9 Endorectal and Anal Sonography
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9.1 Introduction
In the past decade there has been a resurgence of interest in the use of endoluminal ultrasonography (EUS) for a variety of anorectal applications. The introduction of technology that allows real-time, 360° radial scanning of the anorectum and the surrounding structures began a new era in endoluminal imaging. The ability to accurately stage rectal cancer preoperatively was the first real benefit realised by the use of this new modality; many other useful applications in the field of colorectal surgery have since become apparent.

9.2 General Overview
It is necessary to understand the physics of ultrasound so that the maximum information can be collected at each examination, thus avoiding pitfalls and errors in diagnosis. Ultrasonography is an imaging technique, the principle of which is based upon the interaction between transmitted sound waves and the juxtaposed different tissue densities of the body.

9.2.1 What is Ultrasound?
Ultrasound is a sound emitted at a frequency above the limit of human audibility (i.e. above 20 kHz). Many animals, such as dolphins and dogs, are able to hear at certain ultrasound frequencies, a phenomenon that was studied by Sir Francis Galton, who in 1876 developed the Galton whistle (dog whistle or silent whistle), which can produced sounds at frequencies of 1.6–22 kHz, to test differential hearing ability. Other applications for ultrasound include industry, fishing, war and medicine.

Diagnostic ultrasound is based on the detection and display of acoustic energy reflected from interfaces within the body. This mechanical energy travels through matter as a wave, causing the particles therein to vibrate. Sound frequencies used for diagnostic application typically lie in the range 2–15 MHz. Ultrasound is characterised by:
1. Frequency \( f \): > 20 kHz
2. Wavelength \( \lambda \): the distance between two corresponding points on the curve
3. Propagation velocity (m/s): the velocity \( c \) of propagation depends on the tissue (Fig. 9.1). In medical diagnosis application the velocity is considered constant at 1540 m/s

The transmitter energises the transducer; the transducer converts the electric energy provided by the transmitter into mechanical energy, and vice versa. The transmitter comprises a ceramic crystal that has the ability to change shape and vibrate under the action of an electric field; this is called a piezoelectric effect. The transducer emits pulsed sound waves of a specific frequency with defined depth of penetration through the tissue layers. The ultrasound pulses must be spaced by enough time to permit the sound to travel to the organ of interest and return to the transducer before the next pulse is sent. The time difference between sound transmission and reception is calculated, and the digital sequential processing of a multitude of sound waves generates images [19]. When ultrasound pulses are transmitted into the body they are propagated – as a result of the vibration of molecules, which transmits the energy step by step in a longitudinal wave – reflected or backscattered, refracted and absorbed – due to transformation within the tissue of the acoustic energy to heat (Fig. 9.2). The sound waves pass through tissue planes, and at each interface between different tissue densities and acoustic impedance, some of the sound waves are reflected back towards the transducer. These reflected echoes stimulate the transducer, which converts this signal into a voltage. This amplification builds the image on the screen. In diagnostic ultrasound, the different media crossed by the incident energy are characterised by their acoustic impedance \( Z = \rho c \).

When ultrasound passes from one tissue to another, the difference in their acoustic impedance is responsible for the reflection of variable amounts of the incident sound energy. If the difference in acoustic impedance is large (soft tissue/bone or air), the reflection of the incident energy is almost total and the structures behind this interface cannot be analysed (Fig. 9.3). A signal of greatest intensity appears white; absence of signal appears black and a signal of intermediate intensity appears as shades of grey. At least 256 shades of grey are possible for each pixel. Depending on their reflectivity, the analysed structures are characterised by their echogenicity as being hypo-, iso-, or hyperechoic. Their echo patterns may be homogeneous or inhomogeneous.

The appropriate probe is selected according to the region to be analysed. The ultrasound frequency achieved depends upon the thickness of the transmitting crystal. For an anorectal examination, we usually use a rotating endoprobe with a frequency range from 6 to 16 MHz, providing a full 360° transverse view. The rectum and anal canal are well suited for ultrasonographic evaluation because of the variety of tissue density interfaces present in this readily accessible region.

Ultrasonography is less expensive than other imaging modalities, such as magnetic resonance imaging (MRI) and computed tomography (CT), relatively quick and is well tolerated by the patient. Moreover, the patient is not exposed to radiation during the course of the examination. In addition, the examination can be performed as an intraoperative procedure, which may