

compared to human sonographer counterparts. For this reason, ultrasound machine selection and optimization is even more crucial in veterinary compared to human sonography. Plan to spend around \$35,000 to \$50,000 and more for an ultrasound machine to do full body scanning. This may sound daunting at first, but we are talking a clinical sonography that would cover every point in the abdomen or heart/chest imaged in all body types.

This price range (probe configuration is the largest variable here), if priced conscientiously with respect to the quality and clinical support of the machine, should buy you image resolution to define curvilinear patterns and contrasting tissue presentations, adequate acoustic power to penetrate tissues, adequate probes with frequencies and resolutions for every presentation, work-flow optimization, optimized screen size and resolution, and consistent transmissibility of image sets in proper contained file size with minimal steps.

These factors vary greatly by manufacturer, so it is in your, and your sonographer's best interests to test all these factors on multiple machines on a variety of patient sizes, conformations, and body scores with clinically tested presets for each setting. If you aren't optimizing these factors, you risk missing lesions, struggling to find structures like the common bile duct and right adrenal, missing steps in the telemedicine transmission, and having to repeat transmission or encounter erroneously large files caused by software glitches that have not been addressed by the manufacturer or the distributor.

All of these factors cause loss of time which is inherent economic loss with every case. In telemedicine operations, we encounter these issues every day and work through it with our clients as we read from multiple types of machines with different manufacturers, machine capacities and software applications. Therefore, it's best to prevent these issues by optimizing each of them as opposed to trying to cure the problems after you spent \$20-30k on a lesser machine marketed as "good enough" or "just as good." No matter how things are marketed, you get what you pay for or you may even overpay for lesser machines. If purchasing from a clinically oriented company you have clinical support, optimized and extensively tested presets for all body types and structures to image, instruction on which probe to use in each presentation, and a machine that lays out images on your report that represent you at a high level. Your imaging report is your calling card so do it right and ensure your image is enhanced by your optimized machine purchase first.

Consider this quick economic exercise over 5–8-year life of an ultrasound machine. If we just talk economics and painfully eliminate image quality for a moment, consider this simple calculation then have the tax break discussion with your accountant. At 5 ultrasound examinations/week at \$350-400 owner cost/scan, which is a minimal number that every facility should be doing clinically, a \$15k machine is paid for in roughly 3-4 months, a \$35k machine is paid for in 6 months, and a \$45k machine is paid for in 8-9 months. There is essentially no economic reason not to purchase the best possible machine you can to avoid the cost of missing a lesion. Just do the math and high-quality imaging, footprint and accuracy costs a very small difference from a "just as good or good enough machine" that costs \$25,000 or less in the end. Be sure to do your true math calculating your average exam price per patient: your sonographer cost for 15 minutes to scan, your tech cost for holding the patient for those 15 min and 5-10 min to process and send the image set to telemedicine, your telemedicine average cost/report. Sum these costs and subtract from your ultrasound charge to the owner. You will realize \$45k goes away very quickly and if you live "if its sick it needs a probe," the cost of purchase of a machine that is a representative core to your process is truly a non-factor. In other words, do clinical sonography correctly at the beginning and the economics are in your

favor regardless, and will also grow and propagate fostering adjacent procedures in your facility that have their revenue streams as well. This is truly a forest versus tree scenario. Now imagine you miss a few lesions, especially in dogs over 50 pounds or on a cat pancreas that has poor resolution, and those lesions are seen elsewhere on second or third opinions. Confidence in your facility's clinical sonography drops rapidly as a result and you are now left with a \$20-30k cystocentesis machine or one limited to FAST scanning. *This is the cost of missing a lesion.* Moreover, if your lesser machine keeps you from imaging patients over 40-50 pounds then you are losing revenue with all the mid to larger patients by not purchasing a machine adapted to adequately image them.

Sonographer Selection

The sonographer title behind the probe discussion comes up frequently in our clinical sonography circles. Do we need a specialist or veterinarian to perform solid consistent image acquisition? Remember image acquisition and image interpretation are two vastly different concepts. Interpretation depends on optimal complete image acquisition and the title matters little in this regard if the drive and the ability to learn to perform an optimized and complete image set, whether normal or abnormal presentations are in play, is inherent in the novice sonographer. We, as interpreting specialists, see this all the time every day over hundreds of cases. Optimal image sets come in from all types of sonographers with various professional titles as well as suboptimal image sets that need further support and instruction. We have a long history of various results with GP sonographers and, of course, specialists performing ultrasound. However, the relatively new technician model works well in veterinary clinical sonography as it has in human for 30 + years. But the teaching/learning approach differs significantly with high-level imaging needing to be obtained in short time frames largely without the ancillary studies in physics and image optimization that the human medicine RDMS counterpart endures in his/her program. Regardless, our recent double blinded study has shown that technicians, veterinarians, and specialists can have similar image quality results when trained appropriately.

Education: Choose the educational venue best for you, your workflow, and your goals. Which program will get you up to speed the fastest allowing you to image an abdomen or heart in 15 minutes or less without missing pathology? With practice, focus and drive it really shouldn't take you longer than 15 minutes, focusing and training yourself toward 10 or even 5 minutes or less with emergency-oriented techniques maximizing the technology of the \$35-50k ultrasound units currently in the market. Consider your local mobile sonographer or best sonographer in your practice. At some point in the past, yours truly included, we all started somewhere wondering if the bladder had a stone when it was just hard stool in the colon superimposing upon an overdistended bladder. We have all made every mistake possible and have learned from every one of them if we were conscientious about each error. This is one reason why I have written this article and continuously teach clinical sonography and discuss all the entities around the process. Benefit from all the errors I, and my anonymized colleagues, have personally made over 25+ years as a consumer young sonographer, as a semi-seasoned one, and now as a seasoned specialist and educator. I have made the errors intrinsically inherent within my recommendations already, so you don't have to. The technology of today, along with solid persistent education and effort allows you to achieve these goals. Then do the math on efficient clinical outcomes as well as economic ones.

Telemedicine: It's extremely rare that coming off a single educational seminar you will be scanning perfectly and there are vast levels of ability to interpret ultrasound image sets. Therefore, you need support by the company that interprets the images, and a scanning

protocol that will work to your benefit. You should ask yourself as a clinical sonographer, and also ask your telemedicine company these questions: How is my image quality? What am I missing and why? Does my report reflect the level of sonography I intend to practice? Am I learning from the report and the process? Is this process making me a better veterinarian or technician? Most of all, am I confident in the findings? There are services that only read still images and don't want videos because they take longer to interpret and occupy more bandwidth and storage space. However, video protocols exponentially include more information on all the organs and everything adjacent and in between them. Every 3-second video contains about 120 still images. A complete SDEP® scan or equivalent protocol contains about 20-40 videos on average and a few still images for measurement. Doing that math and assuming image quality equal between still image sets and video-based protocols, which set do you want your interpretation to come from? Which image set (still images vs. video) do you want your clinical choice for that patient to depend upon? Do you prefer to risk your cost of missing a lesion on 30-40 still images or on 30-40 properly placed video clips (i.e., 3600-4800 still image equivalent)? Moreover, the video employed protocol such as SDEP™ or equivalent is much more fluid of a scan and saves tons of time as opposed to traditional stop-save still image-move to next position type protocols that force you to get every still image right in line as opposed to retrieving the perfect still image from a video clip passing through the organ.

In regard to interpreting specialists available in veterinary medicine, the recent ACVR/EVDI standardization states that "Interpretation at the time of the examination being performed by a board-certified veterinary radiologist is therefore considered to be the gold standard." 1 Sonographers and referring veterinarians will find rapidly that, in reality, this is not and will never be possible owing to the lack of radiologists available to read sonograms compared to the increasingly vast number of ultrasound image sets being created and sent to telemedicine companies or those for in-house review. The good thing is that many AVMA recognized boarded specialists that have many years of experience in clinical sonography are available to interpret image sets with an approach and emphasis on their specialty such as ACVIM, ABVP, VECCS as well as other accredited specialties that have clinical sonography incorporated into their functional disciplines. With this specialist spectrum of availability, the sonographer and referring clinician can select which type of interpretation to have whether that of a radiologist perspective, or that of internal medicine, practitioner internal medicine and surgical approach, or emergency critical care approach with many years of preparation behind the read.

Screen Size & Resolution:

Take into consideration screen resolution and screen size. You should position yourself about an arm's length away from the screen. If you are trained to find adrenal glands and you are testing out a machine, a feline or canine adrenal should jump on the screen. You should not have to squint to look at it. Consider 15–18-inch monitor screens and at least 1920 x 1080 resolution if possible. Every little technological factor in your favor adds up in image quality and these two factors very often go under considered in purchases.

Ultrasound Knobology/Workflow

I personally despise touch screens as it is too easy to make errors and digital workflow is tedious and frustrating in my hands; when I can feel a keyboard, I can move across knobology workflows faster. Maybe you like touch screens and your brain and fingers work differently than mine, which is fine. Do what works best for you. But ask yourself, how much time does the knobology of the machine take you? Compare machines on knobology workflow. Knobology workflow is an often overlooked concept but one that is inherent in the time elapsed on every scan. How many steps does it take you to get through your case? There is a vast difference

here by different machine producers from very intuitive and user friendly where you will take 3-4 steps to get to the end of a case from a knobology standpoint to others that will take the scenic route to get there with 10 or 12 steps and touch screens that are not consistent. When there is poorly designed knobology, you feel like your fingers are doing a bad ballroom or line dance where you are always a step or two behind and bumping into someone or stepping on toes. Personal experience in both sonography and short-lived ballroom and line dancing experience aside, all I can say is poor knobology workflows translate into time lost and frustration gained.

Image Transmission

Given that image quality is paramount, you must spend adequately to run with a machine that is going to be viable day in and day out, thin ferret to overweight Rottweiler, abdomen to heart to thyroid to stifle cruciate. You want a machine that is capable of high resolution and has a rapid workflow that can move a 30-40 video case around the internet at 500 MB and not 1 GB, or 2 GB or 3 GB. What happens when you try to move a 1 GB, 2 GB, 3 GB file around the internet from your ultrasound machine? It blocks up, your bandwidth cannot keep up with it, your connectivity drops off, you may have to resend it, it will take time to send, and you must double check it, which all eats up time and delays the interpretation and report. Then the telemedicine specialist will be perturbed because of the time involved to download it on their end to be able to see it and manipulate it. So, ensure that the machine you are purchasing can move a large set of videos across the internet readily, otherwise you will be disappointed and frustrated because now that you bought that machine, you have to work with it; if its inherent workflow is poor, you will pay the price over time. So, what is that time and frustration worth to you? We deal with this every day in the telemedicine world, having to employ a technician to specifically work with clients on this issue from a variety of machines; this is why we have created protocol standards to avoid these pitfalls on our end. But I relate this to you to help avoid these frustrating tech and doctor sonographer time-consuming issues on your consumer sonographer side of the workflow equation.

Missing Lesions

If we were just dealing with a standard pancreatitis, cholangiohepatitis, gastroenteritis or a global mass, but no obvious metastatic lesions to the liver, then the lesser machine can likely cover these areas adequately in a 40–50-pound dog or smaller. However, if I were to go through my team's telemedicine archives these global pathologies are only one small aliquot of the pathology that we see coming across the probe every day. The more subtle presentations are just as frequent and even more frequently missed. Therefore, you can do the lesion frequency math and if those more subtle lesions are not coming across your probe and screen, then I assure you that you are missing lesions and what is the cost of that?

In summary, when buying an ultrasound machine (concepts apply to CT or DR system as well) what is the cost of missing a lesion? Think about what happens when you miss a lesion, and you are not correct on your first opinion. That does not bode well for you as a professional, for the facility where you work nor for your reputation as a clinical sonographer. Most of all, it does not bode well for the patient, which is the opposite outcome we desire with respect to the reason we all went into the veterinary profession in the first place.

References

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