Chapter 3
Choosing an Ultrasound System

Ultrasound offers the rheumatologist substantial support in diagnosing and monitoring a variety of musculoskeletal conditions. Thus, when choosing the best system for the office, take plenty of time to research what equipment is available (Fig. 3.1). A list of requirements should usually include the following aspects.

First and foremost, the bread-and-butter of any machine is the quality of the grayscale images. These should be of high-definition so that the operator can be confident of his diagnosis. During scanning, the machine assigns shades of gray to the returning echo signals. The number of shades of gray depends on how many bits of information can be stored for each horizontal and vertical point of image memory. The quality of the images depends on the features of the system's software and hardware. Some manufactures market upgraded models which are more expensive than the older models, yet they contain in essence the same chips and electronics. When considering which system to purchase, a rule of thumb is to look at images that appear on the screen when you scan the palmar side of your own wrist. Small anatomic structures such as the median nerve and the various flexor tendons should be outlined clearly on the system monitor and should be distinct from each other. The monitor should not be too small, but on the other hand the device should also be easy to use. The keyboard is used for entering the patient's data, such as name, and annotations describing the anatomical area that will be scanned. Additional information can be typed on the image using the "Write" function button. Scanned structures can be measured on the monitor, using digital calliper cursors. These callipers can also be used for measuring the cross-sectional area, circumference or volume of a structure, for instance the median nerve. The keyboard should have a logical positioning of the buttons for easy navigation.

Second, careful attention should be paid to the choice of probes. A breadth of transducers is available. Modern probes may offer bandwidths of over 50%. Thus, a probe centred on 12 MHz would cover all frequencies between 6 and 18 MHz, or even around 4 and 20 MHz. This means that in the near field the scanner electronically filters out the low frequencies resulting in higher resolution whereas in the far field the device lets the lower frequencies pass through, giving better penetration. A 10 MHz

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Fig. 3.1 An optimal combination of modern ultrasound machines. On the left, a high-end ultrasound system configured with several probes including a hockey stick, and on the right a handheld pocket-sized probe that includes a convex and linear array scanner and sends the information by Bluetooth to a mobile phone or tablet

linear array probe can be applied to practically all large joints except the hip. To scan down the femoral head in an adult patient, either a lower frequency *curved array* or a linear array probe of lower frequency of about 5 MHz can be used.

Curved array probes that are commonly employed for abdominal ultrasound may be used for hip joint sonography in obese patients and fit better to the anatomy of the groin or arm pit than linear array probes (Fig. 3.2). The width of the transducer, also called footprint, should be taken into account, which is usually about 40–50 mm. A transducer footprint of 40–50 mm is useful for medium-sized to large joints. For scanning small finger joints or toe joints, and small vessels like the temporal artery, a small foot print probe such as the *hockey* stick (e.g., surface area of 26 mm × 10 mm), preferably with a high frequency of up to 25 MHz, is practical, e.g., 6–24 MHz. In conclusion, it is a comfortable luxury to have two to three probes, but, one ultra-broadband linear array probe with a frequency range of 4–20 MHz may adequately serve a rheumatologist too.

All modern machines have a unit capable of visualizing the vascular system. The vascular imaging unit includes color and power Doppler technology. Color Doppler examination is now the non-invasive method of choice for the evaluation of patients

Fig. 3.2 On the left, a linear array probe, and on the right a curved array probe

suspected of deep vein thrombosis. Another application of color Doppler is the assessment of blood flow in arteries, for instance of the temporal artery and its terminal branches, or axillary arteries. Standard examination of arteries is done with a high-resolution transducer of > at least 15 MHz according to the EULAR recommendations on imaging in vasculitis. Particularly hockeystick probes or small footprint probes with >20 MHz frequency provide excellent resolution. Two modalities are required: grayscale imaging and color flow Doppler, both on transverse and longitudinal planes. The two most commonly used imaging techniques to evaluate flow in vessels are color flow mapping and 2D sector scanning. Flow mapping produces a static image of the blood flow within a vessel. Two-dimensional sector scanning produces a sectional image of the vessel's anatomy which is updated many times per second. True simultaneous duplex scanners allow the 2D image to remain in real time while the Doppler beam provides flow information. Power Doppler is useful for the detection of hyperemia with slow flow velocities in joints, tendon sheaths, and entheses and is thus potentially capable of assessing inflammation.

Other relevant aspects are data storage and pricing. The frozen image or sequential real-time images can be recorded and stored in the machine's data storage system. Most machines come with one or several USB ports.

Other components include extras such as elastography, extended panorama view, a biopsy guidance facility, patient records and registration, connection possibilities with the hospital picture archiving and communication system (PACS), and ergonomic design. An interface with the hospital PACS allows images and videos to be safely stored and shared on the hospital network.

Prices for an average complete ultrasound system vary between €30,000 and 70,000, although lower and higher priced systems are available. There are portable

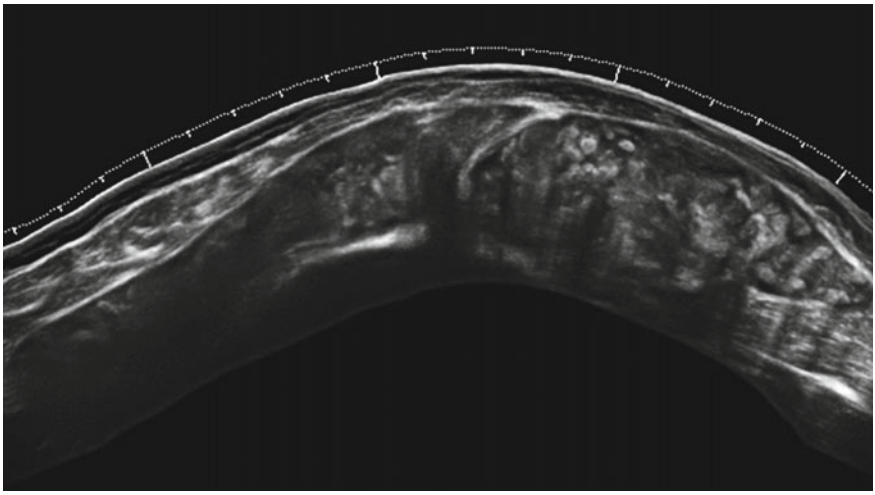

Fig. 3.3 Panoramic view of a subacromial-subdeltoid bursa filled with rice bodies in a patient with rheumatoid arthritis

systems which are affordably priced. These portables may come in a lap top configuration, however more recently improved technology of hand-held probes made it possible to connect wirelessly to your iPhone IOS or Android by an app. Such blue tooth devices improve the availability of ultrasound in the physician's office and at the bedside.

High-end, more expensive, equipment may include modalities such as harmonic imaging, panoramic view (Fig. 3.3), 3D imaging, or shear wave elastography.