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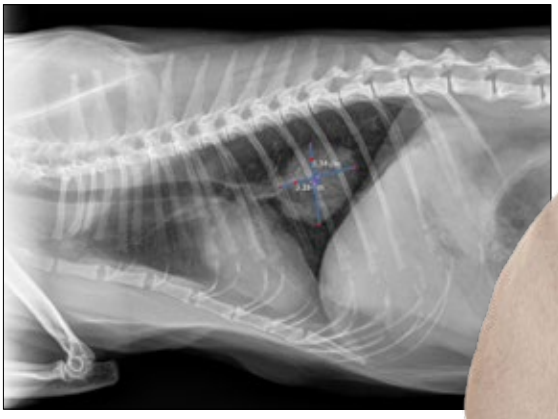
Imaging Services

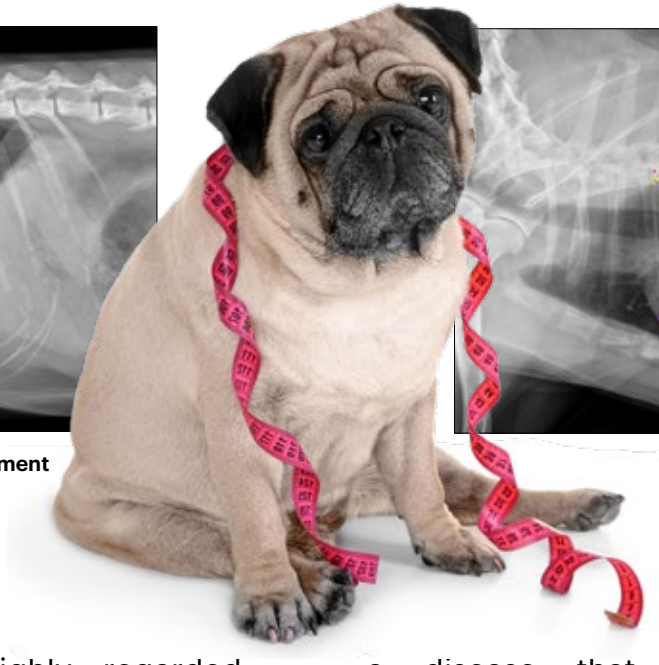
ANTECH IMAGING NEWS

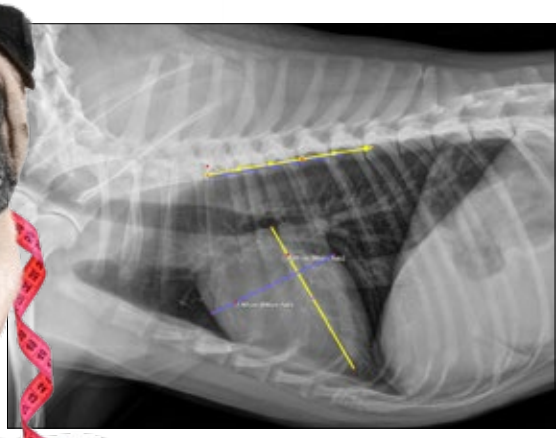
Problems with radiologic measurements

"A radiologist with a ruler is a radiologist in trouble"
-Ben Felson



Vertebral Heart Score (VHS) measurement in a normal 5-year-old dog.





Pulmonary mass measurement in a 13-year-old cat.

This quote from a highly regarded clinical radiologist and teacher is intended to emphasize the value of careful subjective judgment of shadows as a means of diagnosis – basically, if you don't know the diagnosis after looking carefully at the radiographs, making a measurement is unlikely to help you.

Of course, some measurements have a value, for example, those used in the descriptive part of an imaging report (e.g., the diameter of a bladder calculus), to assess the severity of a condition (e.g., angular limb deformity), or to document a change in a lesion as a result of treatment. However, radiologic measurements are not as useful as the basis for diagnosis.

Diagnosis primarily means distinguishing normal from abnormal. If we were using size as a basis for diagnosing a disease that causes enlargement, finding a measurement that exceeded the normal range would be a positive result. Unfortunately, the normal size ranges for many organs are wide, particularly in dogs, so many animals with clinical disease-causing enlargement will still be within the normal range. This problem may be more easily understood by considering it pictorially (Figure 1).

The white curve at left represents the distribution of normal organ lengths (remember that clinical investigators, pathologists, etc. only use the middle 95% animals for the 'normal range'). The gray curve at right is the distribution that results from doubling the volume of the organ.

Note that doubling organ volume does not double length because the increase in volume is shared out between

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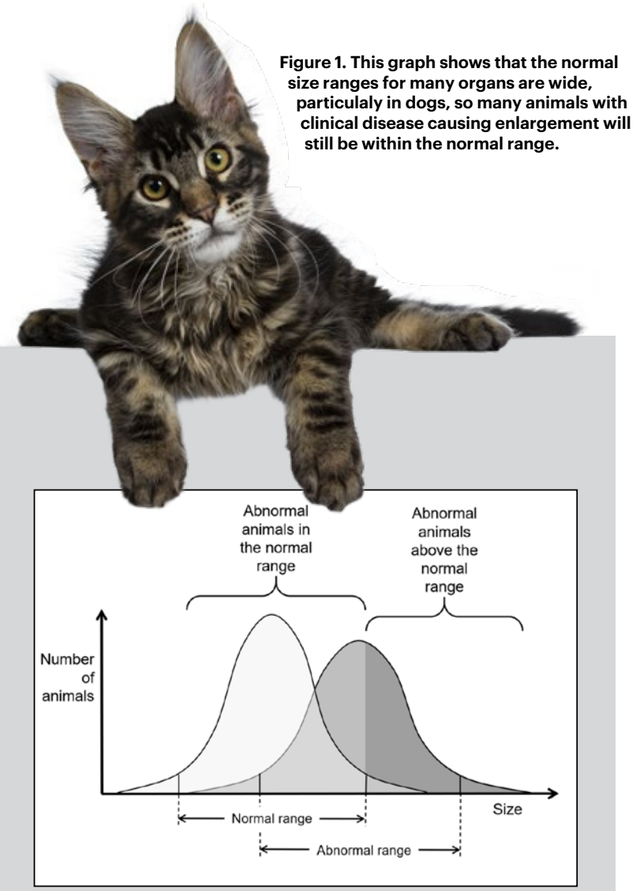

Figure 1. This graph shows that the normal size ranges for many organs are wide, particulaly in dogs, so many animals with clinical disease causing enlargement will still be within the normal range.

length, width, and depth. Despite this marked increase in organ volume, there is still a wide overlap between the normal and abnormal ranges, which means at least half the abnormal animals in this example would still be within the normal length range. Investigators promoting a measurement for diagnostic use often calculate a single 'cut-off' value that separates normal from abnormal, but – as you can see from the above – any cut-off that you pick will include normal and abnormal animals.

I created this figure by using real clinical data about feline renal length, but what applies to feline kidneys also applies to other organs.[1] Furthermore, when making clinical radiologic measurements of organs, the results will vary not just because of actual differences between individual patients, but also because of multiple other factors, including differences in patient positioning for imaging and differences between observers making the measurements. In a study of the vertebral heart scale (VHS), we found that cardiac disease accounted for only 50% of the variation in results. In dogs, the cardiac and respiratory cycles alone cause 1 unit difference in VHS measurements.[2] Although measurement is often cited as an objective method, the measuring tool's placement relies on subjective image interpretation to identify the correct anatomic landmarks, which may be more difficult for inexperienced observers.

Figure 2 on the next page is an example of how choosing the wrong place to make a measurement can lead to diagnostic error. An observer interpreting abdominal radiographs of a vomiting dog measured the intestinal diameter at A, producing a SI/L5 ratio >3, suggesting 100% probability of obstruction; however, that is part of the large intestine. A measurement based on maximal small intestinal diameter at B produces a SI/L5 ratio = 1.8, suggesting a much lower probability of obstruction.[3] In fact, this dog did not have intestinal obstruction; its signs were resolved without treatment.

In a systematic review of publications describing radiographic or ultrasonographic measurements used as

[1] https://doi.org/10.1177/1098612X17736657

[2] https://doi.org/10.2460/javma.246.10.1091

[3] https://onlinelibrary.wiley.com/doi/pdfdirect/10.1111/vru.12032

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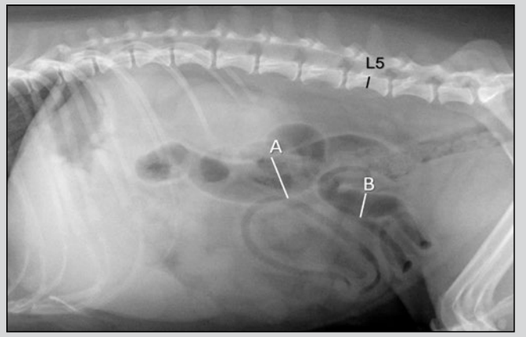
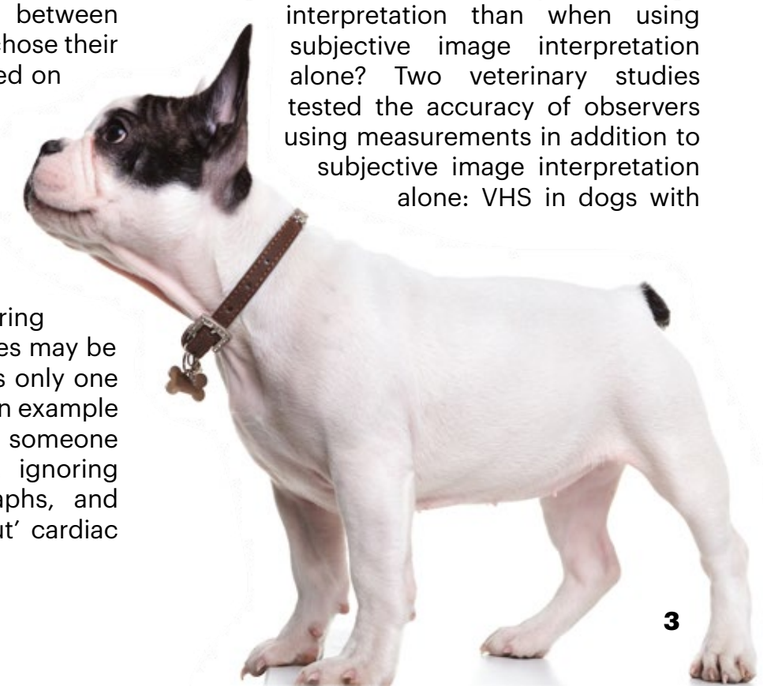


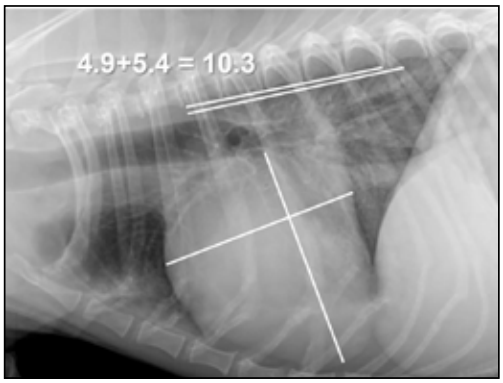
Figure 2. Radiograph showing how choosing the wrong place to make a measurement can lead to diagnostic error. Measurement A incorrectly suggests a 100% probability of intestinal obstruction since it is of the large bowel. Measurement B correctly suggests a much lower probability of obstruction.

a diagnostic test for a naturally-occurring condition in dogs or cats, the median (range) sensitivity was 77% (38-99%), and specificity was 82% (50-99%).[4] This means that someone using such diagnostic measurements (ignoring all other imaging features) would correctly distinguish normal from abnormal in 7-8 cases out of 10. That may sound pretty good, but the authors of many of these publications over-estimated the potential diagnostic impact of radiologic measurements. For example, they selected subjects (patients) in a way that exaggerated differences between normals and abnormals, or they chose their cut-off point retrospectively based on their sample. Also, many studies calculated the accuracy of a test based on measurement without considering the accuracy of concurrent subjective image interpretation. This is not realistic because a measurement should never be used alone, ignoring all the other ways in which images may be abnormal. Remember that size is only one of 6 Roentgen signs. Figure 3 is an example of an error occurring because someone focused on the measurement, ignoring other aspects of the radiographs, and believed that they had 'ruled out' cardiac disease as the cause of respiratory signs. The VHS value may be within the normal range (8.7-10.7), but this dog is in congestive cardiac failure and needs immediate treatment.

If measurements are to be used in a radiology report, they should be used to complement the "careful subjective judgment of shadows" (as Ben Felson put it). So an important question arises: are observers more accurate in diagnosis when using measurement and subjective image interpretation than when using subjective image interpretation alone? Two veterinary studies tested the accuracy of observers using measurements in addition to subjective image interpretation alone: VHS in dogs with



[4] https://doi.org/10.1111/vru.12217



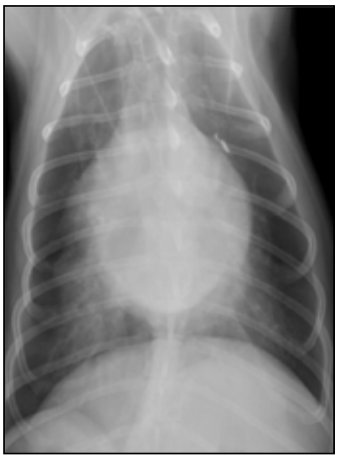


Figure 3. Radiographs from a dog in congestive heart failure. This diagnosis would be missed if someone relied only on the normal VHS measurements.

suspected cardiac disease,[5] and the small intestine to L5 ratio in dogs with suspected intestinal obstruction.[6]

Neither study found any differences. In other words, observers making radiologic measurements were no more accurate than when they relied on subjective image interpretation alone. It is interesting to note that these results are applied equally to experienced and inexperienced observers. There is no substantial evidence that measurements of structures in dogs and cats' diagnostic images are useful for diagnosis. Although measurements may have value in the descriptive part of a radiology report, I do not believe they should be emphasized as a basis for diagnosis in either teaching or clinical imaging reports.

[5] https://veterinaryrecord.bmj.com/content/146/24/687

[6] https://onlinelibrary.wiley.com/doi/pdfdirect/10.1111/vru.12032

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