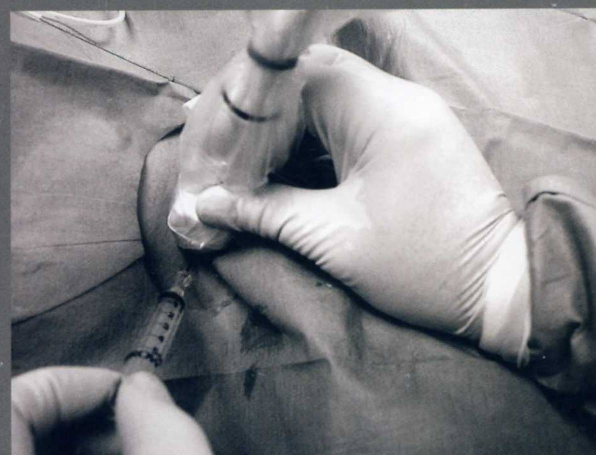

The Handbook of *Ultrasound* in Trauma and Critical Illness

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CHAPTER 3

KNOBOLOGY

INTRODUCTION

Ultrasound is a vast and sophisticated technology that is highly user dependent. An understanding of the basics of knobology will allow the physician sonographer to obtain the highest quality images possible. This chapter will discuss how the physician-sonographer (sonologist) can successfully use the ultrasound machine without a Ph.D. in physics.

THE KEYBOARD

The keyboard can be intimidating to the beginning sonographer due to the number of controls present (Figure 6). For the applications listed in this handbook, proper use of presets (i.e. FAST exam, cardiac, early OB, etc.) which can easily be created by your applications' specialist, and proper settings of gain, time gain compensation (TGC), power, focus, and depth will produce high-quality images. A common mistake is to ignore the basics (i.e. gain, power, TGC, focus and depth) and spend more time on the more sophisticated functions, such as tissue harmonics, coded harmonics, and automatic tissue optimization. It does not matter what "bells and whistles" a machine has if you do not properly set the basic controls!

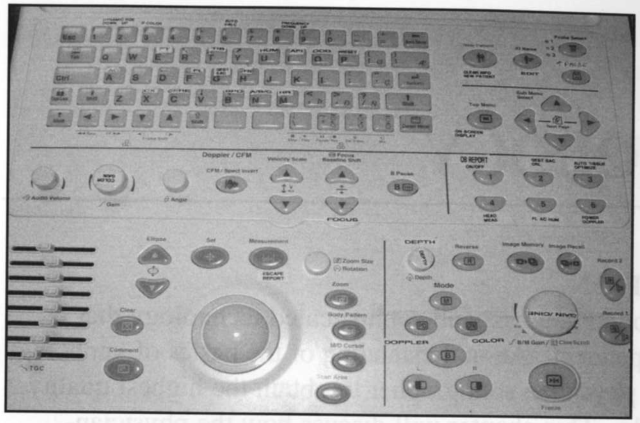


Figure 6. Keyboard of a GE LOGIC 400

THE B-MODE KNOBS

Power- Controls the strength or intensity of the sound wave and is expressed in units of decibels (dB) (Figures 7A and 7B). Decibels, it should be noted, do not represent absolute signal levels but quantitatively describe the ratio of two amplitudes or intensities.[1] An increase or decrease of the intensity of 3-dB multiplies or divides the intensity by 2, respectively (the 3-dB rule). Follow the ALARA (as low as reasonably achievable) principle, since increasing the intensity will increase the acoustic exposure to the patient. A rule of thumb is to start at 50% power (-3dB) and increase the gain settings first. If this does not produce a quality image, then increase the power.

Figure 7A. Correct power setting.

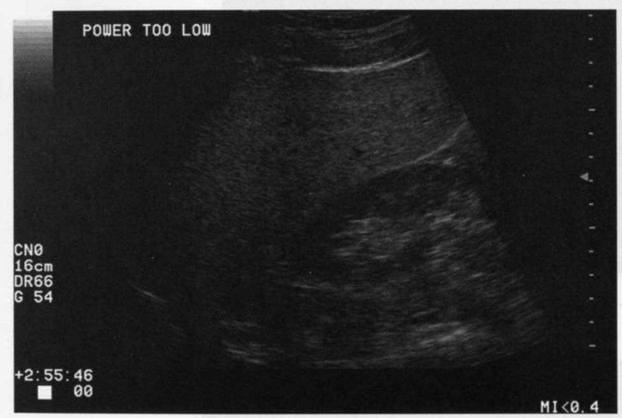


Figure 7B. Power setting too low-note loss of echoes.

Gain- Refers to the degree of amplification of the returning sound. Signal amplification is necessary since the amplitudes of the echo signals at the transducer levels are generally too low to allow visualization. Increasing the gain results in a "whiter" image due to increasing the strength of the returning echoes, while decreasing the gain results in a "darker" image due to decreasing the strength of the returning echoes (Figures 8A, 8B, and 8C). In contrast to increasing the power, increasing the gain does NOT increase the acoustic exposure to the patient.

Figure 8A. Optimal gain setting.

Figure 8B. Too little gain.

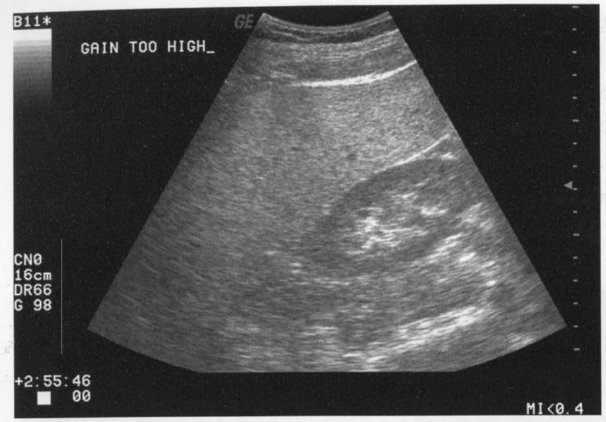
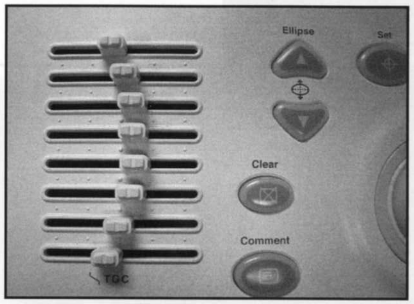


Figure 8C. Too much gain.

Time Gain Compensation- The purpose of these controls is to compensate for a loss of energy in the reflected signal due to attenuation. The sonographer controls the slide pods or the 3 knob controls in order to make identical tissue in the near-field look like identical tissue in the far-field (Figures 9A, 9B and 9C). An even, gentle increase should be maintained to optimize the image.



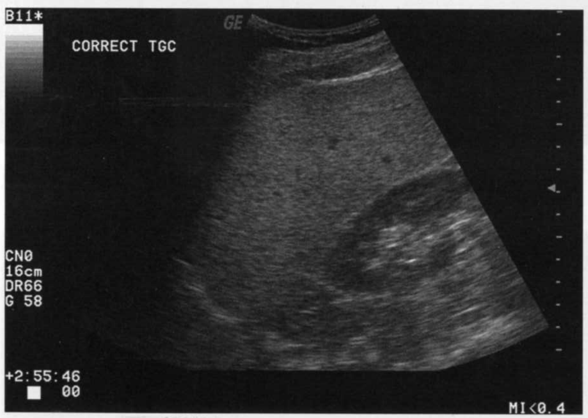


Figure 9A. Correct TGC settings. Note liver in near-field is identical to liver in far-field.

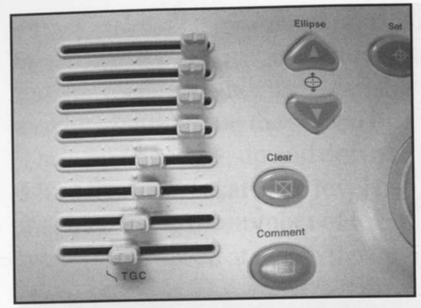
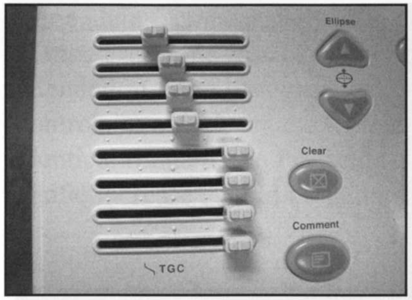


Figure 9B. Too much gain in near-field- note "white-out" in the near-field.



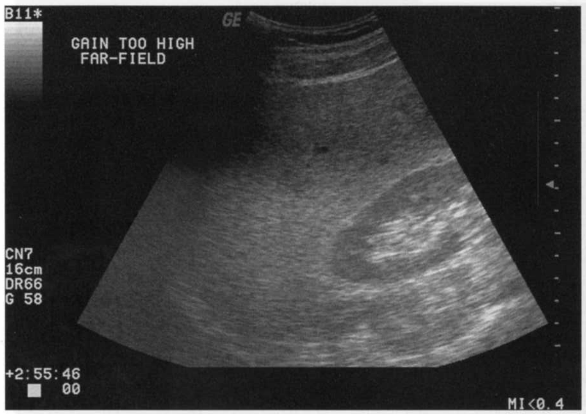


Figure 9C. Too much gain in the far-field- note "white-out" in the far-field.

<u>Focal Zone</u>- The narrowest portion of the beam that gives the best resolution for the image (Figures 10A and 10B). Remember, mechanical transducers do not have variable focal zones. Usually the focal zone can be identified on the screen by an arrow to the edge of the screen. This can be moved up and down to the level of the desired structure. More than one focal zone level can be created but it should be noted that increasing the number of focal zones will decrease the frame rate which is the speed at which the image is replenished.

Figure 10A. Focal zone set in near-field. Gallbladder is the desired organ.

Figure 10B. Focal zones set appropriately for visualizing gallbladder. Note improved resolution of gallbladder walls compared with Figure 10A.

Depth- The maximum depth is limited by the frequency of the transducer. The depth can be increased or decreased depending on the field of view desired. Ideally, the desired structure should be centered on the screen (Figures 11A and 11B). It is best to avoid cramming the desired structure into the near-field.

Figure 11A. Appropriate depth setting for perihepatic window.

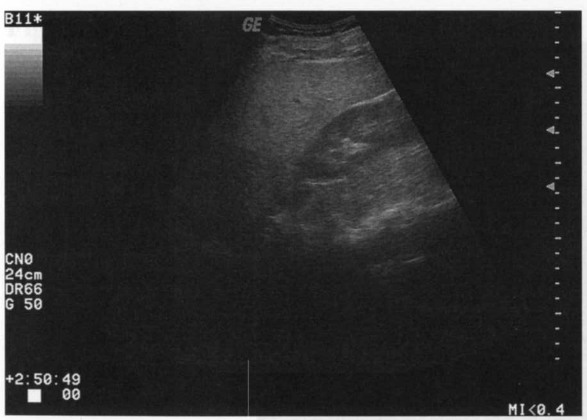


Figure 11B. Inappropriate depth setting for perihepatic window- note that Morison's pouch is crammed into the near-field leaving a majority of the image to unwanted structures.

Dynamic Range- The range of intensity from the largest to the smallest echo that a system can display. It is expressed in units of decibels (dB) with a higher number representing a wider dynamic range. In general, it is desirable to display as wide a dynamic range as possible in order to identify subtle differences in tissue echogenicity (Figures 12A, 12B and 12C).

Figure 12A.

Figure 12B.

Figure 12C.

Figures 12A, 12B and 12C. Same image with different dynamic ranges. Note the higher the dynamic range, the lower the contrast of the image.

Frequency- With a multi-frequency transducer, the higher the frequency used, the better the resolution, but the poorer the penetration.

Frame Rate- The speed at which the image is replenished. The use of a single focal zone allows the fastest frame rate. Multiple focal zones slow down the frame rate.

Write Zoom- The magnification with write zoom is a true magnification of the desired area since the pixels are reallocated and not just enlarged (Figures 13A and 13B). Write zoom cannot be done on a frozen image.

Figure 13A.

Figure 13B.

Figures 13A and 13B. Note how image quality is maintained with write zoom.

Read Zoom- By placing the zoom box on the desired portion of a frozen image, you can enlarge that portion of the screen (Figures 14A and 14B). A disadvantage of read zoom is that there is the potential for the image to lose quality because the memory pixels themselves are enlarged.

Figure 14A.

Figure 14B.

Figures 14A and 14B. Note how magnification of an image with read zoom results in poorer resolution (Figure 14B).

Calipers- Used to measure distances or areas. Image is to be frozen first (Figure 15).

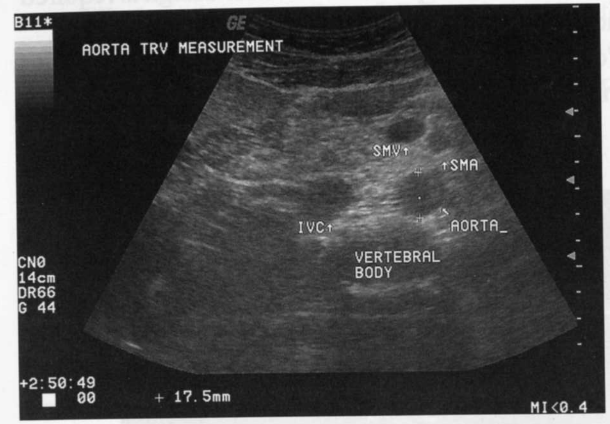


Figure 15: Transverse view of aorta with correct anterior-posterior (AP) placement of calipers.

M-Mode- A one-dimensional motion display (Figure 16).

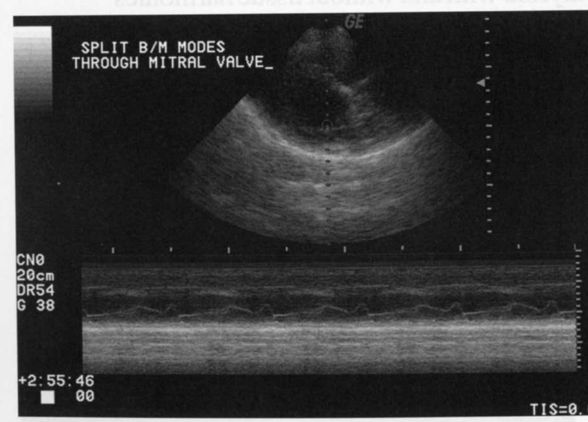


Figure 16. Split screen B-mode/M-mode image of the mitral valve.

Tissue Harmonics- Tissue harmonics is based on the principle that when the ultrasound beam strikes tissue, the tissues resonate at twice the frequency of the incident beam. A specific transducer design is required to produce harmonic imaging. The major advantage with harmonic imaging is that one can use a low-frequency transducer in the obese patient but receive higher frequency images and improved resolution (Figure 17).

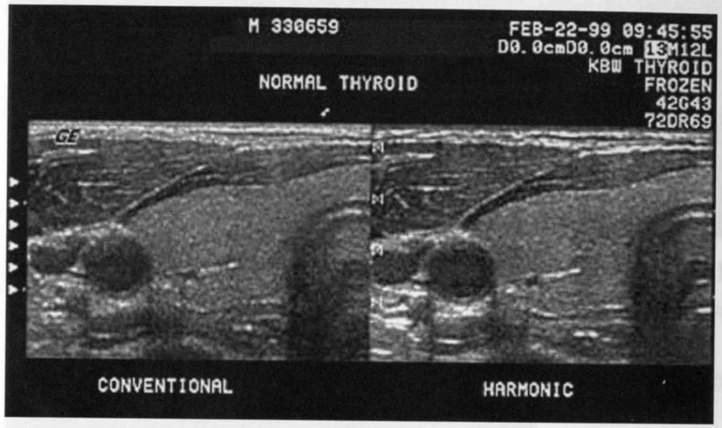


Figure 17. Image of thyroid with and without tissue harmonics (Courtsey of GE).