Diagnostics in Liver Diseases

6 Sonography

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Ultrasonography is a routine examination measure in the diagnosis of hepatobiliary diseases.

After years of experience with ultrasonography, a well-trained sonographer will produce highly reliable results in the field of liver imaging. • The method neither inconveniences nor harms the patient. Thus there is a broad range of indications for examination by ultrasonography in patients with hepatobiliary diseases. There are no contraindications. Specific diagnostic statements, however, are rarely possible.

1 Physical principles

Mechanical oscillations of >18,000 Hz are referred to as ultrasound. In solid bodies, sound waves spread longitudinally as well as transversally; in fluids, gases or body tissue, however, waves only spread longitudinally. The average **velocity of sound conduction** (v) in tissues is approximately 1,500 m/sec.

	v (m/sec)	reflection
Air	331	99.88%
Fat	1,476	0.12%
Water	1,496	0.00%
Muscle	1,568	0.48%
Liver	1,570	0.30%
Bone	3,360	46.00%

Ultrasonic waves are generated by a piezoelectric crystal and emitted via a sound-conductive medium. These waves are reflected, broken, dispersed and absorbed by boundary layers. The piezoelectric crystal also acts as a sound-wave receiver and registers the modified ultrasonic waves (= reciprocal piezoelectric effect). They are then converted into an electric signal and displayed by means of oscilloscopic imaging.

This will result in wavelengths of 0.1 to 1.5 mm in the **diagnostic frequency range** of 1 to 20 MHz. The 3.5 MHz range has proved suitable for abdominal sonography based on the B mode (= *brightness mode*). A 5 MHz transducer will increase the resolution (0.6 mm axially, 1.2 mm laterally) but will also decrease the depth of penetration of sound waves (10 cm). Resolution in tissues is approx. 1 mm towards the sound beam (= axial) and 2−6 mm perpendicular to the axis of the sound beam (= lateral). Resolution thus depends on ultrasonic frequency and focus. An increase in ultrasonic frequency therefore produces higher resolution and greater penetration depth. • A **linear scanner** applies parallel sound waves, while a **sectorial scanner** emits waves of a focal or curved source. Both of these techniques rapidly produce images at a rate of 30/sec (= *real time*). This allows (*1.*) direct monitoring of internal physical motion and (*2.*) mobile handling of the transducer for **dynamic portrayal** and analysis of the image. In this way, the image can be frozen at any stage for documentation purposes, or the process of examination can be videotaped. (1)

2 General principles and echo types

The sonographic technique is based on *reflection*; it works by measuring and portraying differences of impedance. Differences in *acoustic characteristics* of structures and tissues are the basis of sonographic differentiation.

The product of sonic speed in the respective tissue, together with the specific tissue density, yields the **acoustic impedance** (= acoustic resistance). Each medium has its own value with regard to sonic resistance. The partition between two media of different acoustic impedance is termed **acoustic interface** (which should not be confused with the anatomical interface). The magnitude of difference of impedance determines the acoustic effectiveness of this interface. • Continuous technical development in grading the degrees of brightness of image points has made it possible to define the **different shades of grey** between the two extremes of reflection, black and white. Various organs, including the liver, exhibit characteristic shades of grey. Connective tissue, fat deposition, liquids, air or cellular infiltration will each alter the **grey scale.** This has considerably improved the differentiation of both the organs and the findings − thus a more exact diagnosis is guaranteed. (1)

Ultrasound impulses emitted into the body are reflected by interfaces, so that boundaries of organs are received as **contour echoes,** whereas internal heterogenicities of organs are received as **structure echoes.** Analysis of the echo structure is seen as a specific feature of ultrasonography. The sonic energy reflected by interfaces is visible on the screen in the form of bright spots. • As a rule, the echo represents an acoustic interface within a solid structure. Sonography can differentiate between various zones: (*1.*) **hyperechoic,** (*2.*) **isoechoic,** (*3.*) **hypoechoic,** and (*4.*) **echofree**. Echofree areas point to the absence of acoustic interfaces, which as a rule corresponds to a "liquid" consistency. (s. figs. 6.4, 6.11)

► *The terms "hypodense", "isodense" and "hyperdense" depict pathological changes observed in CT.* For physical reasons, they are reserved for CT examinations and should not be used in sonography. (s. p. 171)

3 Artefacts

Sonographic artefacts may at times impede the assessment considerably. (47) Artefacts are mainly associated with the method applied and hence can often be eliminated simply by changing the examination technique. The occurrence of artefacts is largely fostered by extensive differences in acoustic impedance within a particular substrate, especially in the abdomen. In some 5% of cases, artefacts render sonographic examination impossible. They may appear in **multiple forms:**