1 Principles of Ultrasound

What Is Ultrasound?

The normal range of sound that human beings can perceive is 20–20000 Hz. A sound wave with a frequency higher than 20000 Hz is called ultrasound. The ultrasound used in abdominal imaging has a frequency of 3.5 or 5 MHz (1 MHz = 10⁶ Hz). Ultrasound of such high frequency is barely transmitted in air but is transmitted well in solid or fluid materials (Fig. 1.1). In the human body, ultrasound is transmitted well in the abdominal organs and soft tissues but is not transmitted in air-containing organs such as the lungs or the gastrointestinal tract. Since bones do not transmit ultrasound, organs surrounded by bones cannot be examined.

Production of Ultrasound

Figure 1.2 illustrates what happens when electrical current is applied to each side of a piece of quartz coated with silver. The quartz expands or contracts from its original thickness, depending on the polarity of the current applied. This phenomenon is called the piezoelectric effect, and a substance with this property is called a piezoelectric element. Ultrasonographic transducers are made of ceramic materials, commonly lead zirconate titanate. Newer piezoelectric elements are also being developed. When alternating current is applied to each surface of the piezoelectric element, ultrasound is produced, vibrating at a stable frequency determined by the thickness of the element (also called the resonant frequency). When the piezoelectric element is physi-
ally compressed by externally applied ultrasound, it produces a current. Hence, the piezoelectric element serves a dual function as both transmitter and receiver.

The part of the ultrasonographic equipment which transmits and receives ultrasound on the skin surface of the patient is called the transducer head. The piezoelectric element is located near the surface of the transducer head and is coated with a watertight, insulated cover.

In the transducer head of a contact compound scanner, there is only one round crystal element of 10–20 mm in diameter, whereas the linear electronic scanner is composed of multiple thin rectangular crystals lined up side by side (Fig. 1.3).

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**Fig. 1.2.** Piezoelectric effect. A piezoelectric element changes its thickness when an electric current is applied.

**Fig. 1.3.** Various types of transducer heads: a. linear electronic (linear array); b. electronic sector (phased array); c. convex electronic (curved linear array); d. mechanical sector; e. contact compound