GET BETTER ULTRASOUND IMAGES (WITH YOUR EQUIPMENT TODAY)

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Ultrasound is a versatile tool and with some basic ultrasound skills users can perform a variety of diagnostic and interventional procedures. Practice devices made from a variety of materials are called phantoms. Phantoms are sold commercially or can be made at home and range from low-cost models made from Jell-O and olives in your home kitchen or work break room to very expensive, highly detailed, life-like silicone models produced commercially. Recipes for making ultrasound phantoms abound on the internet and learners are encouraged to make practice devices to hone ultrasound skills.

Ultrasound can be used to direct therapy and deliver ultrasound-guided interventions once the basic skills of obtaining high-quality images and placing a needle in a target are acquired. Ultrasound can be used to differentiate a deep tissue abscess from cellulitis. Once the differentiation is made a decision regarding surgery, medical therapy, or percutaneous drainage (of an abscess) can be made. Even with superficial cellulitis and abscesses this is useful information: cellulitis is not going to benefit from surgery, and the tissue will take longer to heal once incised. Conversely, an abscess will resolve faster if it is drained. With ultrasound the two disease processes can be differentiated, and if surgery or percutaneous drainage is indicated the best site can be quickly identified. Fractures can be identified using ultrasound, and ultrasound can then be used to inject local anesthetic directly into the fracture site and to ensure the local anesthetic is distributed all around the fracture site prior to reducing the fracture and splinting in the emergency room or primary care office. Nerve blocks can be performed using ultrasound to direct needle placement immediately adjacent to the nerve bundle. Local anesthetic can be visualized as it is injected to ensure it is delivered immediately around the nerve. Other uses include ocular ultrasound to evaluate segments of the eye that cannot be seen on physical exam due to injury or disease, and visualization of the retrobulbar space. Fluid accumulations in body cavities can be drained, pulmonary edema can be identified on ultrasound earlier than it can be detected on radiographs, ultrasound can guide needle placement for joint taps and CSF taps, and to achieve vascular access in patients who are in shock, are hypovolemic, or have difficult peripheral veins.

ULTRASOUND TRANSDUCERS – “THE PROBES”

In small animal medicine we typically use three types of transducers: the curvilinear array, the linear array, and the phased array (also called the sector probe). Large animal practitioners and some specialty areas of small animal medicine may also use intracavitary transducers. Transducers may function on a fixed (single) frequency, or may have an adjustable frequency setting. Low frequency penetrates deeper into tissues and allows the user to look at deep structures while high frequency transducers produce a finer, more detailed image but cannot penetrate deep into the tissues. The phased array (sector probe) is typically used for looking at the heart and performing the echocardiogram. The linear array is usually a high-frequency transducer used for looking at structures near the body’s surface, but in small animals (cats and small to medium dogs) can often see all the structures of the abdomen. The curvilinear array is usually a lower frequency transducer used to look deep into the abdomen. On ultrasound units with a single transducer the curvilinear array is the most common type of transducer.

The footprint of a transducer refers to the size of the transducer where it comes into contact with the patient. Small-footprint, high-frequency curvilinear arrays with variable frequency are commonly used in small animal medicine. Practice working with all the transducers available as each will have unique characteristics for interventional procedures.

A transducer has two functions: to send out a sound signal, and to listen for the sound signal that comes back to it. The returning sound signal is sent from the transducer to the computer, which performs a complex series of tasks and converts the sound signal into a picture that is then displayed on a screen. In order for the sound to be clearly transmitted in both directions, a good acoustic interface between the patient and the transducer is needed. Ultrasound gel is specially designed to transmit sound energy and should be the main coupling agent used to obtain a high-quality image.

KNOBOLOGY: AKA WHAT BUTTONS DO I PUSH TO MAKE THE IMAGES LOOK GOOD?

There is no standardization between manufacturers, or even between different product lines within a brand for labeling the function of various knobs and buttons on the ultrasound machine. However, the vast majority of machines will have a knob, button, or toggle that adjusts the following variables.

Gain

Gain is the ultrasound equivalent of the sound knob on a stereo. Just like a stereo can be turned too low to hear clearly or so loud the sound is distorted, the gain can be too low (the image is mostly black) or too high (the image is mostly white). When the gain is properly adjusted fluid filled structures will be black, the interface between two structures will be bright white, and the remainder of soft tissues in the field of view will be shades of grey. The terms that define how black or how white an image appears on the screen are:

- Echogenic – a structure will show up very white on ultrasound. Bone and bladder stones are echogenic
- Anechoic – the structure will be totally black. Fluids are anechoic
- Hyperechoic – the structure will be more white in comparison to another structure
- Hypoechoic – the structure will show up but will more black in comparison to another structure

On some machines there are separate knobs for the near gain (the half of the image closest to the probe/top part of the image) and the far gain (the bottom half of the image farthest from the probe/bottom half of the image). This can be useful because sometimes only the bottom half of the image for deep structures needs to be adjusted.

Time-Gain Compensation (TGC)

This is another type of gain, but instead of adjusting the whole screen with one knob, or the top and bottom halves of the screen with the near/far gain knobs, TGC divides the screen into multiple sections and you can control each section. It is uncommon to need to adjust the screen in this much detail, however if a small creature rearranged all the buttons on your machine knowing about these sliders will help you to reset the machine. When the sliders are too far left, the image will be too black. When the sliders are too far to the right, the image will be too white. For general ultrasound purposes set all the sliders to the middle position and leave them alone – use the other knobs and toggles to adjust the image. However, if only the very deep (bottom of the screen) part of your image is too black, moving the bottom few sliders a little bit to the right can help lighten of up the far field.

Depth

The depth defines how far into the structure we will look with the ultrasound. There is a scale on the side of the screen that indicates how deep a structure is. When setting the depth, the goal is to have the entire structure of interest in the view without excessive depth beyond the structure of interest. Increasing depth makes structures appear smaller, and decreasing depth makes them appear larger.

Frequency

The frequency of a transducer determines how far into the body the ultrasound sound signal can penetrate, and the resolution (how sharp or grainy) of the image. Low frequency can penetrate deeply into the body but produces a grainy image. Higher frequencies produce sharper images but cannot penetrate as deep into the body. Some transducers have a fixed frequency – they can only emit and receive sound on a single frequency, and others have a variable frequency – we can adjust a knob on the machine to change the frequency of the sound emitted by the transducer. For structures near the surface of the body use a high-frequency transducer/setting. For structures very deep in the body, use a low frequency transducer/setting.

When attempting to differentiate between two structures stacked one on top of another – so in the same vertical plane, but at different depths – a higher frequency will do a better job of clearly defining the two structures than a lower frequency. This property is called axial resolution, and is important to remember when trying to place a needle into a target structure. When choosing a frequency setting, use the highest frequency that penetrates to the required depth.

Focus

The focus function allows us to set the depth where we want the clearest resolution. Above, we noted that higher frequencies allow us to differentiate two structures stacked one on top of another in the image (axial resolution). The focus controls the <u>lateral resolution</u> – in other words, differentiation of two structures that are side-by-side. The focus position is usually denoted by a small arrow head or dot superimposed on the depth scale at the side of the image. The depth of the focus position is usually controlled by a knob or toggle, and it should be set at, or just below, the structure of interest for the best lateral resolution.

STEPS TO GET A DIAGNOSTIC OR INTERVENTION QUALITY IMAGE

1. Choose the transducer best-suited to the task based on frequency and footprint of the transducer
2. Achieve a good transducer-patient interface (ultrasound gel)
3. Adjust the transducer position to center the structure of interest in the screen in the horizontal (left to right) plane
4. Adjust the depth to center the structure of interest in the vertical (top to bottom) plane
5. Adjust the frequency to the highest frequency that penetrates to the needed depth and shows good detail
6. Adjust the gain so you see black, grey, and white images clearly. Images that are very dark (lots of black and not much detail) the gain is too low. Images that are very bright (too much white and the image looks washed out) the gain is too high. If the image remains too dark after turning up the gain, try a lower frequency setting.
7. Adjust the focus point to at or just below the structure of interest
8. When placing a needle into a target structure remember: higher frequencies help to differentiate between structures that are stacked one on top of another, while the focus point is going to help differentiate between structures that are side-by-side at the same depth