Emergency Imaging

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Diagnostic imaging has a pivotal role to play in many common emergency cases including animals in respiratory distress, acute trauma cases, and cases of severe abdominal pain. The stress of emergency cases and importance of recognizing life-threatening abnormalities places additional demands on the clinician when both performing and interpreting radiographic studies.

Acquiring diagnostic imaging studies in emergency setting

When acquiring these studies preparation is key. Being prepared will lead to more efficient and more useful studies as well as reduced patient mortality. Acquiring diagnostic imaging studies should always be secondary to patient stabilization. The choice of diagnostic test used in the emergency setting can be dependent on many factors. One of the main factor dictating diagnostic testing is the availability of the test. In the "after-hours" setting an abdominal ultrasound performed by a qualified individual may not be available and in many emergency clinics, CT or MRI is unavailable. The patient condition may also dictate what and when diagnostic imaging can be used. Our own experiences as well as the client's financial limits may also guide our recommendations.

When choosing which imaging tests to be performed it is important to consider the vital systems first. For example, in cases of vehicular trauma thoracic radiographs should be considered before any radiographs assessing for fractures if the trauma carries risk of thoracic disease. We should also consider what imaging findings may dictate the stopping points for certain case management. For example, thoracic radiographs may be just as vital as an abdominal ultrasound for a hemoabdomen case as it may identify the presence of pulmonary metastasis.

Radiographs for emergency cases

It is important not to sacrifice radiographic quality and radiation safety in the emergency cases. Too often a quick snapshot is taken with staff manually restraining a patient. The area of interest should be determined and radiographs should be appropriately taken centred on this region with appropriate collimation. This will increase the chance of identifying important lesions. A whole-body radiograph can be overwhelming, especially when there are multiple abnormalities or multiple incidental findings. Focusing on a region of interest will give you the best image quality and the best chance at identifying important pathology. Taking the time to plan the radiographs, prepare the room for the radiographs and ensure the patient is

properly prepared with appropriate sedation or analgesics if needed will allow for high quality radiographs to be taken in a timely fashion. It is possible to do this without staff being in the room for the radiographs thereby minimizing exposure to personal. You also need to consider which radiographic views should be acquired for specific studies as certain views will be more useful than others (e.g. right lateral radiograph for GDV or dorsoventral radiographs for congestive heart failure).

The approach to emergency radiographic interpretation may be different since it is typically focused on answering a specific question (e.g. is there a GDV or not); however, the interpretation still needs to be complete as to not miss other clinically significant findings. In the emergency setting it can be hard not to get overwhelmed by radiographs or to get tunnel vision. Finding time in a quiet place to review any radiographs is an important process in the work up of emergency patients. Approaching these studies using a systematic approach or even blocking out the main lesion initially while you evaluate everything else can help. Many animals presenting in emergency states may have very overwhelming radiographic findings that are not commonly seen. It is important in these cases to take your time and start with what you know. Approach these cases reviewing normal anatomy and a systematic approach and you can often come up with a short list of differential diagnosis for these odd findings. There are many fantastic diagnostic imaging texts that can be useful to keep in your emergency room to reference for these cases.

Radiographs can also be challenging because they only provide a snapshot at a single time frame. Using multiple radiographic studies or a combination of imaging tests (e.g. radiographs and ultrasound) can help us to get a better picture of what may be occurring. We can use this to monitor for improvement or worsening of disease. Radiographic studies that are suspicious for a mechanical ileus but not conclusive could be followed up by recheck fasted radiographs in 6-12hrs in stable patients and may show progression of the findings making the reader more confident. There is no timing that is the gold standard and factors such as patient stability, treatment decisions (e.g. to continue or change dose of a medication), in hospital services available (e.g. it may not be ideal to plan a recheck at 3am if surgery is unavailable until 7am), and interventions all need to be considered.

Ultrasound for emergency cases

Focused ultrasound examinations

Abdominal focuses assessment with sonography for trauma (AFAST) has been used for many years in human medicine to identify and assess free fluid consistent with hemorrhage. Recently in veterinary medicine this same principle has been applied and utilized not only for trauma cases but also for triage and trending abdominal effusion[1,2,3,4]. Some cases that a focused ultrasound examination may be useful for include blunt trauma, collapse, anemic, “ain’t doing right”, post-surgical or post-interventional techniques at risk for bleeding, and suspect peritonitis cases. These examinations are advantageous because they are quick, non-invasive and more sensitive than radiographs for small amounts of free fluid. Focused abdominal ultrasound can detect small amounts of free fluid, anticipate the degree of anemia

associated with hemoabdomen (e.g. small vs big bleeder), and follow progression/improvement of abdominal effusion[1,2,3,4]. The presence of abdominal fluid is not specific for a type of abdominal fluid and cytology is still required. The AFAST examination has also been found to not be as reliable predicting anemia in cats and to be less sensitive in cases of penetrating trauma as it does not exclude localized trauma[3,5]. It is often important to recheck any dehydrated or hypotensive patient as free fluid may develop following rehydration. These examinations are not a comprehensive ultrasound examination and not intended to be an assessment of cause. The AFAST examination is performed by quickly scanning 4 regions and recording if fluid is present or not. These 4 quadrants consist of the diaphragmatic-hepatic view, splenorenal view, cysto-colic view, and hepatorenal view. It has been shown that using a scoring system of the number of quadrants that have fluid present in cases of acute trauma the likelihood of anemia and need for transfusion can be predicted. Animals suffering from with fluid seen in 3 or 4 of the quadrants are more likely to become anemic and may need transfusions[1]. The AFAST is also useful from a serial examination standpoint. Performing examinations every 4 hours also for detection of delayed accumulation of fluid or timely detection of changes in quantity. Seventy-five percent of those animals that had increasing scores have ongoing hemorrhage with 50% of these being negative on initial examination[1]. The AFAST examination is intended to be used for emergency causes with a focus on trauma or acute hemorrhage. There are many other causes of abdominal effusion (e.g. hypoalbunemia, peritonitis, urinary bladder rupture, right heart failure) that the AFAST is useful for identifying fluid but is not as reliable from a quantitative standpoint.

The thoracic focused assessment with sonography (TFAST) is intended to be used in a similar manner to the AFAST with a focus on trauma, triaging and trending changes. The TFAST examination may be used to detect pleural or pericardial effusion, pneumothorax or with a combination of a lung scoring system (VetBlue) be used to detect pulmonary disease[2,3]. This test does not replace thoracic radiographs as the sound waves will be reflected off any gas in the lung and lesions deep to aerated lungs will not be evident. For these examinations 5 sites are typically evaluated; the right and left chest tube site or caudodorsal thorax, right and left pericardial site and the diaphragmatic-hepatic view. By performing the TFAST examination on a dog in sternal recumbency the degree of pneumothorax or pleural effusion can be determined by recognizing where the pathology meets normal anatomy. The lung scoring system for irregular lung, VetBlue, is focused on the distribution of lesions[3]. By determining the distribution of normal and abnormal lung the likelihood of certain diseases can be predicted. For example, in a patient with acute respiratory distress if there is normal lung ventrally and abnormal lung caudodorsally than congestive heart failure should be prioritized as a differential diagnosis.

Complete Abdominal ultrasound

A complete abdominal ultrasound is often necessary in many emergency cases; however, many animals need to be stabilized prior to the ultrasound examination. Once stable the purpose of the abdominal ultrasound is to identify any cause of the clinical signs, physical examination findings, or other clinical abnormalities. An abdominal ultrasound is most useful when there are clear clinical questions attempting to be answered. The hunt for a cause of

vague clinical signs can be challenging especially when multiple abnormalities are found. Having a list of differential diagnosis or clinically relevant questions prior to the ultrasound examination can help the sonographer and the clinician interpret the findings. When performing ultrasound for patients in the emergency setting it is important to consider things like analgesics, sedatives, oxygen availability, monitoring equipment, and personal prior to the examination so it can be done in a timely manner that is safe for our patients.

Advanced diagnostic tests for emergency cases

Contrast gastrointestinal studies

Positive contrast gastrointestinal studies can be used to assess the stomach and small intestine. These are less common in today's practice due to the availability of abdominal ultrasound which requires less time, is more sensitive for many gastrointesintal lesions and may be less stressful for our patients. In the emergency patients the goal of a contrast study would be to assess for a potential obstruction. A positive contrast study done appropriately will be useful for this; however, the amount of time required to perform this study may not be in the patient's best interest. Also administering positive contrast orally to a vomiting dog or cat can be challenging and may increase the risk of aspiration pneumonia. The presence of positive contrast may also prevent or complicate gastroscopy for gastric foreign bodies as the barium can interfere with visual inspection. A gastrogram requires appropriate preparation which may not be appropriate in emergency cases. Fasting for 12-24 hours is recommended as food in the stomach will interfere with interpretation. It is ideal for assessing gastrointestinal motility that the radiographs be performed without sedatives as this may alter gastric emptying times. The dose for a gastrogram is typically 2.3 to 3.6ml of barium/kg[6].

Positive contrast study of the small intestine may be used to assess the location of the small intestine and identify complete bowel obstructions. These studies are referred to as upper gastrointestinal contrast studies because the stomach is also opacified. In animals with clearly defined evidence of small intestinal obstruction on survey radiographs there is no need for a positive contrast study. The decreased peristalsis of the small intestine will lead to slow passage of the positive contrast and the study may be non-diagnostic. The use of contrast studies in these cases may also delay and possibly complicate surgery. If there is any evidence of abdominal free air, without reason for iatrogenic causes, a positive contrast study is not indicated as this is suggestive of a gastrointestinal perforation. The use of positive contrast may also complicate an abdominal ultrasound study due to acoustic shadowing artifact from the barium. One of the most common errors leading to non-diagnostic studies is an insufficiency dose of positive contrast. The dose for upper gastrointestinal contrast studies using barium in dogs is 6-12ml/kg (20% barium mixed with water) or 6-10ml/kg (60% barium mixed with water), and the dose for cats is 12-16 ml/kg[6]. A minimum of two radiographic views should be performed at various time intervals following administration of the positive contrast is recommended; however, I recommend right and left lateral as well as ventrodorsal radiographs since the gas and positive contrast may distribute differently. In dogs radiographs should be performed immediately, 15min, 30min, 1hr, 2hr and 4hrs following positive contrast. In cats the gastrointestinal transit time may be faster and to minimize stress radiographs can be

performed immediately, 5min, 30min and 1hr following contrast administration. Both are guidelines and specific cases may require radiographs performed at other time periods. Repeat radiographs should be performed until positive contrast is seen in the colon.

Another study that can be very useful for differentiating large and small bowel and is simple to perform is a pneumocolonogram or negative contrast colonography. For this study a catheter is placed rectally and air is administered. A Foley catheter can be used with the balloon inflated to prevent air from leaking from the colon. Radiographs should be performed following administration of air and with the catheter still in place. There is no standard dose of air to be injected so radiographs should be performed to monitor distension. This study is very useful in cases where there is question about whether a distended segment is small or large intestine.

Positive contrast cystogram

A retrograde cystogram is fairly easy to perform and is a useful study for evaluating the location of the urinary bladder and integrity of the lower urinary tract in the emergency setting. The location of leakage from the urinary tract will dictate treatment recommendations. A urethral tear may be treated more conservatively by indwelling urinary catheters while a urinary bladder rupture may require surgical correction. A retrograde cystogram can also be used to assess for causes of urethral obstructions when calculi are not evident such as strictures or non-radiopaque stones. Retrograde injection of positive contrast is made through a sterile urinary catheter. Water soluble non-ionic iodinated positive contrast should be used. Barium should never be used. An approximate dose of 10mls of contrast medium per kg can be used[6]. The positive contrast can be diluted with sterile saline at a 20% to 50% dilution to reduce the amount of positive contrast used. The degree of urinary bladder distension can be estimated by palpation and injection should be stopped if the urinary bladder feels adequately distended. When performing this test to assess for bladder wall integrity it's important to realize some degree of distension is required to diagnose a tear and it is possible to "re-open" a healing defect. If the intent is to evaluate the urethra injection of positive contrast while the urinary catheter is being removed will lead to better opacification and distension of the urethra. This is usually best evaluated under fluoroscopic imaging. Leakage of positive contrast typically occurs into adjacent visceral soft tissues, perineal region, or the abdomen. The identification of leaking positive contrast requires at least orthogonal radiographs and often oblique radiographs. False positives can occur with misinterpretation of normal vesicoureteral reflex, urachal anomalies or traumatic urinary bladder diverticula.

Computed Tomography

Computed tomography plays a large role in emergency medicine for human patients and is becoming more readily available in veterinary medicine. Computed tomography offers two large advantages over conventional radiology; a tomographic image and better contrast resolution. The better contrast resolution allows us to differentiate between soft tissues, especially when intravenous contrast is used. The tomographic nature of the images resolves superimposition that may prevent accurate evaluation of lesions on radiographs. Traditionally in our patients CT is performed with animals under sedation or general anesthesia. These scans

are typically fast but motion results in artifacts that can degrade image quality. Some of the uses of CT in emergency practice include penetrating wounds, complex traumatic injury including head injury, gastrointestinal obstructions and respiratory distress cases. Some obtunded or minimally responsive dogs may tolerate CT examinations without sedation. A cylindrical tube structure termed the VetMouseTrap™ has been developed for imaging of cats and small animals awake[7]. This can be useful as it may be less stressful for some animals than restrain for thoracic radiographs. Due to the increased radiation dose and distribution of radiation personal should not be in the room during the acquisition of these studies and this should be considered when determining if a patient is stable enough to undergo this study. As CT scanners become more available this test will become more requested or sought after for our emergency patients rightfully and wrongfully.

Magnetic Resonance Imaging

Magnetic resonance imaging has even better contrast resolution than CT; however, acquisition times are much longer (typically 30 minutes or more) and motion creates even more artifact. Therefore, the use of MRI in emergency cases is very limited. As new imaging sequences are developed with newer machines this may be a modality in the future that is used more often for advanced cases.

References:

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