Review Article

Ultrasound—New Techniques Are Extending the Applications

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Summary

Background: Sonography is often the first imaging procedure to be used in diagnostic investigation of the abdomen. The aim of this article is to provide a new interdisciplinary overview of recent groundbreaking advances in this modality.

Methods: A selective survey of the literature in PubMed was conducted. The literature search was carried out in 2021–2022 and included publications over the period 2004–2022.

Results: The novel sonographic software techniques can be divided into algorithms that deal with conventional B-scan optimization and new programs that extend the scope of sonographic examination. The latter include elastography, contrast-enhanced sonography, and image fusion in combination with other cross-sectional imaging modalities. Elastography can be used to assess the presence of steatosis, fibrosis, or cirrhosis in patients with liver disease. One study reported diagnostic accuracy of 84–87% for the diagnosis of significant fibrosis (F2), 89–91% for the diagnosis of severe fibrosis (F3), and 92–93% for the diagnosis of liver cirrhosis (F4). Contrast-enhanced sonography is used for evaluation of tumors and trauma. A prospective multicenter study found sensitivity of 95.8% for the characterization of malignant lesions and specificity of 83.1% for benign lesions. Image fusion has the potential to improve the diagnostic assessment of parenchymatous organs, vascular conditions, and the prostate.

Conclusion: With continuous improvement of the B-scan and the development of high-frequency probes and novel investigation techniques, sonography has become established as an increasingly autonomous examination procedure.

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Sonography is often the first imaging procedure to be used in the diagnostic investigation of the abdomen by representatives from different specialties, such as internal medicine, urology, gynecology, obstetrics, and radiology. New techniques in sonography are divided into software options that primarily aim to optimize B scans and those that extend the scope of sonographic examination. The term B scan is an abbreviation of "brightness scan." Each investigation starts with optimization of the conventional B scan and is followed by additional examination protocols. To this end, in abdominal diagnostic investigation, multi frequency convex probes are habitually used. Structures or lesions localized on the surface can be examined by using higher frequency linear probes. A higher transmission frequency enables a more precise detail of the surface structures with the limitation that higher transmission frequencies have a shallower depth of penetration. Depending on the question and the location of the organ under examination, different probes and their available resolutions are used.

New techniques to optimize the B scan and examination techniques are discussed separately in the following article.

We carried out a selective literature search in PubMed in 2021–2022, which covered publications from 2004 to 2022.

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Ultrasound technique

The basis of ultrasound diagnostics is the conventional B scan. The aim is therefore to improve the quality of the B scan individually by applying different software algorithms. The most commonly used algorithms are tissue harmonic imaging, spatial compounding, and

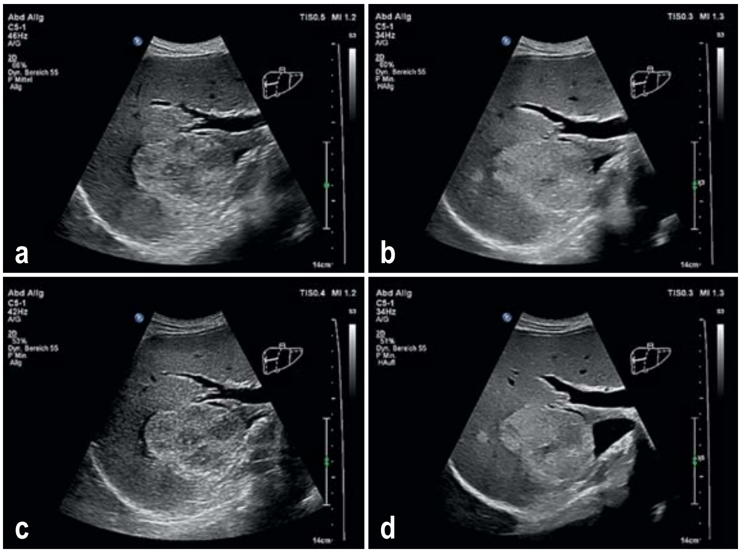

Figure 1: a) Conventional B scan sonography of a solid echoic space occupying lesion of the liver; b) tissue harmonic imaging enables a better outline of the lesion through modification of the soft tissue exposure compared with the conventional B scan. c) Spatial compounding enables the sound waves to spread simultaneously into different directions and leads to an improved signal to noise ratio, thus reducing artefacts. d) Optimized exposure of the liver focus with simultaneous combination of tissue harmonic imaging, spatial compounding, and speckle reduction technique.

speckle reduction. These techniques are explain in detail in the *eMethods* section (1, e19). All described techniques can simultaneously be used for B scan optimization (2, e2) (*Figure 1*).

Elastography

Image acquisition by elastography entails as a first step the mechanical or acoustic stimulation of the tissue under study, which leads to a tissue shift (3, e7). An ultrasound impulse generates shear waves—also known as transverse waves. The speed at which the shear waves spread correlates with the deformation of the tissues that is to be examined (4, e8).

As an additional imaging modality for the characterization of significant fibrosis or cirrhosis ultrasound elastography is the first method for assessing liver stiffness. The method most commonly used in this setting is transient elastography, whose findings are highly consistent with histopathological findings after liver biopsy (e7).

Ferraioli et al. (5) studied the sensitivity and specificity of 2-D shear wave elastography in 121 HCV patients in order to grade the liver fibrosis compared with the gold standard of liver biopsy and transient elastography (TE). Liver fibrosis was categorized into significant fibrosis, severe fibrosis, and cirrhosis *(Table 1)*.

Friedrich-Rust et al. in their studies showed diagnostic accuracy of 84–87% for the diagnosis of significant fibrosis (F2), 89–91% for the diagnosis of sever fibrosis (F3), and 92–93% for the diagnosis of liver cirrhosis (f4) (6, 7).

When using elastography for evaluating the liver it should be borne in mind that the stiffness measurements can be affected negatively by patient dependent co-factors. Raised transaminases in the sense of active hepatitis, a postprandial examination, certain medications, and chronic heart failure are considered as disruptive factors in the assessment of liver stiffness (8, e9).

In one of the first publications on the subject of liver shear wave elastography, Friedrich-Rust et al. compared a conventional ultrasounds system with integrated shear wave elastography with the gold standard at the time, transient elastography (TE). They concluded that this new technique is a promising ultrasound based method to assess liver fibrosis in chronic viral hepatitis. The diagnostic accuracy in this preliminary study matched that of transient elastography (9).

Spoera et al. pointed out as early as 2014 that shear wave elastography as well as transient elastography yield reliable results in assessing liver stiffness. They can be used as a predictor for the severity of the fibrosis, and the need for liver biopsy in patients with chronic liver disease can be reduced (10).

Li et al. carried out a prospective study in 166 patients to investigate the diagnostic accuracy of 2-D shear waves to assess possible liver fibrosis in patients with chronic hepatitis B. The authors concluded that the values, correlated with histology, agree well for the differentiation of severe liver fibrosis and cirrhosis, but are of only limited value for diagnosing mild fibrosis (11), and no conclusion can be drawn about the genesis of liver damage.

Many studies have shown that 2-D shear wave elastography (SWE) and point-shear wave elastography are superior to transient elastography for assessing liver stiffness and fibrosis (12, e10-e13).

Point-shear wave elastography can acquire data only within a small region of interest; by comparison, 2-D shear wave elastography can utilize the entire B scan.

To evaluate current studies, Zhou et al. undertook a meta-analysis of 186 publications, aiming to find out which of the two shear wave modalities, 2-D SWE or point-SWE, is better at assessing liver fibrosis. They concluded that 2-D SWE as well as point-SWE have high sensitivity and specificity in detecting fibrosis, with 2-D SWE having higher sensitivity to detecting significant fibrosis and advanced fibrosis than pSWE (13). *Table 2* shows the statistical analysis.

The liver is a target organ for the use of shear wave elastography. The stiffness correlates with the grade of fibrosis and indirectly with the degree of portal hypertension and the risk of developing hepatocellular carcinoma (*Figure 2*). Liver lesions can appear soft or hard on stiffness measurement, independent of their entity. Because of overlaps in the stiffness measurements, guidelines do not recommend using shear waves to distinguish between benign and malignant focal liver lesions (14, 15, e14–e16).

TABLE 1

SWE and TE compared with the METAVIR stage (meta-analysis of histological data in viral hepatitis) (5)

Fibrosis stages	Sensitivity	Specificity	PPV	NPV
2-D SWE				
F ≥2	90.0 (80.5–95.9)	87.5 (74.8–95.3)	91.3 (82.0–96.7)	85.7 (72.8–94.1)
F ≥3	97.3 (85.8–99.9)	95.1 (87.8–98.6)	90.0 (76.3–97.2)	98.7 (93.1–100)
F = 4	87.5 (67.6–97.3)	96.8 (91.0–99.3)	87.5 (67.6–97.3)	96.8 (91.0–99.3)
TE				
F ≥2	69.6 (57.3–80.1)	89.6 (77.3–96.5)	90.6 (79.3–96.9)	67.2 (54.3–78.4)
F ≥3	89.2 (74.6–97.0)	88.8 (79.7–94.7)	78.6 (63.2–89.7)	94.7 (86.9–98.5)
F = 4	91.7 (73.0–99.0)	96.8 (90.9–99.3)	88.0 (68.8–97.5)	97.8 (92.4–99.7)

F, fibrosis; NPV, negative predictive value; PPV, positive predictive value; 2-D SWE, 2-D shearwave elastrography; TE, transient elastography

Contrast enhanced ultrasound (CEUS)

The prevalence of focal liver lesions in the overall population is some 5%. They are often an incidental finding in the context of abdominal ultrasounds or targeted oncological staging (16).

Strobel et al. carried out a prospective study in a patient population of n=1349, investigating the diagnostic certainty of contrast enhanced ultrasound in characterizing space occupying lesions of the liver. Based on the gold standard, 573 benign lesions and 755 malignant lesions were included.

Compared with the gold standard, the diagnostic certainty of contrast enhanced ultrasound to assess a hepatic lesion was 90.3%.

Contrast enhanced sonography correctly identified 723/755 malignant lesions (sensitivity 95.8%) and 476/573 benign lesions (specificity 83.1%). The positive predictive value for the presence of a malignant tumor was 95.4%, the negative predictive value for the presence of a malignant tumor was 95.7% (17, e17) (*eFigure*).

In the setting of contrast enhanced diagnostic evaluation of the liver, Sono Vue (Bracco, Milan, Italy) is available in Germany. It consists of 1–10µm sized microbubbles that are filled with an inert gas (sulfur hexafluoride). The contrast medium is stabilized by an outer shell of phospholipids. Compared with contrast agent computed tomography (CT) or magnetic resonance imaging (MRI), no spillover into the interstitial space takes place. The ultrasound contrast medium remains in the vascular system and can therefore expose the capture of organ perfusion (18, e18).

No nephro-, hepato-, or cardiotoxic effects occur. Administration of the contrast medium does not affect thyroid function. The incidence of severe anaphylactic reactions is 1/10,000 applications (18, e19).

As with every application of contrast medium (CT, MRI, ultrasound) anaphylactoid reactions may develop in rare cases. As these are unpredictable, emergency medications should be ready in the examination room. In cardiovascular instability and severe cardiac arrhythmias, the indication should be stringently checked before every application of contrast medium and where needed should be defined cautiously or conservatively.

In contrast enhanced liver examinations, three different phases are considered that enable the detection and characterization of hepatic lesions (e18).

Torres et al. evaluated 287 CEUS examinations in children in a retrospective study. In this patient population, 36 children with unclear hepatic lesion were included. In a subgroup analysis the specificity for the correct categorization of a lesion as benign was 96% and the negative predictive value was 100%. No adverse effects were recorded for the CEUS examination (19).

Geyer et al. in a retrospective study investigated the diagnostic certainty of contrast enhanced ultrasound in the characterization of liver lesions and correlated these with the gold standard of histopathology.

Contrast enhanced ultrasound has a sensitivity of 94.5% and a specificity of 70.6%. The positive predictive value was 87.3% and the negative predictive values was 85.7% compared with histology as the gold standard. No adverse effects were observed (20). The authors concluded that contrast enhanced ultrasound is a safe imaging method with high diagnostic accuracy in the assessment of benign as well as malignant hepatic lesions.

In spite of the many advantages/benefits, the use of CEUS in the liver has limitations. Very small lesions below the detection threshold of 3–5 mm may be overlooked because of the limited resolution. Furthermore, one can assume that liver foci in liver localizations that are difficult to access—such as the subdiaphragmatic sections of segment VIII—cannot always be exposed. The depth of penetration of CEUS is limited, so deep seated lesions or lesions in steatosis are more difficult to capture (18). In addition to patient related parameters, such as meteorism or obesity, the diagnostic confidence of contrast

TABLE 2

Statistical summary of the meta-analysis by Zhou et al. (13)

Fibrosis stages	Sensitivity	Specificity
2-D SWE		
F ≥2	0.84 (0.80–0.87)	0.81 (0.75–0.85)
F ≥3	0.90 (0.86–0.93)	0.87 (0.83– 0.91)
F = 4	0.89 (0.85–0.92)	0.87 (0.83–0.90)
Point SWE		
F ≥2	0.76 (0.73–0.80)	0.79 (0.75–0.83)
F ≥3	0.83 (0.80–0.86)	0.83 (0.80–0.86)
F = 4	0.85 (0.80–0.88)	0.84 (0.81–0.87)

Point SWE, Point shearwave elastography; 2-D SWE, 2-D shearwave elastography

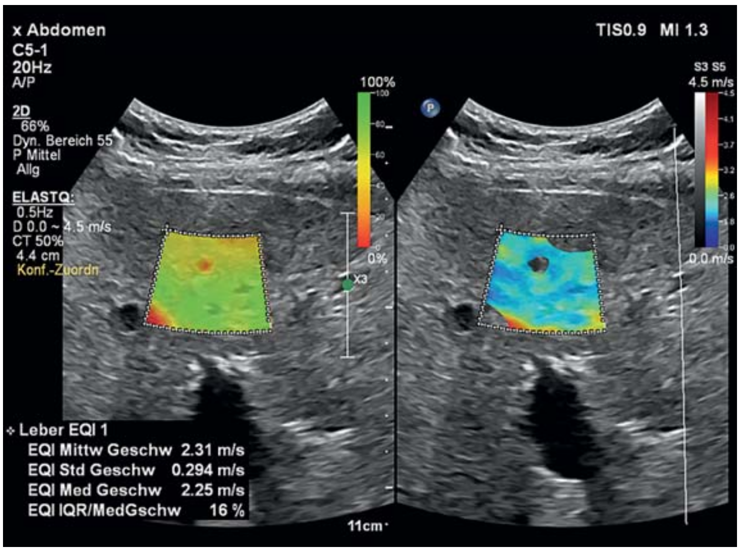

Figure 2: 2-D shearwave elastography of the liver. Tissue stiffness is determined within the selected region of interest and quantitatively reported with the unit m/s. The mean of the shearwaves is 2.31 m/s and therefore clearly raised, which matches the picture of cirrhosis.

enhanced ultrasounds depends on the experience of the doctors carrying it out (21, 22).

ESFUMB (the European Federation of Societies for Ultrasound in Medicine and Biology) in its recommendations explicitly points out that contrast enhanced liver sonography should be undertaken only by professionals who have sufficient experience in conventional as well as contrast enhanced ultrasound (21, 22).

Image fusion

To ensure dynamic image fusion between the ultrasound and a tomographic modality in real time, the required hardware consists of a magnetic field generator and a sound detection sensor. The software makes it possible to locate the transducer in the magnetic field and therefore to calculate the precise spatial position of the sensor in the room. Image formats that can be used are the established DICOM data of tomographic approaches (such as CT, MRI, positron emission tomography [PET]-CT, PET-MRI). The datasets can be fused manually or automatically and then move simultaneously with the sonographic scanning plane (23, 24). By simultaneous use of image fusion, a tumor related assessment can be done in the immediate comparison to CT or MRI (25, 26, e20).

Combining contrast enhanced ultrasound with subsequent tomography can enable improved detection and characterization of liver lesions, with the option of consecutive therapy (26, 27) (*Figure 3*).

Wobser et al. studied in a patient population (n=40) the response of hepatocellular carcinoma to the chemoembolization undertaken. Image fusion with CEUS rated the effectiveness of the treatment with a specificity of 100%, a sensitivity of 80%, and a positive predictive value of 1 (negative predictive value 0.63) (27).

In addition to the primary detection of lesions, image fusion enables an improved biopsy technique (e20). An example is detection of prostate cancer in transrectal ultrasound (TRUS). Prostate cancer foci are often anechoic, but they can also be isoechoic or hyperechoic (28–31). New multimodal MRI examination protocols enable improved cancer detection (32–34). The combination of B scan and MRI dataset in the context of image fusion makes it possible to undertake, in addition to a systematic biopsy, a targeted fusion MRI ultrasound biopsy of the suspect MRI lesion.

In addition to the improved detection rate of significant prostate cancers, this type of targeted biopsy is technically simpler than a biopsy undertaken directly in the MRI scanner. For this so called in bore biopsy, the patient is put in a prone position in the scanner tube and the biopsy is done as a rule via the transgluteal route, which requires more time.

Drost et al. in a Cochrane analysis studied the diagnostic accuracy of different biopsy methods for the detection of clinically significant prostate cancers and compared these. 13 of the 18 included studies were prospective. The authors maintain as their most important finding that using MRI/ultrasound fusion biopsy does actually detect more significant prostate cancers and that fewer punch specimens need to be taken to this end (35).

As a positive side effect, fewer clinically nonsignificant cancers are found in this war, which reduces the risk of overtreatment for the affected patients. In the meantime, the now very good evidence for multiparametric MRI and fusion biopsy has led to a modification of the guideline recommendations. In the current version of the S3 guideline prostate carcinoma (version 6.2) (36), the use of multiparametric MRI is recommended not only after a negative biopsy finding but during the primary diagnostic evaluation.

Different studies at our hospital have shown that combining data from prostate MRI and targeted B scan biopsy significantly improved the diagnostic accuracy compared with the gold standard of histology (35–40) (Figure 4). Schlenker et al. studied a patient population of n=408. In this population, 41 patients had a PIRADS-3 lesion on MRI, which was then biopsied in a targeted fashion, conventionally and fusion enhanced. On fusion biopsy, a relevantly increased score (Gleason 7a or above) was diagnosed (6/41 patients; 14.6%) than on conventional prostate biopsy (2/41 patients; 4.9%).

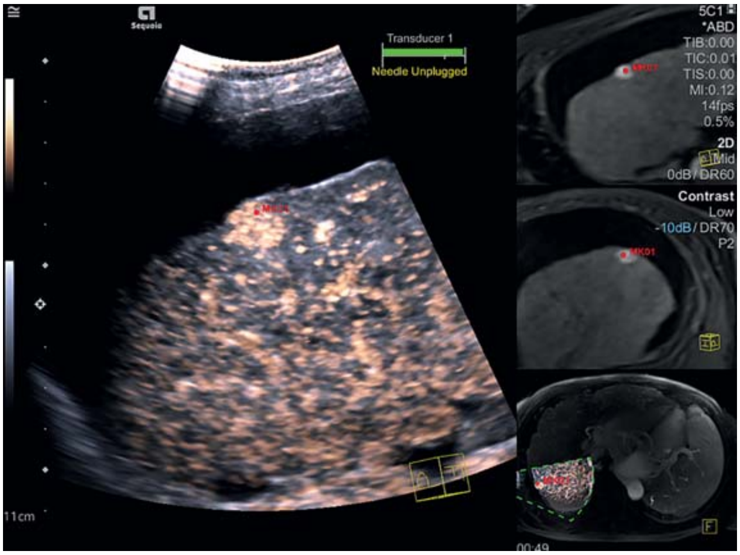

Figure 3: On the contrast enhanced MRI scan, a suspect liver lesion is visible (red marker) in a cirrhotic liver. In the same position and with a comparable size, this lesion shows increased early arterial contrast medium absorption on ultrasonography. MRI morphologically and sonographically the finding is consistent with a hepatocellular cancer about 1 cm in size.

Conclusions for clinical practice and outlook

Continuous improvements to B scans and novel diagnostic techniques have established sonography as an increasingly independent examination method. Ultrasound elastography is an established procedure that is easy to carry out and can be used as an add-on in the setting of routine ultrasound. Broad and comprehensive data of the use of elastography in patients with liver disorders already exist. The detection and characterization of hepatic lesions succeeds thanks to the use of contrast enhanced ultrasound and is therefore actually comparable with contrast enhanced MRI. Image fusion makes it possible to combine different tomography methods in the context of the primary detection of lesions or to plan an intervention. In routine clinical practice, this approach is now standard in large ultrasound centers.

Unfortunately, the same method-immanent limitations of ultrasonography apply for the techniques under discussion. Obesity, meteorism, or lacking compliance on the part of the patient can result in restricted interpretability of the results.

What can we expect in the near future increasingly as an additional diagnostic investigation in the setting of ultrasonography?

One focus is on the development of new broadband power Doppler or techniques that expose the flow in the vessels by means of vectors (e28, e29). The development of novel, contrast enhanced ultrasound techniques makes it possible to work with an image rate of up to 60 images/second and therefore notably improve the temporal resolution of contrast enhanced sonography.

Routine diagnostic evaluation has in the meantime become the standard in private practices. Special questions can only be answered by using high end equipment because of the substantial technical requirements, and they require a lot of time and effort. Under economic considerations this is akin to squaring the circle. For this reason it makes sense for particular clinical questions to refer the patient for further investigations in specialized institutions, in addition to basic diagnostic tests. In addition to the continuous further development of novel ultrasound techniques, the focus should be on comprehensive sonography training. This can be undertaken in centers locally or by means of the nationally available program of courses provided by the German Society of Ultrasound in Medicine (DEGUM).

Jointly with the International Contrast Ultrasound Society (ICUS) we have succeeded in developing and further developing continuing medical/professional development, by using social media, such as the Instagram account „ultrasound campus."

Conflict of interest statement

Prof. Clevert received honoraria for continuing medical educational events from Philips, Siemens, Esaote, Samsung, Mindray, und Bracco. He sits on the extended advisory board of Philips, Esaote, Samsung, Mindray, und Bracco.

The remaining authors declare that no conflict of interest exists.

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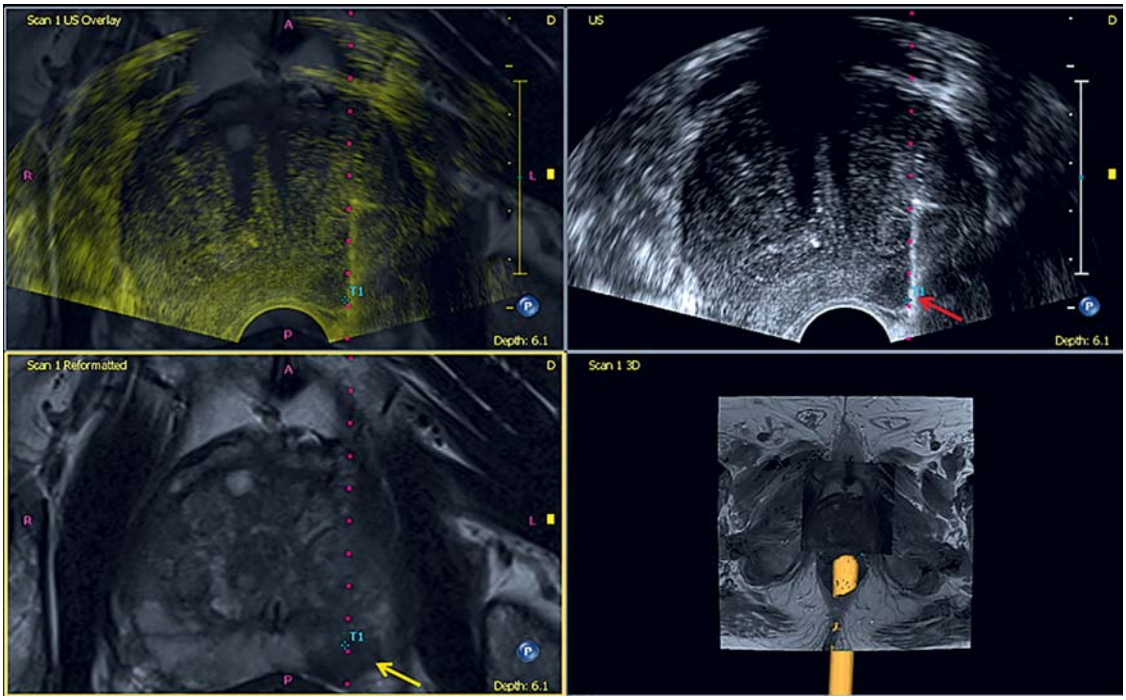

Figure 4: On the MRI scan of the prostate a suspect PI-RADS-4- lesion is detected (yellow arrow) in the peripheral zone on the left side. Image fusion yields a fusion guided prostate biopsy (red arrow) of a suspect prostate lesion. GPS tracking (blue marker T1) correlates well with the lesion in both modalities. Histology confirmed a poorly differentiated acinar prostate carcinoma (Gleason score 3 + 4 = 7a).

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► **Supplementary material**

eReferences, eMethods, eFigure:
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Supplementary material to:

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eMETHODS

Tissue harmonic imaging

Tissue harmonic imaging has been used in the diagnostic evaluation of different organ systems for more than 20 years and it is being improved continually. Tissue harmonic imaging enables modification of tissue exposure, linked with improved capture of the tissue structure (e26). Defocusing and /or phase shifts owing to tissue inhomogeneities will usually lead to a significant loss of lateral resolution and reduced contrast exposure in conventional ultrasound examinations (e1, e3, e27).

Lateral resolution describes the resolution potential in the direction of the sounds spread/distribution and strongly depends on the shape/form of the sound field. The highest lateral resolution is found in the area of the focal point.

The compression and decompression of the ultrasound impulses within tissue bring about harmonic non-linear oscillations that correspond to double the frequency of the selected baseline frequency. In tissue harmonic imaging these harmonic echo components are additionally used for image construction/composition and lead to a better quality image (e2, e4-e5, e28).

Sodhi et al. showed in a cohort of 50 patients with focal hepatic lesions that using harmonic tissue imaging yielded additional information in 16% of cases; in 6% of cases these insights prompted treatment adjustments (e38).

Ranga et al. studied a patient population (n=100) with solid but also cystic hepatic lesions and assessed the overall image quality of the lesions on the basis of a point scale with different presets. The authors concluded that a combination of harmonic tissue imaging and spatial compounding yielded images of the highest quality. Using the mere B image had the lowest diagnostic value in characterizing the lesions (e29).

In the early years, tissue harmonic imaging was only temporarily used in the diagnostic evaluation of the breast as this technique was associated with a reduced frame rate (e1). The frame rate describes the number of images per second that are visible on the monitor. The fewer images are calculated the more the image acquisition is delayed. By using the higher frequencies, this technique is particularly advantageous in structures localized at the surface level. For lesions that require a great depth of penetration, the usefulness of this technique is limited (e1, e26).

Spatial compounding

The spatial compounding technique is based on the multidirectional electronic use of the transducer. This sends the sound waves into different directions at one level, and several of these images are subsequently composed into a single overlapping image in real time.

An improved signal to noise ratio, a reduction of artefacts, and a higher contrast resolution are the advantages of this technique compared with the conventional native B scan (e30–e33).

Different graded settings (low, medium, high, maximum) are available options for this technique, of which a low level has proved beneficial/advantageous on examination (e34).

Speckle reduction

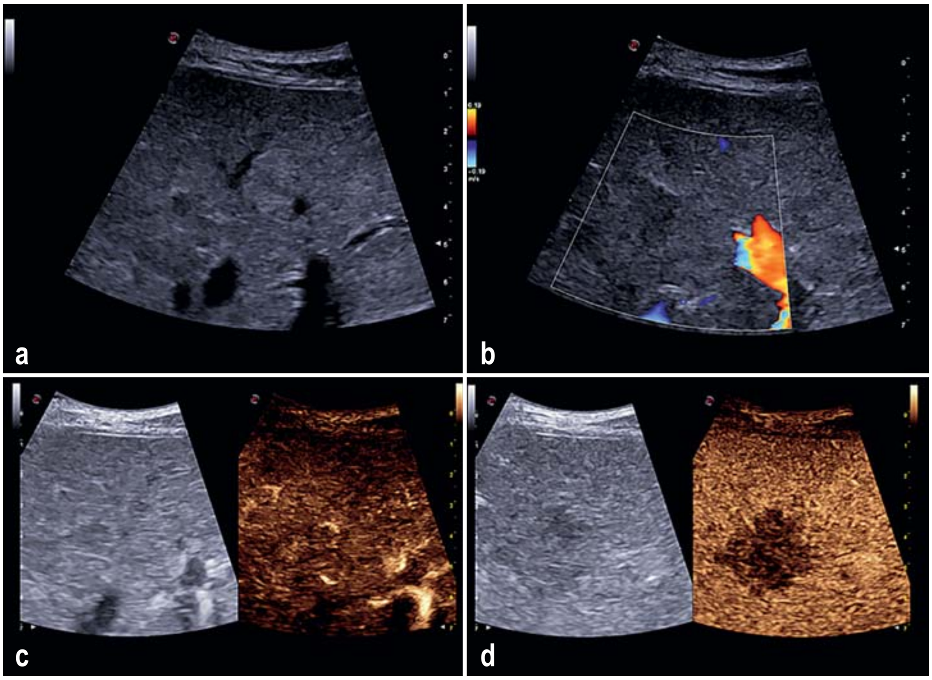
The inherent occurrence/appearance of artefacts is known as “speckle” in sonography. These speckles are coupled with a reduction in contrast and spatial resolution; deeper-seated tissue structures appear darker. Speckle reduction technology allows smoothing and homogenizing of the surrounding structures in the image by suppressing the appearing artefacts. While differences in echogenicity are captured, the contours of the focal finding are maintained and a structural creation is prevented (e1-e26). Depending on the user choice, different pre-sets with different smoothing algorithms can be applied. These algorithms lead to increasing homogenization and smoothing of the surrounding tissue, comparable to imaging in modern MRI scans (e1-e26).

In different studies—such as that by Hyun et al—artificial neuronal networks were successfully trained with the aim to improve ultrasound imaging by optimizing speckle reduction imaging (e34–e35).

The use of new algorithmic filters while using speckle reduction technology leads to improved image quality, according to Choi et al. and Yu et al. (e6, e36).

AI algorithms are increasingly integrated into routine clinical practice.

In the area of endoscopic ultrasonography, this technique enables exact identification and sizing of lymph nodes for staging cancers of the gastrointestinal tract, according to Afshari et al. (e37).



eFigure: Sonography of a 63 year old female patient with newly diagnosed cervical carcinoma. She presented for a liver check-up. a) On conventional B scan sonography a definitely suspect hepatic lesion cannot be outlined. b) Color coded duplex sonography does not show up any atypical increased vascularization. c) On contrast enhanced sonography a hypervascularized hepatic lesion in the arterial phase cannot be exposed/captured. d) In the portal venous phase a 2 cm sized liver metastasis is demarcated.

Questions on the article in issue 4/2023:

Ultrasound—New Techniques Are Extending the Applications

cme plus+

The submission deadline is 26 January 2024. Only one answer is possible per question.
Please select the answer that is most appropriate.

Question 1
What does the "B" in "B scan" stand for?
a) "better"
b) "bundle"
c) "black"
d) "brightness"
e) "budget"

Question 2
Which term—which is mentioned in the text of the article—can used as an alternative term for "shear waves" in ultrasound?
a) Beta waves
b) Longitudinal waves
c) Transverse waves
d) Gamma waves
e) Delta waves

Question 3
What distinguishes 2-D shear wave elastography from point shear wave elastography?
a) Lower sensitivity regarding the detection of advanced fibrosis
b) Use of the entire B scan
c) Lower sensitivity regarding the detection of significant fibrosis
d) Lower specificity regarding the detection of all fibrosis stages
e) Fibrosis cannot be diagnosed

Question 4
What, roughly, is the prevalence of focal hepatic lesions in the total population?
a) 1 %
b) 5 %
c) 10 %
d) 20 %
e) 35 %

Question 5
Which inert gas is used as a contrast medium in contrast enhanced diagnostic evaluation of the liver?
a) Helium
b) Krypton
c) Nitrogen
d) Xenon
e) Sulfur hexafluoride

Question 6
Which statement regarding the mechanism/mode of action of the sonography contrast medium is correct?
a) It is hepatotoxic.
b) It affects thyroid function.
c) It is nephrotoxic.
d) It is cardiotoxic.
e) It remains in the vasculature

Question 7
In contrast enhanced sonography of the liver, what is the approximate estimated incidence of severe anaphylactic reactions?
a) 1/100 applications
b) 1/500 applications
c) 1/1 000 applications
d) 1/10 000 applications
e) 1/100 000 applications

Question 8
Which recommendation does the S3 guideline prostate carcinoma make for the diagnostic evaluation of prostate cancer?
a) Use of mpMRT only after a negative biopsy result
b) Use of mpMRT only after a positive biopsy result
c) Use of mpMRT in the primary diagnostic evaluation
d) No use of mpMRT without prior biopsy
e) No use of mpMRT if the PSA value is abnormal

Question 9
Which patient dependent co-factor – which is mentioned in the text of the article – can negatively affect liver stiffness measurements taken by elastography ?
a) Ingestion of a meal
b) Thyroid function disorder
c) Respiratory infection
d) Gastritis
e) Diarrhea

Question 10
Approximately in which range is the detection limit for contrast enhanced sonography of the liver?
a) 0.5–1 mm
b) 1–2 mm
c) 3–5 mm
d) 5–8 mm
e) 8–10 mm