How to Optimize Your Endoscopic Ultrasound (EUS) Image

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Introduction

Optimizing an ultrasound image can be challenging, especially for the new practitioner. The aim of this paper is to advise the operator of the first parameters to adjust in order to optimize their EUS image. When faced with a "fuzzy" image, what is the first control on the processor that can be adjusted to "clean up" the image? Throughout the following pages, we will discuss the first four "go to" parameters to adjust when attempting to optimize an ultrasound image.

Too often the operator is faced with the challenge of an unacceptable image. Suboptimal images are sometimes inevitable whether it is due to patient body habitus, outdated equipment, improper settings or physician experience; any one or all of these factors can impact the end result of image quality.

Some terms to keep in mind that describe a structure compared to its surrounding structures:

- **Anechoic** indicates that a specific structure will appear black or completely void of echoes compared to its surrounding structures (anything fluid filled, i.e. cyst, Gallbladder).
- **Hypoechoic** indicates a structure will appear with some echoes, but still darker than its surrounding structures, though not completely void of echoes (i.e. lymph node).
- **Isoechoic** indicates a structure will appear very similar to that of its surrounding structures and may even blend in (i.e. metastatic lesions).
- **Hyperechoic** indicates a structure will appear bright white with many echoes (i.e. gallstones, needle, stent).

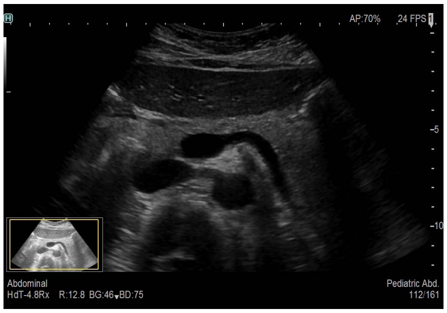
Suboptimal Image Quality

What controls are the first line of defense against a suboptimal image?

Is the gain too high, the frequency too low, depth/range too deep or focal zone placed incorrectly? What do these controls do and why or when should they be changed?

- **Gain:** Measures of the strength of the ultrasound signal; overall gain amplifies all signals by a constant factor regardless of the depth.[1] Increases or decreases the overall brightness of the image.

Structures can and will be impacted by too much or too little gain. It is wise to adjust gain levels while evaluating an organ such as the liver or pancreas as they contain many of the above types of structures. Anything fluid filled should appear black on ultrasound. Therefore, when evaluating the liver or pancreas, the blood vessels and ducts should appear black. The gain should then be adjusted so that the vessels are black or anechoic and the walls of the vessels are white or hyperechoic.



Gain too low overall

Gain too high overall

Ideal overall Gain

Note: The anechoic blood vessels compared with the hypoechoic liver (anterior) and the slightly hyperechoic pancreas (center of image).

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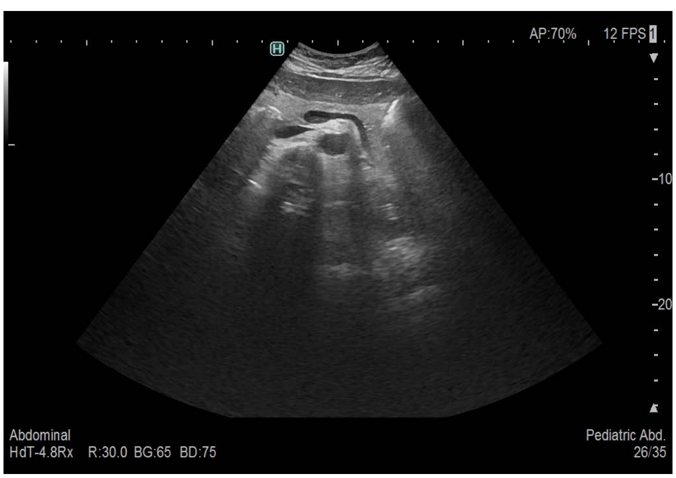
Suboptimal Image Quality (Continued)

- **TGC:** Time Gain Compensation (sometimes referred to as STC or Sensitivity Time Control) – Displayed as slide pods that are used to compensate for the attenuation of the transmittal beam as the sound wave travels through tissue in the body.[1] Whereas the Gain controls the brightness of the overall image, the TGC/STC has the ability to control the brightness at different depths within the image. These slide pods can remain in the center for EUS applications and is a control that is not typically adjusted, but should be addressed when discussing gain.
- **Frequency:** Number of cycles per second that a periodic event or function undergoes; number of cycles completed per unit of time; the frequency of a sound wave is determined by the number of oscillations per second of the vibrating source. It is measured in MHz for diagnostic ultrasound.[1]

Diagnostic ultrasound frequencies range from 3 MHz to 30 MHz. Low frequencies penetrate the tissue better than higher frequencies. High frequencies provide better resolution or detail in the near field, but sacrifice depth of penetration. A low frequency of 5 MHz may be considered for a structure or mass that lies deep within the abdomen, or a larger patient, whereas a higher frequency of 10 MHz may be considered for a structure that is closest to the transducer such as the submucosa. Using a frequency that is not optimal for the area of interest can negatively impact the ultrasound image.

- **Depth/Range:** On many processors, the term depth is interchangeable with range. It defines how deep a structure is from the transducer and is typically measured in centimeters. The depth/range should be set at the minimum required to visualize all structures of interest.[1] It is also important to remember that depth is inversely proportional to frequency. When discussing frequency, we learned that a low frequency penetrates and a high frequency provides better resolution in the near field.

With that in mind, if the submucosa is the area of interest (structure close to transducer), a high frequency, perhaps 10 MHz or 12 MHz will be selected. Therefore, a depth of 3 cm or 4 cm should be selected. If a deeper range such as 9 cm is selected, the area of interest will be too small to evaluate. There will also be much wasted information in the far field that appears very dark because the sound wave from 10 MHz or 12 MHz cannot penetrate beyond 3-4 cm. So, high frequency number, low depth/range number. Low frequency number, high depth/range number.



Too much depth for pancreas

Note: The dark far field with little to no useful information.

Ideal depth for pancreas

Note: The entire space is utilized and provides useful information.

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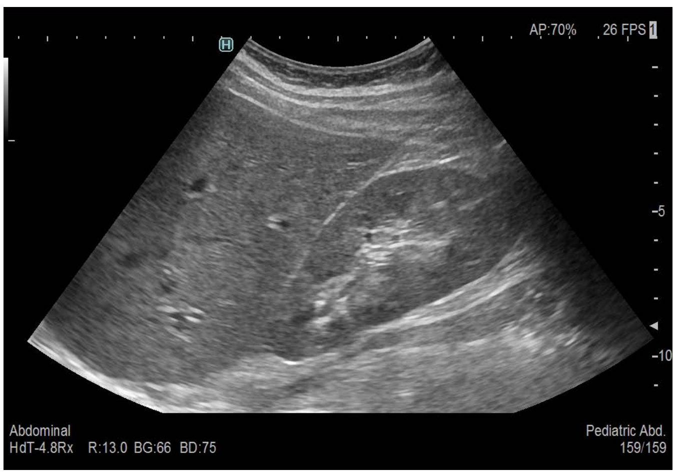
Suboptimal Image Quality (Continued)

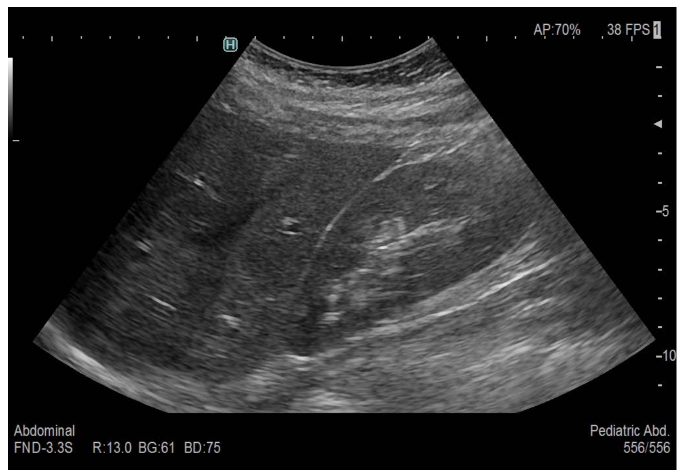
- **Focal Zone:** The region over which the effective width of the sound beam is within some measure of its width at the local distance.[1] This is the most overlooked parameter when attempting to improve an ultrasound image. Adjusting the position of the focal zones will improve lateral resolution. Improving lateral resolution allows for better differentiation between two structures that are side by side at the same depth in the image. Focal zones are displayed on the right side of the ultrasound monitor as arrows or carrots. There may be one or multiple focal zones displayed, though, the more focal zones that are displayed, the slower the image will be, as multiple focal zones (more than two) will affect the image frame rate.

The space between two focal zones is described as the focal area. This is the area of interest. If the aim is to evaluate the overall image, having a singular focal zone or two focal zones toward the bottom portion of the image, or the far field, is suggested. However, if there is a specific area of interest, perhaps a lymph node in the near field, then the focal zones should be positioned in that area. This can dramatically change the quality of the image.



Ideal focal zone position and depth/range for liver and kidney

Note: Focal zone position [arrow on bottom right] and range of 13cm.



Focal zone too high for liver

Note: Focal zone position [arrow on top right], and degradation of image quality compared with image to the left.

Conclusion

While there are many controls, functions and parameters that can be changed on an ultrasound processor, minor adjustments of a few key controls can be made to make a world of difference. Gain, frequency, depth and focus. These are the first four “go to” controls that can dramatically improve a “fuzzy” image. As much as we would love for our processors and transducers to be “plug and play”, every patient will image differently if only due to body habitus. If these parameters are not routinely checked, the end result could be a misdiagnosis; that is why it is so important to reevaluate and possibly readjust each of these four parameters for every patient to ensure we are getting the most out of our processors and giving the best and most accurate information possible to our patients.

References:

1. Ultrasound Imaging Guide – Learn What to Adjust First Posted by Jeanette Ashby on Thursday, January 19, 2017
2. Module Title – Tutorial: Ultrasound Physics without the Physics Teaching Medicine.com

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