



Ultrassom em biomedicina

Artefatos em US

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US Artifacts¹

CME FEATURE

See accompanying
test at [http://
www.rsna.org/
education
lrg_cme.html](http://www.rsna.org/education/lrg_cme.html)

LEARNING OBJECTIVES FOR TEST 6

*After reading this
article and taking
the test, the reader
will be able to:*

- List the assumptions of US image processing.
- Describe the imaging features of US artifacts.
- Discuss the physical origins of US artifacts.

TEACHING POINTS

See last page

Myra K. Feldman, MD • Sanjeev Katyal, MD • Margaret S. Blackwood, MS

Image artifacts are commonly encountered in clinical ultrasonography (US) and may be a source of confusion for the interpreting physician. Some artifacts may be avoidable and arise secondary to improper scanning technique. Other artifacts are generated by the physical limitations of the modality. US artifacts can be understood with a basic appreciation of the physical properties of the ultrasound beam, the propagation of sound in matter, and the assumptions of image processing. US artifacts arise secondary to errors inherent to the ultrasound beam characteristics, the presence of multiple echo paths, velocity errors, and attenuation errors. The beam width, side lobe, reverberation, comet tail, ring-down, mirror image, speed displacement, refraction, attenuation, shadowing, and increased through-transmission artifacts are encountered routinely in clinical practice. Recognition of these artifacts is important because they may be clues to tissue composition and aid in diagnosis. The ability to recognize and remedy potentially correctable US artifacts is important for image quality improvement and optimal patient care.

Associados às características do feixe

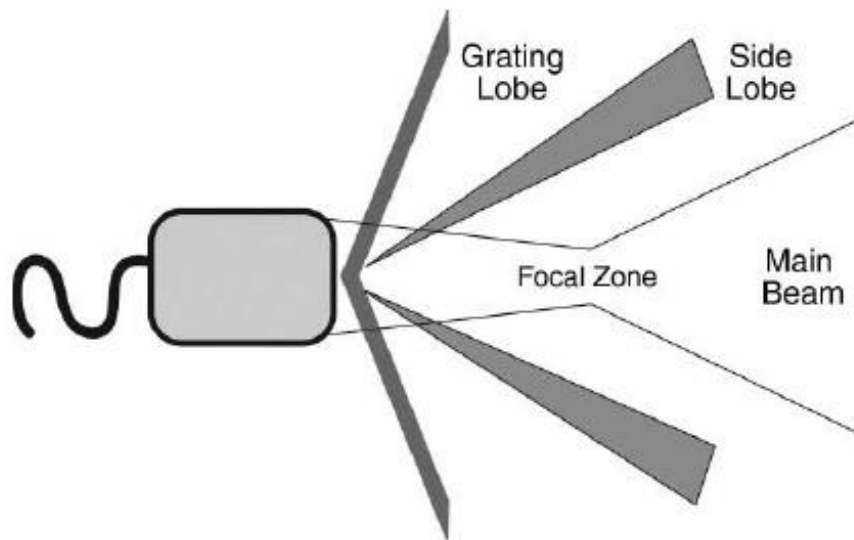
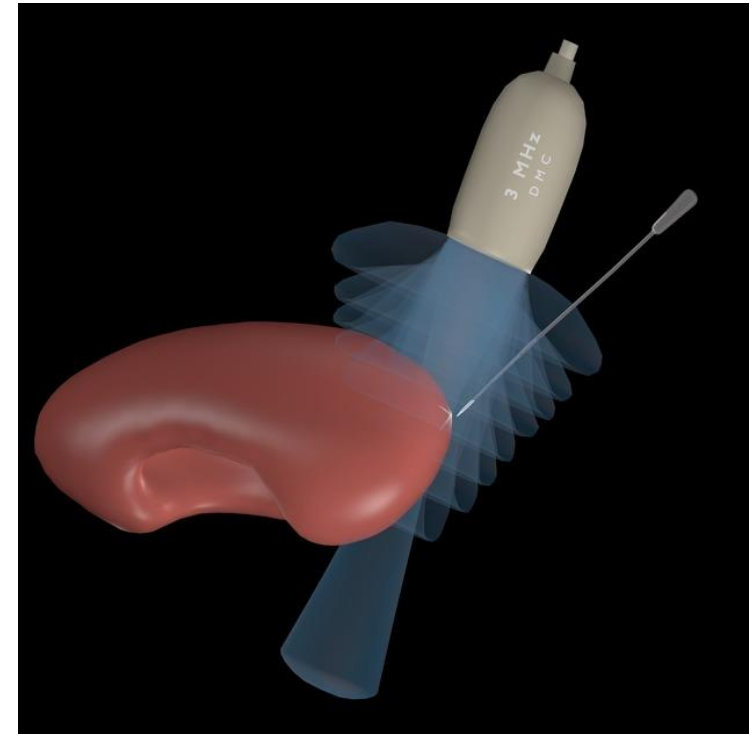
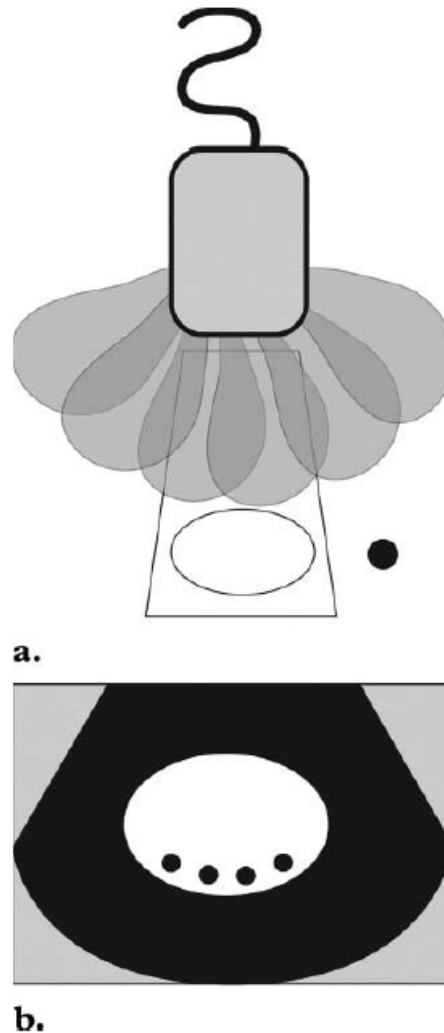


Figure 1. Diagram of an ultrasound beam. The main ultrasound beam narrows as it approaches the focal zone and then diverges. Grating lobes and side lobes are forms of off-axis energy.

Um forte espalhador das ondas de ultrassom localizado fora do feixe principal (lobo principal) pode gerar ecos detectáveis pelo transdutor.

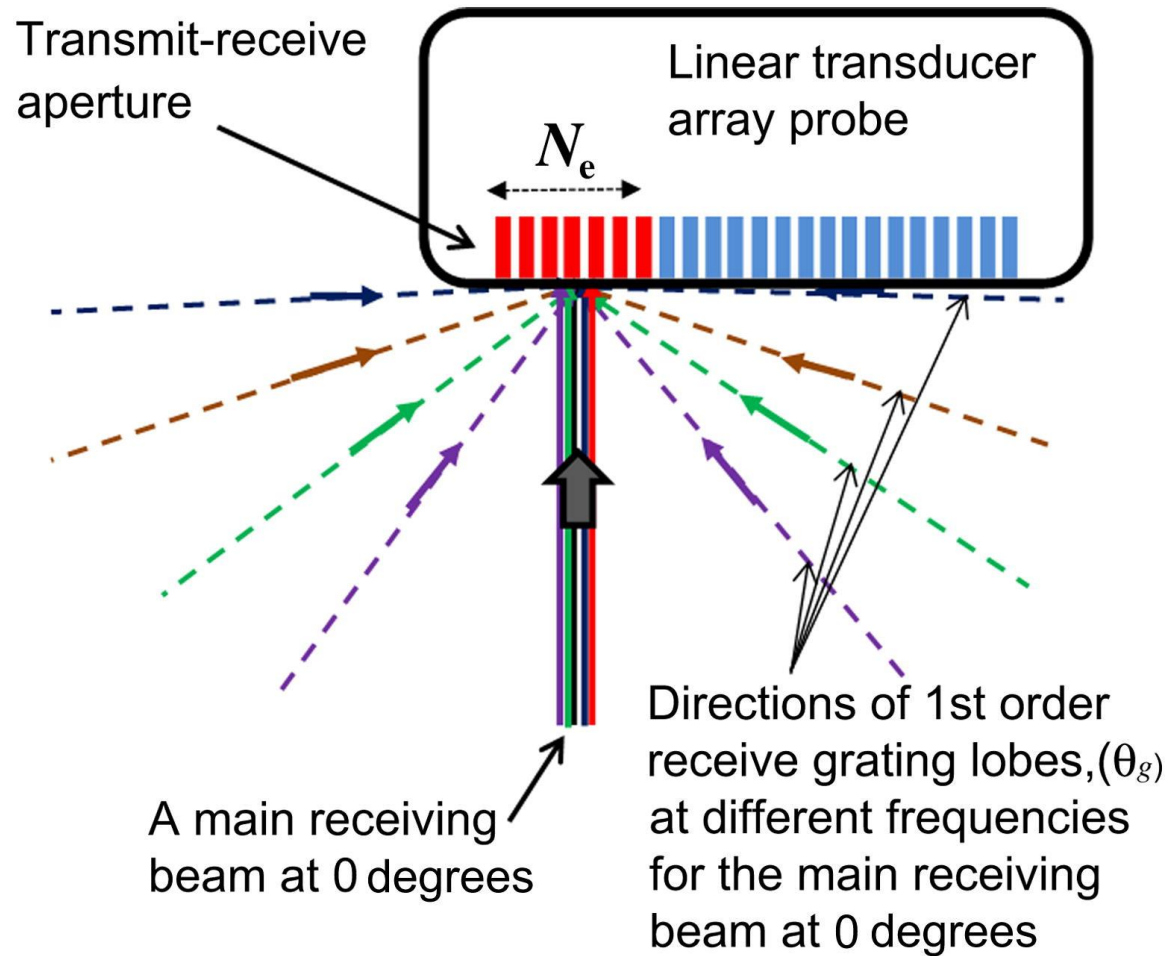
Associados às características do feixe

Figure 3. Side lobe artifact. (a) Diagram shows multiple beams of off-axis side lobe ultrasound energy encountering an object (black circle). (b) The display assumes that the echoes returning from this off-axis object came from the main beam and misplaces and duplicates the structure.



<https://radiopaedia.org/articles/side-lobe-artifact-2>

Associados às características do feixe



Associados às características do feixe

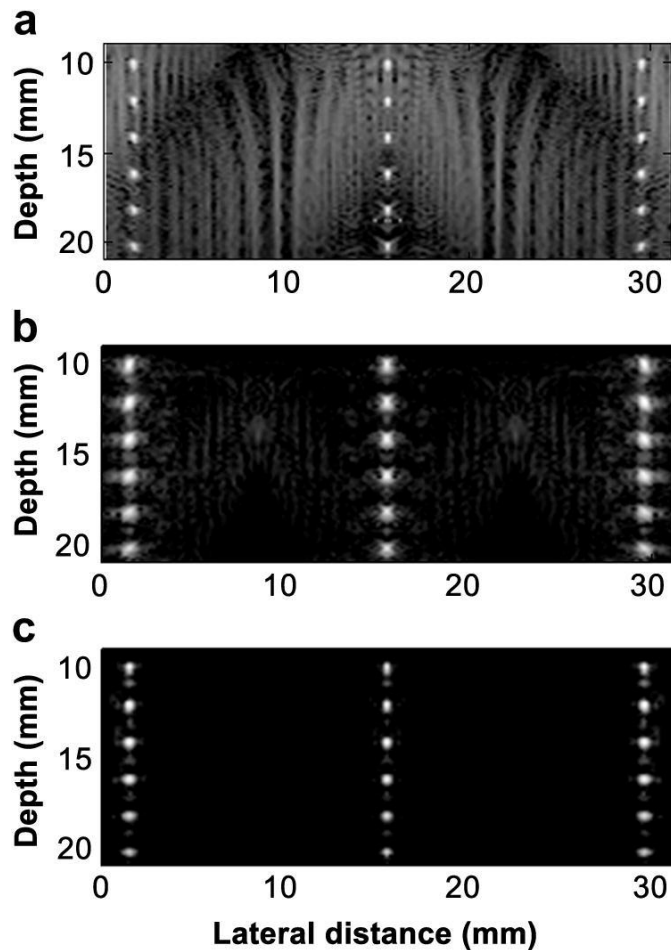


Fig. 9.21 • Artifact in a cyst caused by information obtained by the side lobes and leading to possible misdiagnosis of a septated cyst

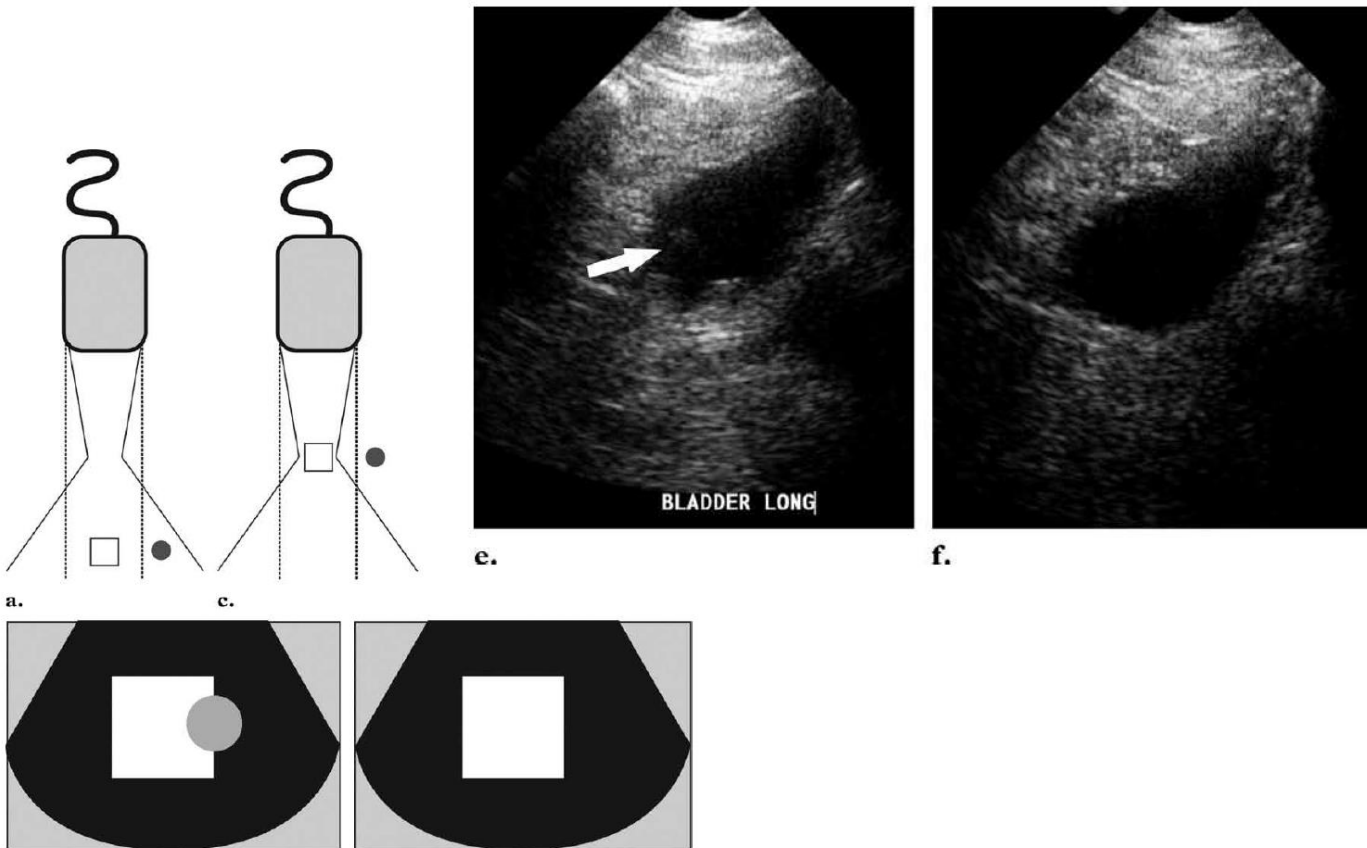
**Exemplo de cisto no
ovário com septo.**

<http://www.cancernetwork.com/ovarian-cancer/some-ovarian-tumors-can-be-safely-followed-ultrasound>

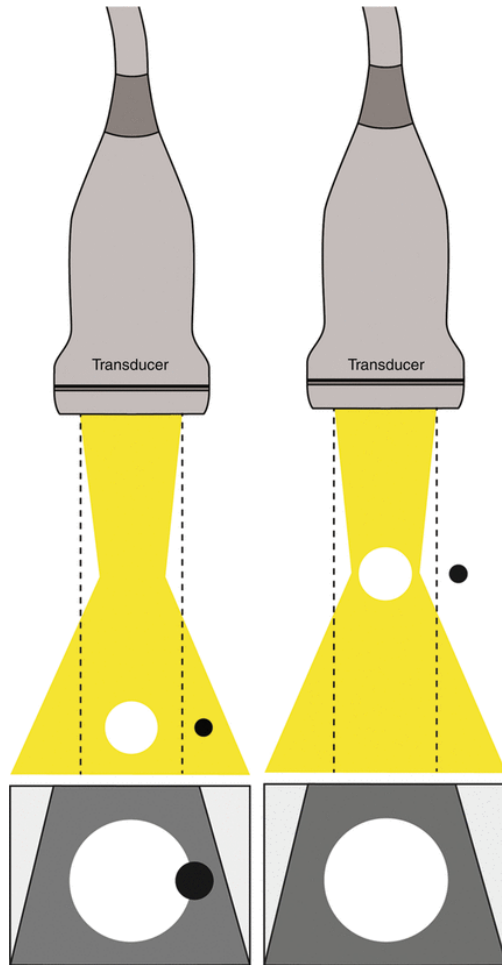


Associados às características do feixe

Figure 2. Beam width artifact. (a) The ultrasound image localization software assumes an imaging plane as indicated by the dotted lines. (b) Echoes generated by the object located in the peripheral field (gray circle) are displayed as overlapping the object of interest (white square). (c, d) Adjusting the focal zone and placing the object of interest within the center of the focal zone (c) will eliminate the misplaced echoes on the display (d). (e) Longitudinal US image of a partially filled bladder shows echoes (arrow) in the expected anechoic urine. The focal zone is improperly set too shallow. (f) Longitudinal US image obtained after adjustment of the focal zone and optimal placement of the transducer shows resolution of the intravesical echoes.



Associados às características do feixe

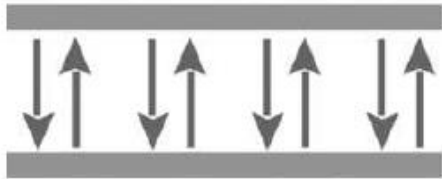


Associados a múltiplos ecos

- Na presença de duas superfícies paralelas altamente reflexivas, os ecos gerados a partir de um feixe de ultrassom primário pode ser repetidamente refletido para frente e para trás antes de retornar ao transdutor para detecção.
- Quando isso ocorre, ecos múltiplos são gravados e exibido.



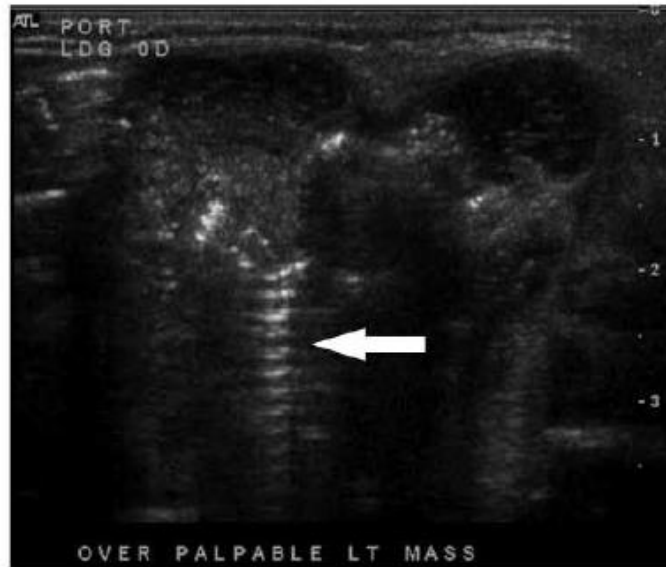
Artefato associados a múltiplos ecos



a.



b.



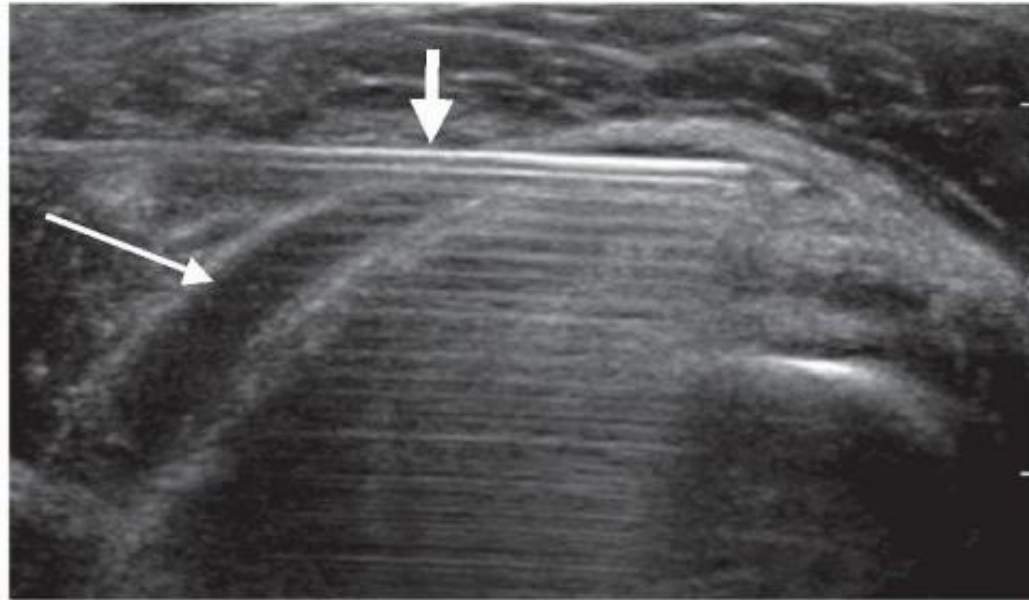
c.



d.

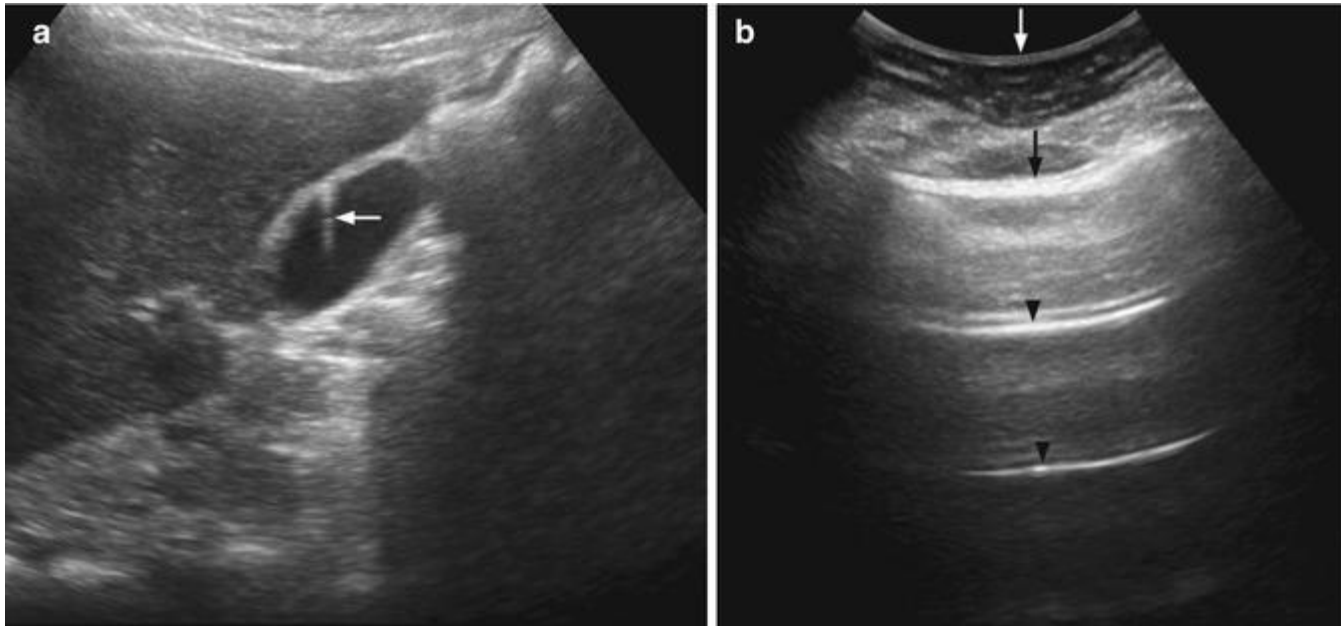
Figure 4. Reverberation artifact. (a) Diagram shows ultrasound echoes being repeatedly reflected between two highly reflective interfaces. (b) The display shows multiple equally spaced signals extending into the deep field. (c) Transverse US image obtained over a palpable mass in a neonate shows reverberation artifact (arrow). (d) Longitudinal US image of the gallbladder shows comet tail artifact (arrow) caused by cholesterol crystals in Rokitansky-Aschoff sinuses. This finding is diagnostic of adenomyomatosis. Shadowing gallstones are also identified.

Artefato associados a múltiplos ecos

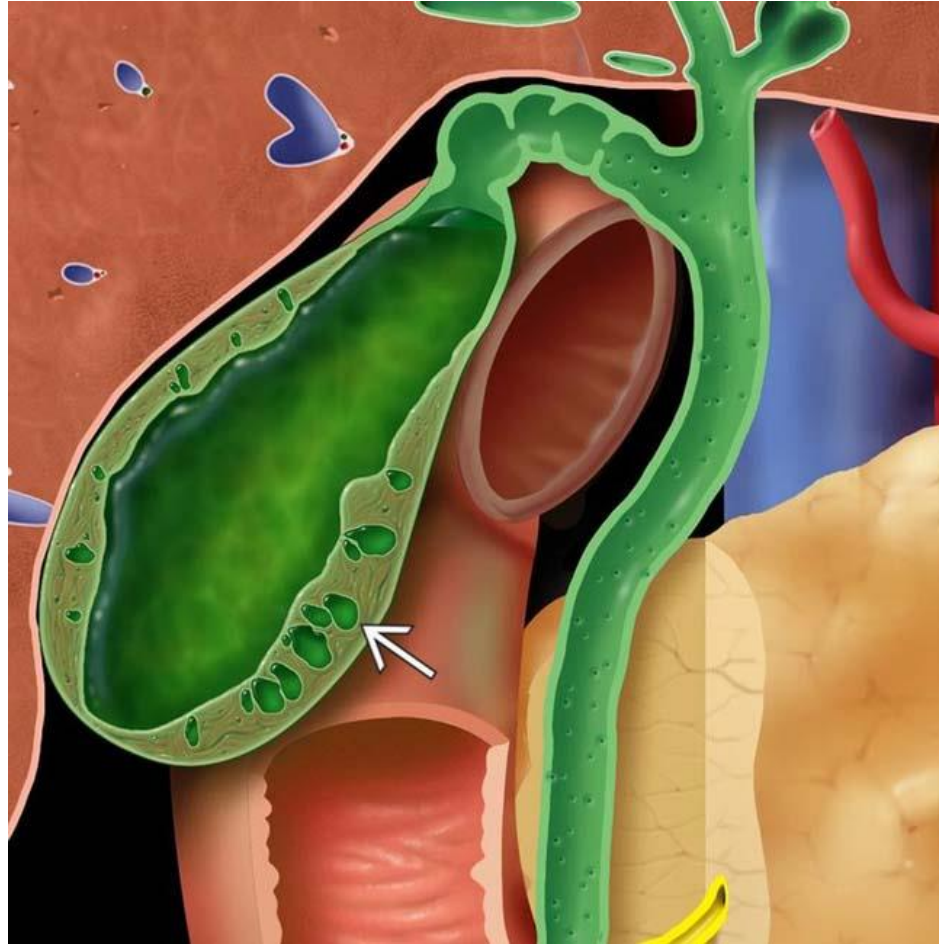


<https://radiologykey.com/ultrasound-guided-interventions-2/>

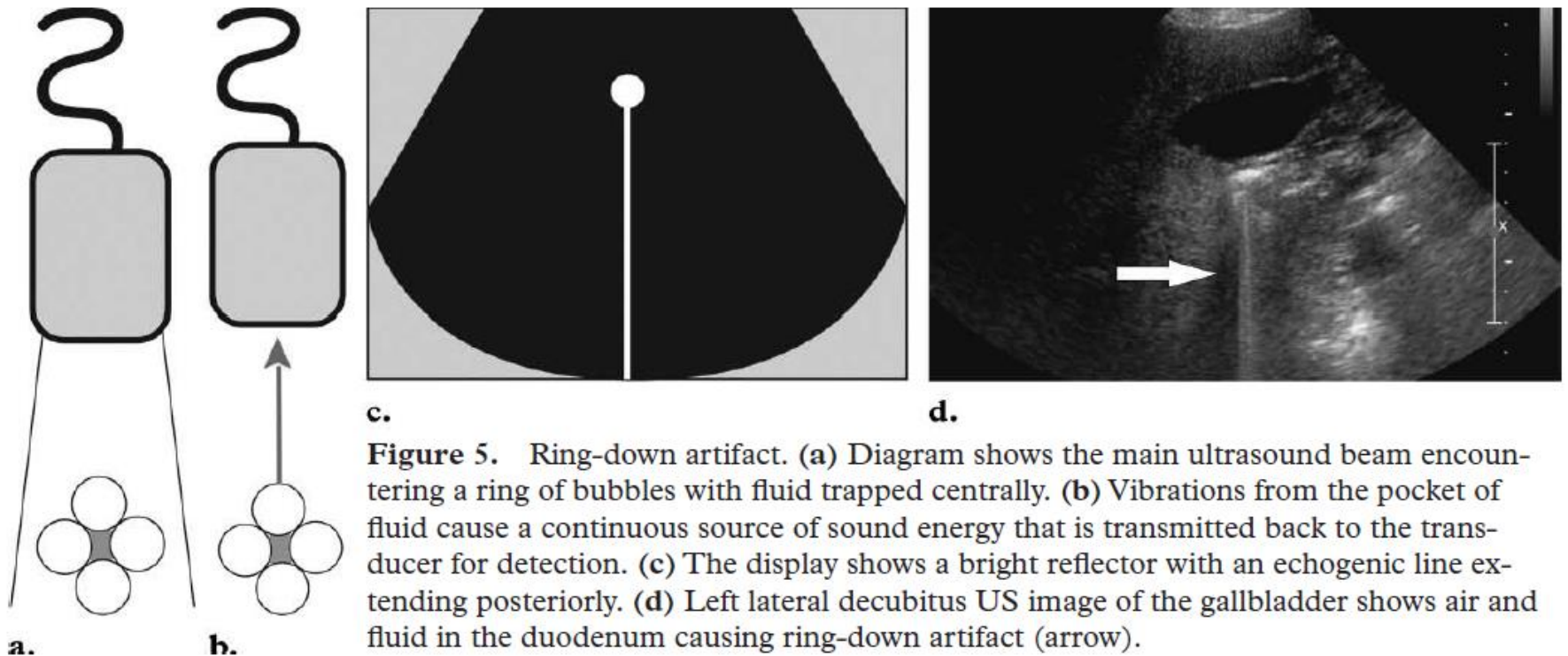
Artefato associados a múltiplos ecos



(a) US image shows the comet-tail artifact (*white arrow*) from cholesterol crystals trapped in an Aschoff-Rokitansky sinus of the gallbladder wall. (b) US image shows reverberation artifacts (*black arrowheads*) arising between the transducer-skin interface (*white arrow*) and strongly reflective gas in a bowel loop (*black arrow*)



Artefato ring-down



Artefato Imagem Espelhada

- Os artefatos da imagem em espelho também são gerados pela falsa suposição de que um eco retorna ao transdutor após uma única reflexão.
- O feixe primário encontra uma interface altamente reflexiva. Os ecos refletidos então encontram o "lado de trás" de uma estrutura e são refletidos de volta para a interface reflexiva antes de ser refletido no transdutor para detecção.
- O display mostra uma estrutura dupla equidistante, mas profunda para a interface fortemente reflexiva.

Artefato Imagem Espelhada

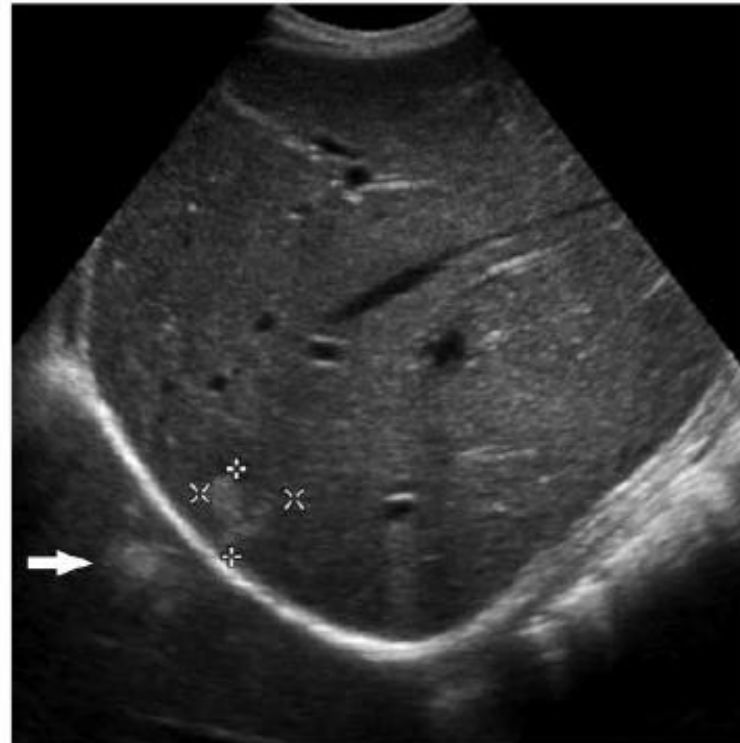
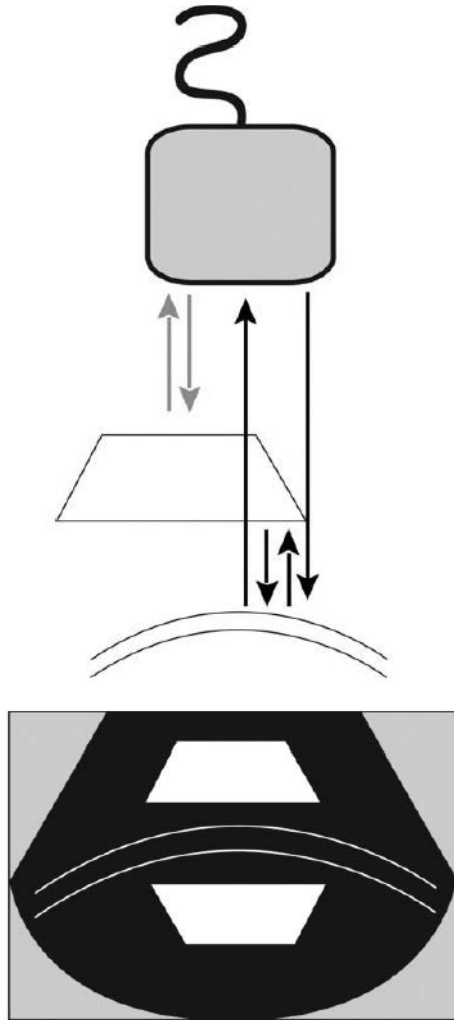


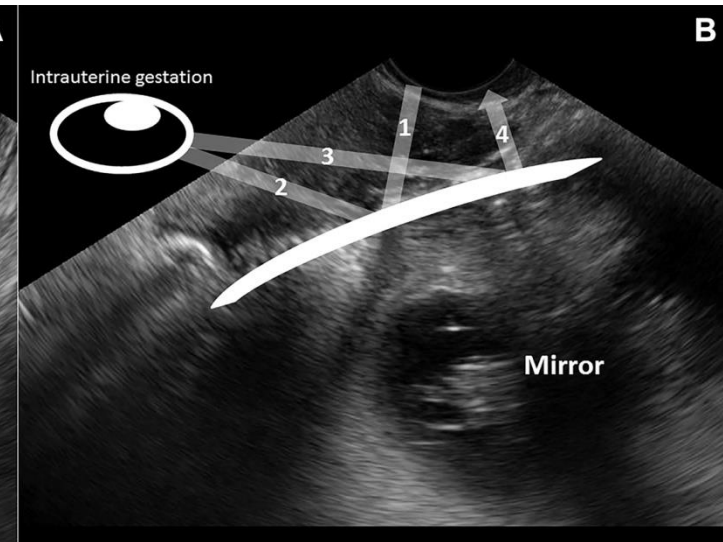
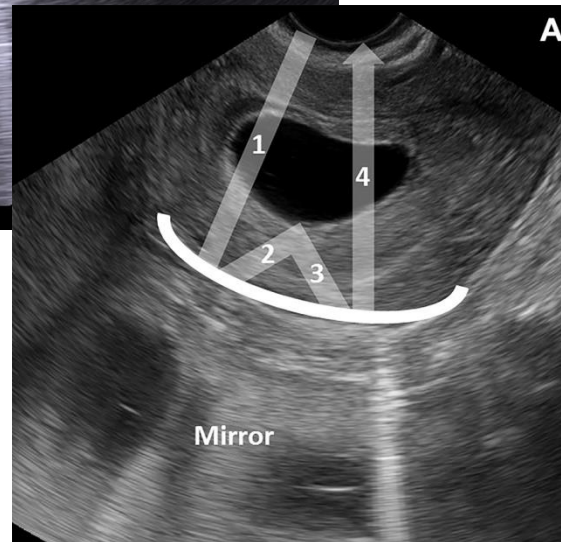
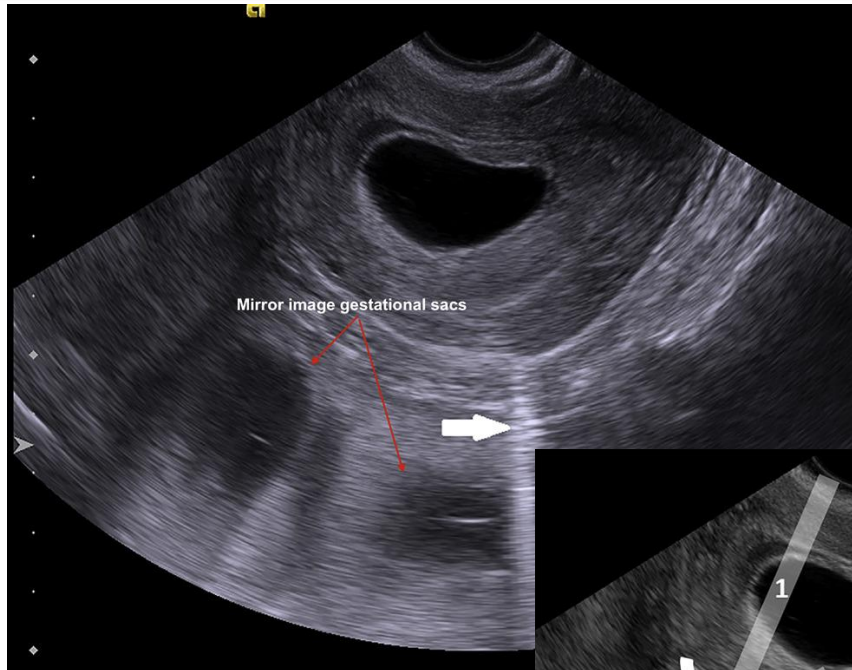
Figure 6. Mirror image artifact. (a) In this diagram, the gray arrows represent the expected reflective path of the ultrasound beam. These echoes are displayed properly. The black arrows show an alternative path of the primary ultrasound beam. In this path, the primary ultrasound beam encounters the deeper reflective interface first. (b) The echoes from the deeper reflective interface take longer to return to the transducer and are misplaced on the display. (c) Longitudinal US image obtained at the level of the right hepatic lobe shows an echogenic lesion in the right hepatic lobe (cursors) and a duplicated echogenic lesion (arrow) equidistant from the diaphragm overlying the expected location of lung parenchyma.

Artefato Imagem Espelhada



Example of a mirror image artifact in which liver tissue appears to be present cranial and caudal to the diaphragm–lung interface. In this image, a complex lesion is seen in the hepatic parenchyma; it is also seen as an artifact deep to the diaphragm-lung interface.

Artefato Imagem Espelhada



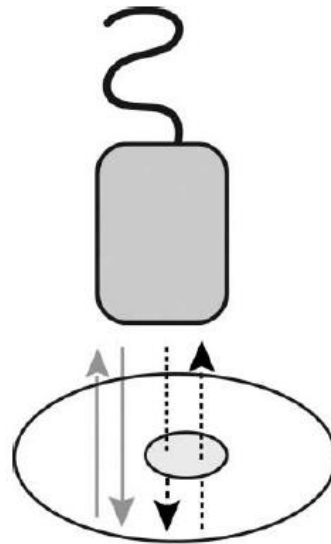
Associado a erros de velocidade

- O equipamento de ultrassom assume velocidade do som constante de 1540 m/s.
- O feixe pode encontrar uma variedade de tecidos como ar, fluido, gordura, músculo, osso. A velocidade do som em cada estrutura pode variar.

Table 1
Density and Speed of Ultrasound for
Selected Tissues

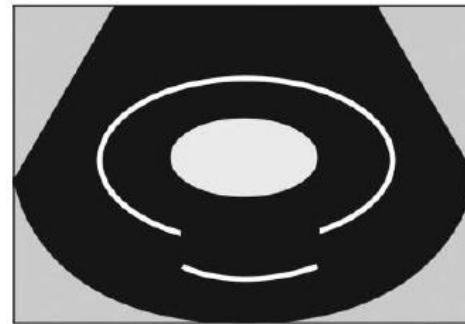
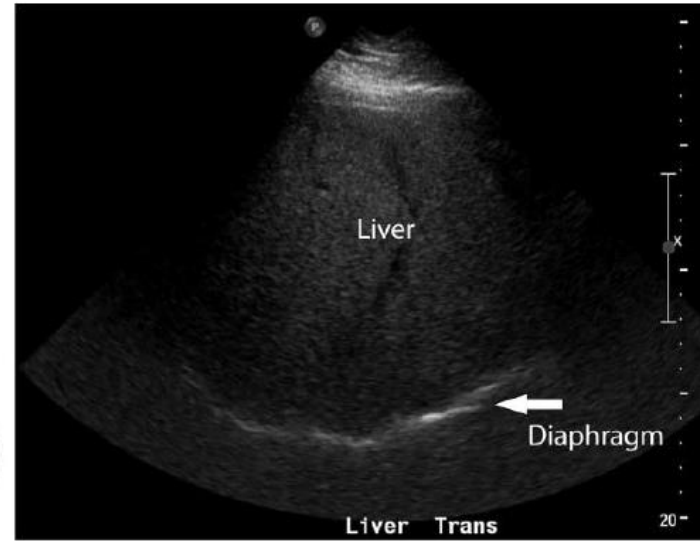
Material	Density (kg/m ³)	C (m/sec)
Air	1.2	330
Fat	924	1450
Soft tissue	1050	1540
Bone	1912	4080

Source.—Reference 3.

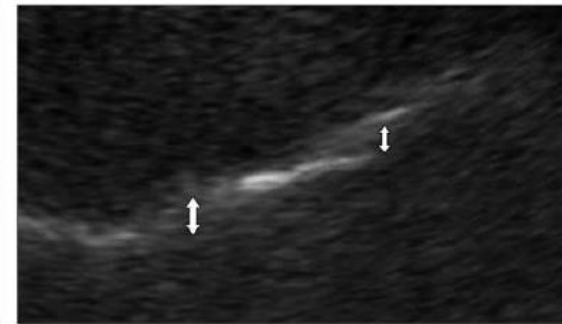


a.

c.



b.



d.

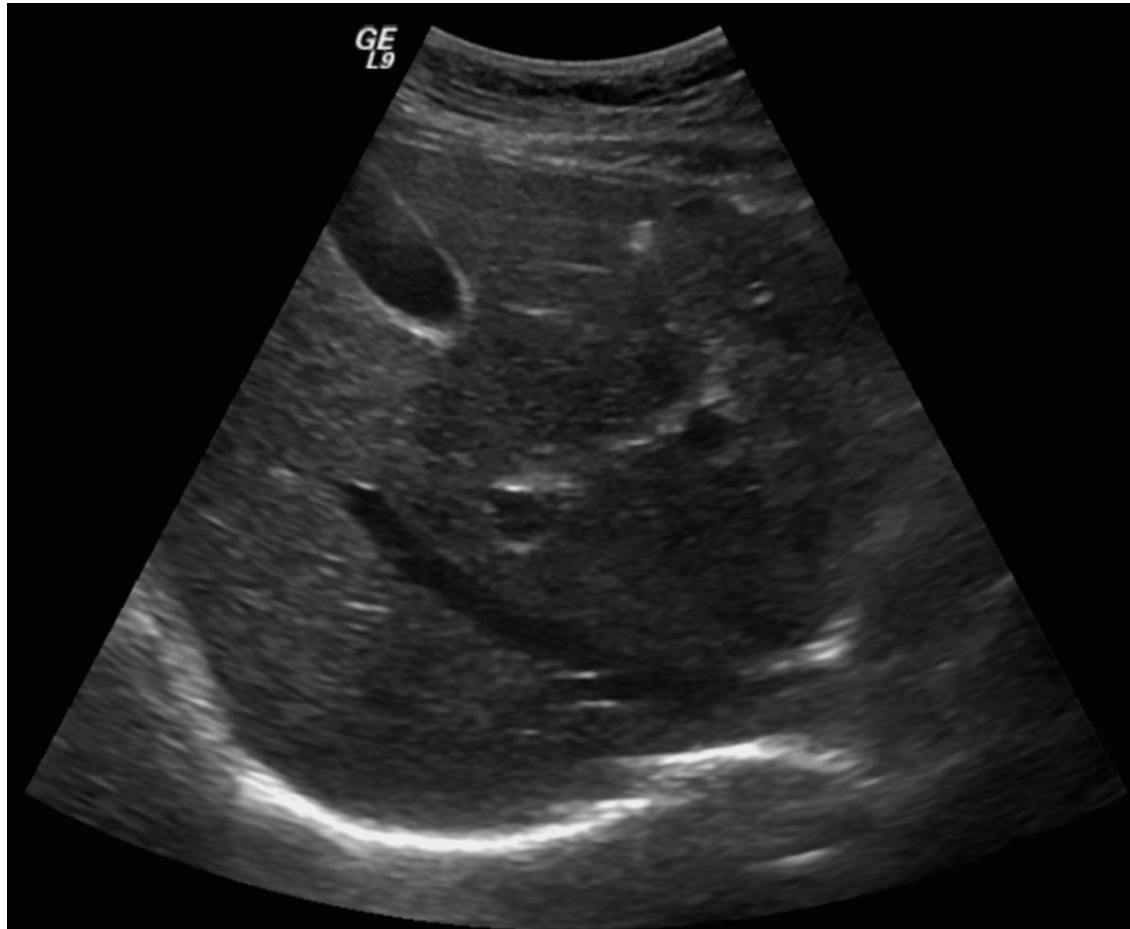
Figure 7. Speed displacement artifact. (a) In this diagram, the gray arrows represent the expected reflected path of the ultrasound beam. The echoes returning from the posterior wall of the depicted structure will be displayed properly. The black arrows represent the path of an ultrasound beam that encounters an area of focal fat. The dashed lines indicate that the sound beam travels slower in the focal fat than in the surrounding tissue. (b) Because the round trip of this echo is longer than expected, the posterior wall is displaced deeper on the display. (c, d) Transverse US image of the liver (c) and close-up detail image (d) show that the interface between the liver and the diaphragm (arrow in c) is discontinuous and focally displaced (arrows in d). This appearance may be explained by areas of focal fat within the liver.

Associado a erros de velocidade



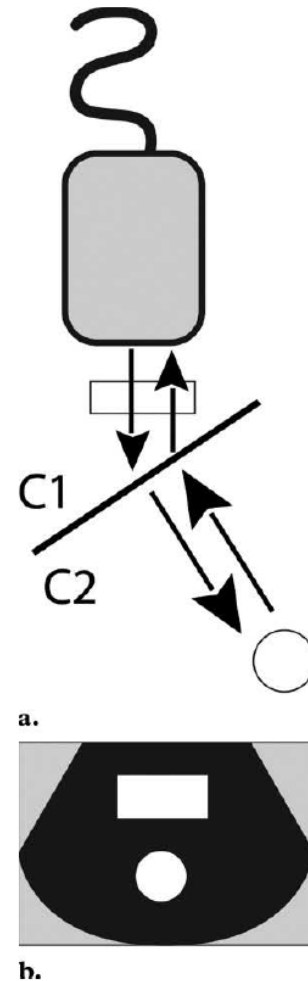
The diaphragm appears undulating (*black arrows*) due to a velocity speed error caused by the heterogeneous hyperechoic liver mass (*white arrows*)

Associado a erros de velocidade

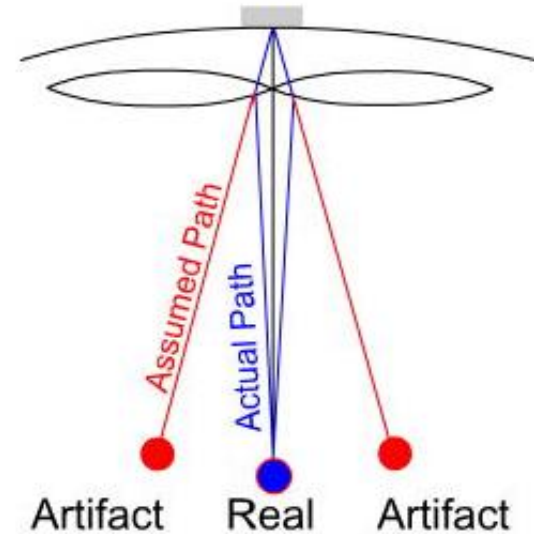


Artefato de refração

Figure 8. Refraction artifact. (a) Diagram shows the refraction or change in direction of the obliquely angled incident ultrasound beam as it travels between two adjacent tissues with different sound propagation velocities ($C1$ and $C2$). The incident ultrasound beam with refraction encounters two structures. (b) The object in the path of the refracted portion of the beam is misplaced because the processor assumes a straight path of the beam.



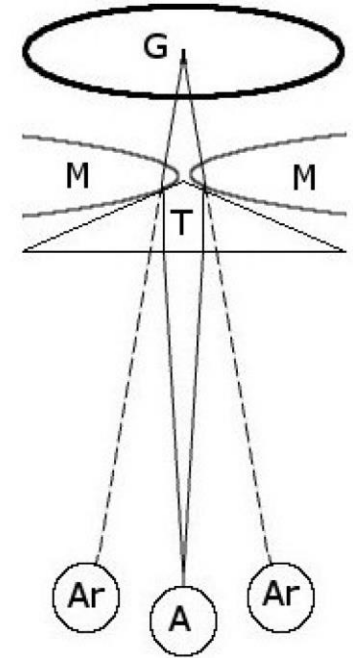
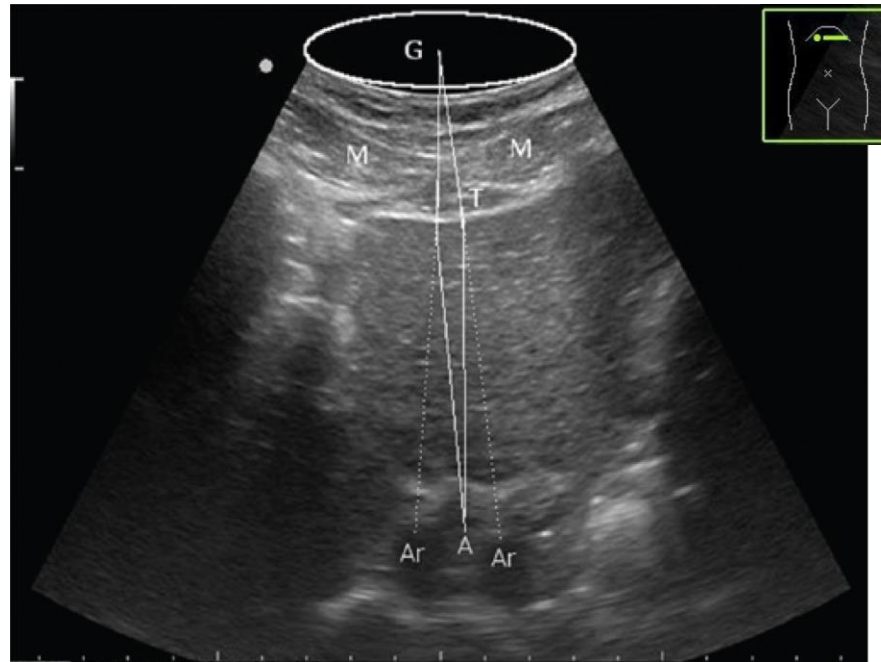
Artefato de refração



Left: transverse abdominal scan showing what appears to be twin gestation sacs (arrow).
Right: diagram showing how a single gestation sac (blue) has been imaged twice

Double aorta artifact in sonography – a diagnostic challenge

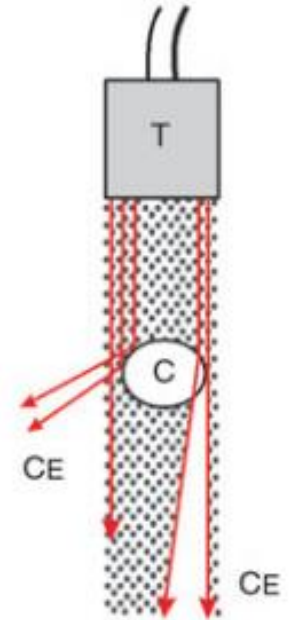
Robert Hadzik / Przemysław Bombiński / Michał Brzewski



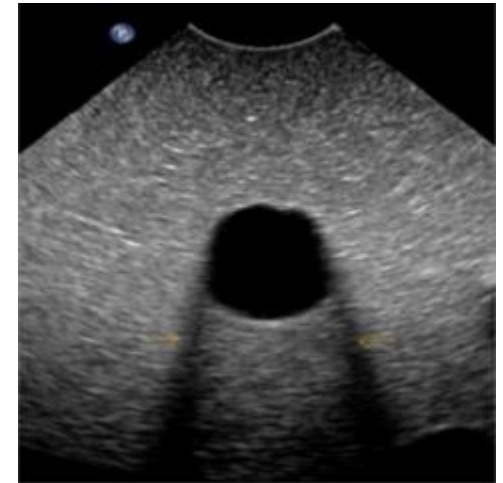
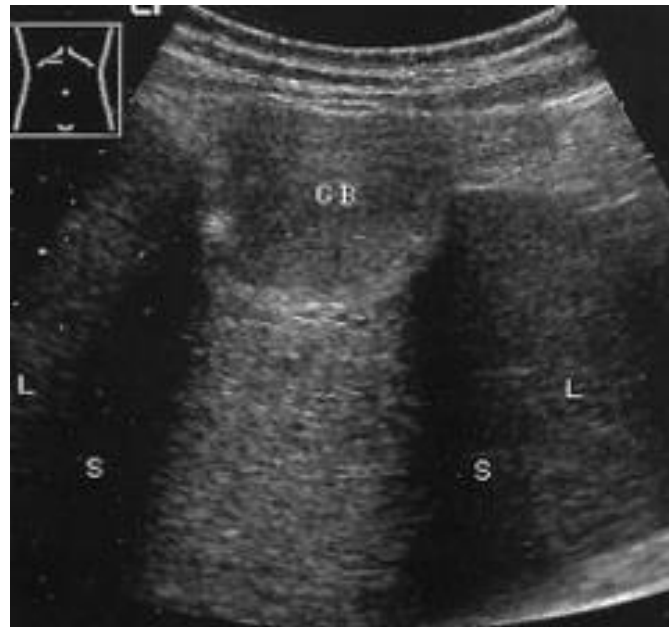
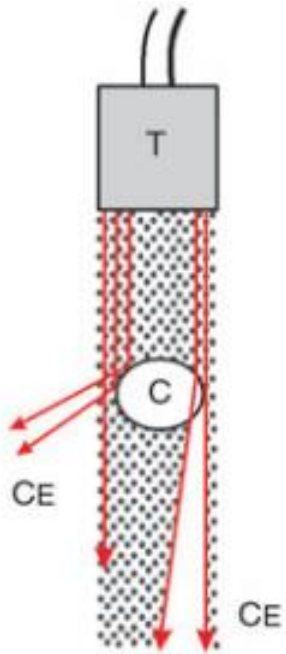
A beam (continuous line) sent by the transducer (G) crosses the superficial fat tissue and rectus abdominis muscle (M), and refracts medially on prismatic slow-conductive deep fat tissue (T). The base of the prism is made by the edge of the liver. Subsequently, ultrasounds reach the aorta (A) through soft tissues. Produced echoes undergo identical refraction (continuous line) on their way back to the probe. The monitor shows two vessels (Ar).

Sombreamento de borda

- **Definição:** sombras acústicas laterais causadas pela angulação do feixe tangencial, espalhamento, refração, atenuação do feixe de ultrassom nas paredes de cisto.
- **Descrição:** Faixas ou sombras hipoecoicas estreitas nas bordas das estruturas císticas, muitas vezes mostrando um padrão divergente.
- **Significado:** O sombreamento da borda é um critério útil para o diagnóstico de cistos.
- T = transdutor,
- C = cisto,
- CE = sombras de borda de cistos.



Sombreamento de borda



TGC – Time Gain Control

Compensar a atenuação!

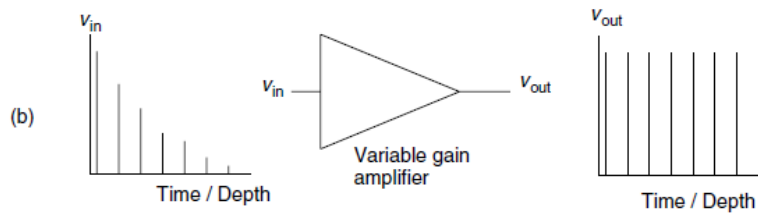
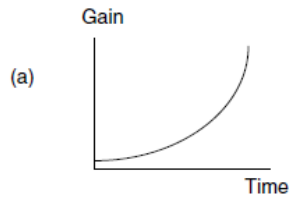
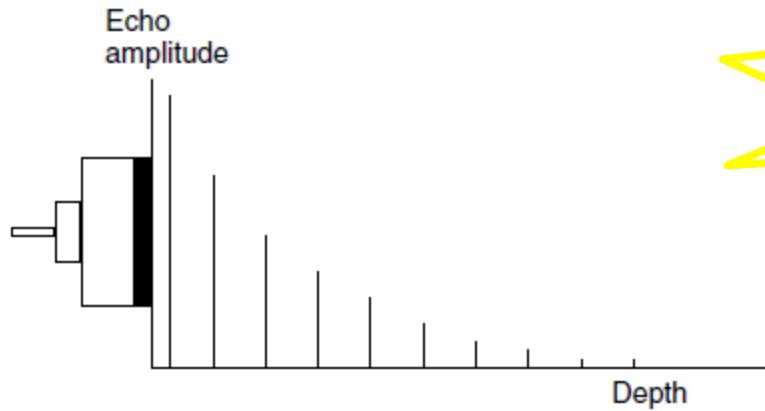


Fig. 4.4 Time–gain compensation (TGC). (a) The gain applied by the TGC amplifier increases with time after transmission to compensate for the greater attenuation of echoes from larger depths. (b) After TGC, echoes from similar interfaces should be equal in amplitude regardless of depth.



TGC slide controls

Artefatos associados a atenuação

- 🌀 O feixe de ultrassom ao encontrar uma região que atenua o som em maior ou menor grau que os tecidos adjacentes, modifica a magnitude do sinal de regiões mais profundas .
- 🌀 Portanto a imagem pode ter um brilho aumentado ou diminuído nessas regiões mais profunda.

Artefatos de sombra

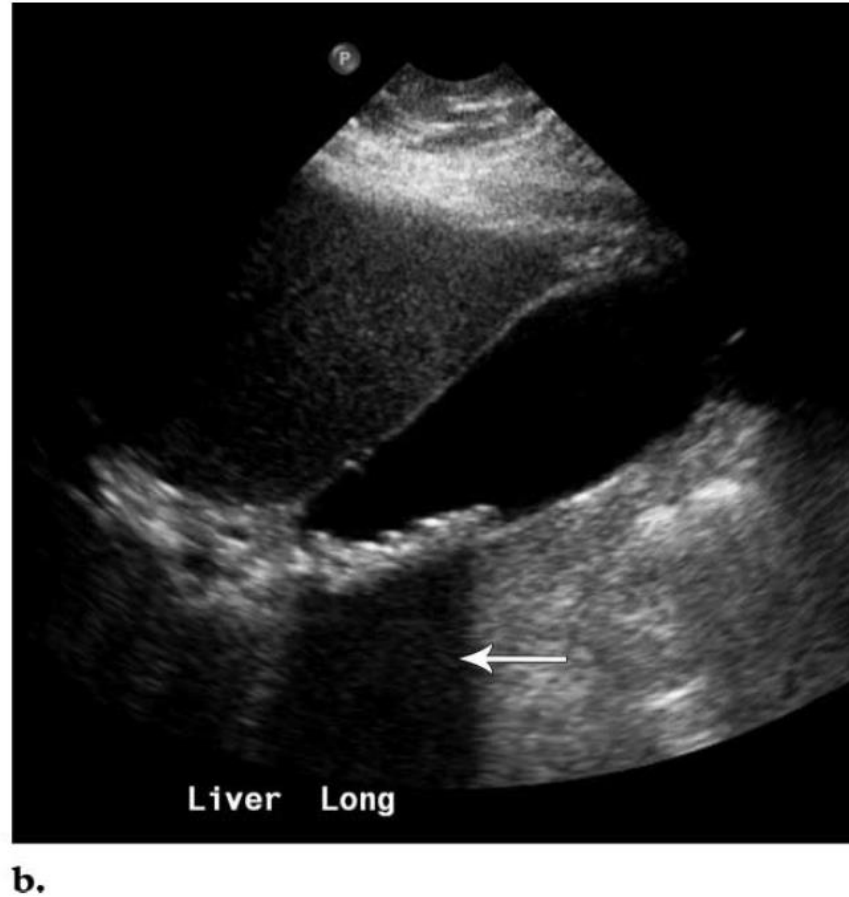
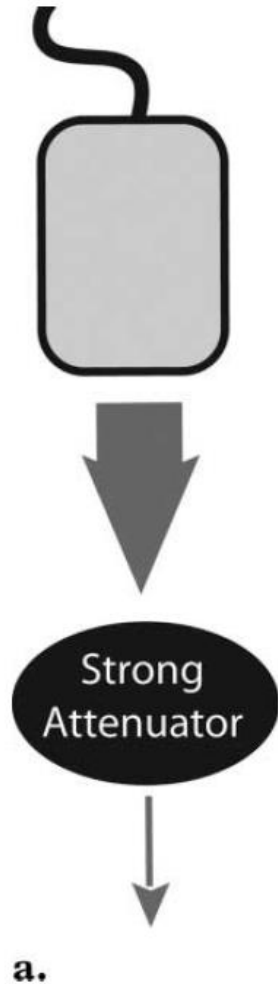
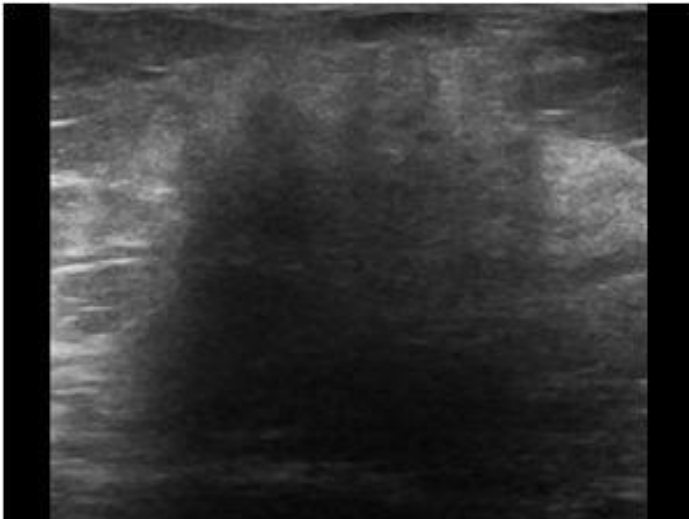


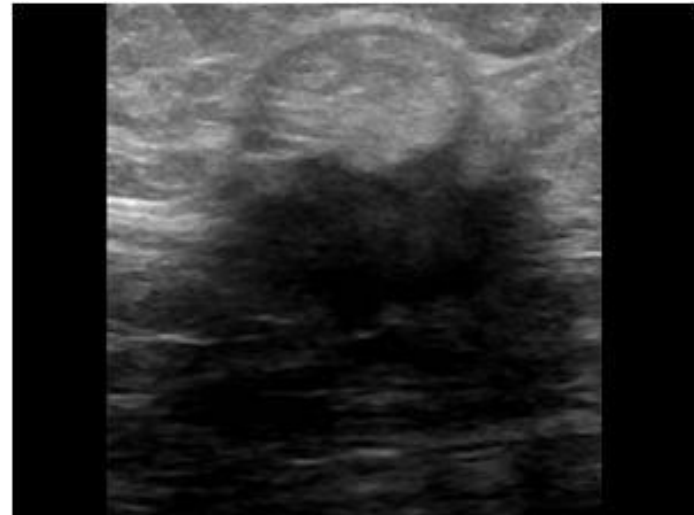
Figure 9. Shadowing.
(a) Diagram shows the ultrasound beam encountering a strongly attenuating material. The echoes received from points distal to this material are significantly lower in intensity than echoes received from a similar depth. (b) Longitudinal US image of the gallbladder shows shadowing (arrow) posterior to echogenic gallstones.

Artefatos de sombra – Lesão de mama

- Lesão Maligna
- Infiltrative breast carcinoma with acoustic shadowing

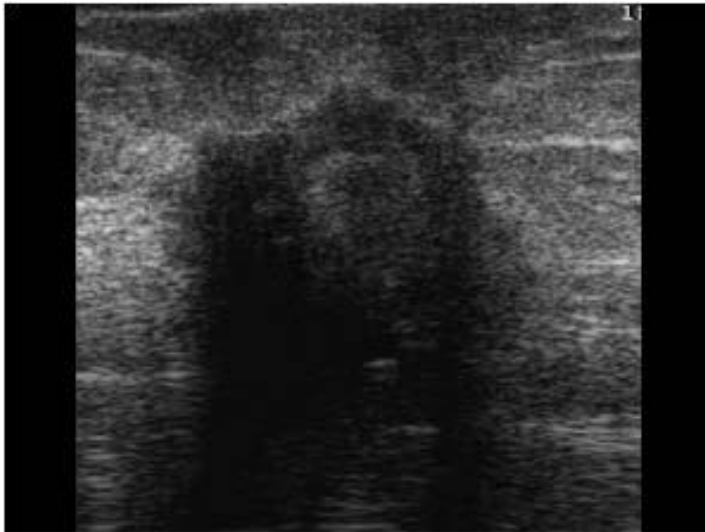


- Lesão Maligna
- Ductal carcinoma with for a part acoustic shadowing

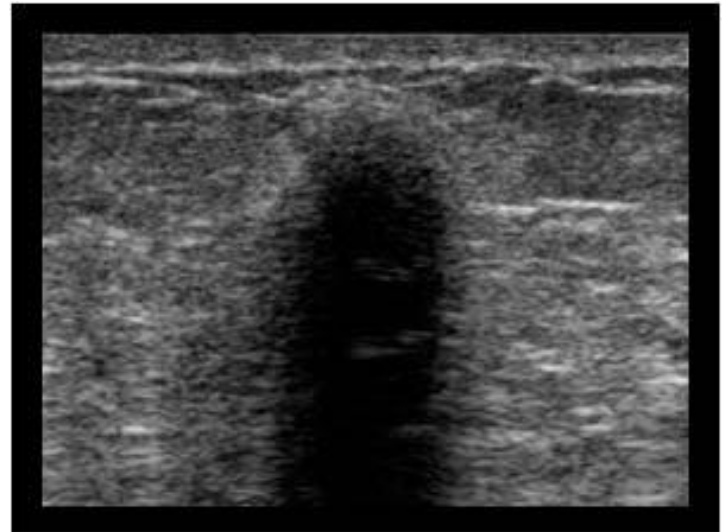


Artefatos de sombra – Lesão de mama

- Lesão Benigna
- Scar mimicking a malignant lesion



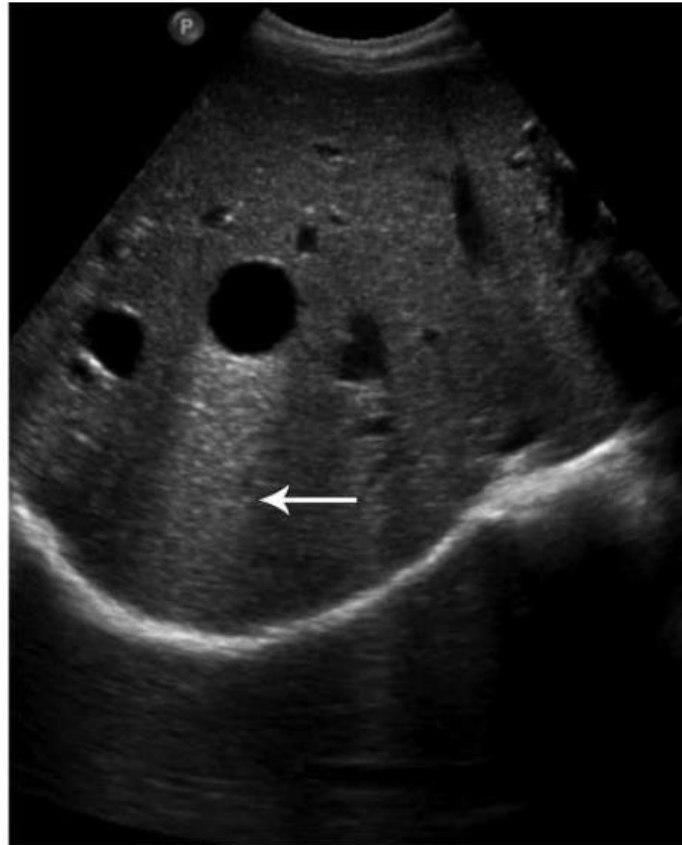
- Lesão Benigna
- Fat necrosis with a dense hyperechoic lesion with acoustic shadowing



Artefato de reforço posterior



a.



b.

Figure 10. Increased through transmission. **(a)** Diagram shows the ultrasound beam encountering a focal weakly attenuating material. The echoes received from points distal to this material are higher in intensity than echoes received from a similar depth in the imaging plane. **(b)** Transverse US image of the liver shows hypoechoic and weakly attenuating hepatic cysts. The hepatic parenchyma distal to the cysts is falsely displayed as increased in intensity (arrow) secondary to increased through-transmission artifact.



a.



b.

Figure 11. Use of attenuation artifacts to analyze the composition of tissue. **(a)** Transverse US image of the breast shows a small hypoechoic nodule with increased through transmission (arrow). The nodule was stable over a 2-year period in a patient with multiple cystic breast lesions. **(b)** Transverse US image of the breast shows a small hypoechoic nodule with posterior shadowing (arrow). The lesion was a pathologically proved breast cancer.