. AB US images show multiple dark areas (arrowheads). Sound waves refract and scatter from the edges of a curved structure, in this case an uncomplicated cyst.

SINUSOIDAL WAVE PATTERN

AB US acquisitions should be performed while the patient breathes superficially, and patients should be instructed not to talk during the acquisition.

Heavy breathing or talking causes a sinusoidal wave pattern on AB US images.

This wave pattern is more evident closer to the chest wall and can distort the deeper regions of the coronal and sagittal reformations.



(Courtesy of André R. Grivegnée, MD, PhD, Institute Jules Bordet, Brussels, Belgium.)

Figure 8. Sinusoidal distortion due to heavy breathing in a 70-year-old woman with IDC.

AB US images show patterns of heavy breathing during the acquisition (between arrowheads).

The original transverse image is not affected by breathing. However, both the coronal and sagittal reformatted images show sinusoidal distortion of the deeper breast regions.

A small IDC is seen (*) but is hardly visible on the coronal image, likely because of heavy breathing artifacts.

References:

1. van Zelst JCM, Mann RM. Automated Three-dimensional Breast US for Screening: Technique, Artifacts, and Lesion Characterization. *Radiographics*. 2018;38(3):663-683. doi:10.1148/rg.2018170162.

2. Mostafa, A.A.E., Eltomey, M.A., Elaggan, A.M. *et al*. Automated breast ultrasound (ABUS) as a screening tool: initial experience. *Egypt J Radiol Nucl Med* **50**, 37 (2019). https://doi.org/10.1186/s43055-019-0032-9.

3. D.O. Watermann, M.F Oldi, A. Hanjalic-Beck, A. Hasenburg, A. Lughausen, H. Prompeler et al. Three-dimensional ultrasound for the assessment of breast lesions

THANK YOU