THE 5 MINUTE ABDOMINAL ULTRASOUND ANY ONE CAN USE TO ANSWER SIMPLE BINARY QUESTIONS!

Søren Boysen, DVM, DACVECC
Faculty of Veterinary Medicine, University of Calgary, Calgary, Alberta, Canada
srboysen@ucalgary.ca
https://vet.ucalgary.ca/vcds/podcasts

NOTE: To request a PDF copy of the ppt, which will closely follow the proceeding and contains images, please send me an email at the address above.

OVERVIEW OF THE ISSUE

Ever wonder if the cat that ate lilies is producing urine when it's not possible to pass a urinary catheter? Ever wonder if the dog with an acute abdomen has free abdominal air in the abdomen, or if the post-operative patient that is not eating has ileus? Using a binary approach to ask the right question at the right time makes learning and applying abdominal point of care ultrasound easy!

OBJECTIVES OF THE PRESENTATION

- This lecture will cover the core principles to understand and interpret veterinary point of care sonographic findings of abdominal ultrasound including the identification of free fluid, urine production, GI motility, free abdominal air and the gall bladder halo sign. All clinically relevant questions when asked at the right time, in a binary fashion, based on patient assessment! Self-assessment will be used throughout to help the audience feel confident at interpreting findings!
- By the end of this session attendees will be able to:
    - Describe and interpret the key abdominal findings that are assessed with veterinary point of care ultrasound
    - List differential diagnosis and describe how to answer binary questions using point of care abdominal ultrasound.

ABDOMINAL POINT OF CARE ULTRASOUND

- The abdominal FAST exam (A-FAST), described in 2004 (Boysen et al), was the first VPOCUS exam to be validated in small animals.
- The goal was to detect free peritoneal fluid following blunt abdominal trauma, and therefor concentrated on 4 key sites of the abdomen; sites where organs were most likely to be injured following trauma (liver, spleen, kidneys and urinary bladder), and where fluid is most likely to accumulate based on patient positioning and gravitational forces.
- This and subsequent studies demonstrated A-FAST was sensitive and specific for the detection of free abdominal fluid, was more accurate at detecting free fluid than radiographs, and helps find the ideal location to perform abdominocentesis.
- A further study by Walters et al (2018) demonstrated a strong correlation in the comparison of CT for detection of abdominal fluid and the original 2004 abdominal FAST protocol (kappa 0.82).
- The value of using VPOCUS exams (including A-FAST) to detect free fluid in animals in the absence of trauma was subsequently published by McMurray et al in 2016.
    - The probability of finding free fluid in a stable (as assessed by triage examination) non-trauma patient (any cavity, thorax or abdomen) is <10%. However, in unstable non-trauma patients, free fluid is found in > 75% of patients. Therefore, serious insults result in sonographically detectable findings. This study demonstrated that abdominal (and thoracic) VPOCUS is an important triage tool for all patients regardless of the presenting complaint.

- Centesis is recommended when identified on abdominal VPOCUS scans because fluid type varies greatly (hemoabdomen, uroabdomen, bile peritonitis, septic abdomen, non-septic exudate, and transudates, chylothorax, pyothorax, and hemothorax).

PATIENT POSITION, PROBE AND COUPLING AGENT

- Patients are placed in either left or right lateral recumbency. In some instances, abdominal VPOCUS can be performed in a sternal or standing position (consider the effects of gravity and patient positioning when looking for pathology).
- Unstable patients should NEVER be placed in dorsal recumbency as this can compromise the patient (increased work of breathing, decreased venous return and cardiovascular collapse).
- Minimal restraint is required.
- A microconvex/curvilinear probe is used for all abdominal VPOCUS scanning, with a frequency generally between 5 MHz (patients >15 kg) and 7.5 MHz (patients < 15kg).
- Gain is adjusted to maximize detection of anechoic fluid using either bile in the gall bladder or urine in the urinary bladder as a reference echogenicity for fluid.
- Depth is adjusted as needed during the abdominal VPOCUS with the greatest depth setting generally at the subxiphoid location, which allows evaluation of the pleural and pericardial spaces.
- It is not wrong to shave the patient, but shaving is not required unless the patient's fur coat is too thick to allow good image resolution (e.g. Husky and Northern breeds with thick undercoats).
- Alcohol, or a combination of alcohol and gel is used but it is important to part the fur before or after applying the alcohol.

- **ABDOMINAL VPOCUS INDICATIONS**
  - Trauma patients
  - Unstable patients
  - Emergency and/or critically ill patients
  - Any patient as part of the triage exam
  - Post-surgery patients not recovering as expected
  - Surgery patients with difficult anesthesia
  - As part of the routine daily assessment of hospitalized patients

ABDOMINAL VPOCUS PROTOCOL

- Abdominal VPOCUS probe positions include: 1. subxiphoid view, 2. urinary bladder view, 3. right paralumbar view, 4. left paralumbar view, and the additional 5th umbilical view.
- Each location is evaluated in longitudinal and transvers orientation with rocking and fanning of the probe to maximize the area evaluated and to ensure all target sites for fluid accumulation are thoroughly assessed.
- *A note on nomenclature:* The authors prefer to use external landmarks to help identify where to place the probe vs. internal organs as the number of structures targeted at each location has increased since the original VPOCUS studies were published (e.g. the pleural and pericardial space is part of the subxiphoid evaluation, but not included in the Diaphramatico-hepatic nomenclature, nor is the gall bladder, which is also now routinely scanned as part of abdominal VPOCUS).
- Regardless of the nomenclature used it is important to be thorough and evaluate ALL target structures at each probe location in light of the binary question being asked!

THE ABDOMINAL VPOCUS SITES IN MORE DETAIL:

1. Subxiphoid or Diaphragmatico-hepatic (DH) site: just caudal to the xiphoid process.

- Key structures to identify include the 1) diaphragm, 2) liver, 3) gallbladder, 4) ventral stomach wall (the latter for GI motility), 5) the areas between these structures, 6) caudal vena cava, 7) pleural space 8) heart and 9) pericardial space.
- See later sections on volume status for more detail on the vena cava evaluation, and the respective sections on pleural and pericardial space evaluation.
- Note you cannot detect individual liver lobes in a normal patient.
- Also note the presence or absence of mirror image artifact; Mirror image artifact distal to the diaphragm can only occur when there is air distal to the diaphragm, and therefore can be used to rule out pleural effusion at that location.
- It is important to consider patient positioning and the effects of gravity when evaluating any VPOCUS sites, including the subxiphoid location.
- Be sure to fan the probe through all liver planes to ensure a thorough evaluation of the liver is complete, and to rock the probe to assess the most ventral and cranial parts of the liver, where small accumulations of fluid may gather between the liver and diaphragm.

2. Urinary bladder or Cysto-colic (CC):

- Key organs and structures to identify include the 1) entire urinary bladder, 2) gravity and non-gravity dependent body walls 3) apex of the bladder and 4) the areas between these structures. Fluid tends to accumulate between the body wall and the bladder, at the apex of the bladder and between the bladder and the body wall.
- The probe is placed in long axis to the body between the pelvic limbs.
- Pushing too hard will compress and can displace the bladder making it a challenge to identify.
- Ideally, the probe should also be placed on the non-gravity dependent side of patient and the ultrasound beam angled through bladder and fanned to catch fluid in deeper gravity-dependent sites at the body wall.
- Once the bladder is found, it is important to manipulate the depth to see both dorsal and ventral walls of the bladder.
- The probe should then be slid cranially to locate the apex of the bladder.
- Once at the apex, fan the probe through all planes of the bladder.
- The probe is then slid caudally to evaluate the caudal/trigone region.
- When all regions of the bladder have been assessed in longitudinal orientation the probe is rotated into short axis (and the probe is slid cranially and caudally with a fanning motion to assess all planes in the transverse orientation) will allow visualization of abdominal effusion.

3. Right paralumbar or Hepato-renal (HR) site:

- Key organs/structures to identify include the 1) right caudal liver lobe, 2) right kidney, 3) body wall and 4) intestines and 5) areas between these structures.
- This view can be difficult to obtain as often it is necessary to go between ribs to visualize the normal structures. It may sometimes be necessary to start in short axis to the body so that the probe can be placed within an intercostal space between ribs.
- In smaller dogs and in cats, the probe can be placed in long axis to the body caudal to the 13th and final rib, just below the hypaxial/lumbar muscles.
- In dogs, if the liver is visualized in the right paralumbar region, or between ribs, the probe can be slid caudally until the kidney is visualized. The right kidney is located quite lateral relative to midline.

4. Left paralumbar or Spleno-renal (SR) site:

- Key organs and structures to identify include the 1) spleen 2) left kidney, 3) intestines 4) body wall and 5) the areas between these structures.
- The probe has to be placed quite lateral to midline to find the left kidney and spleen.
- The spleen is located cranial and often lateral to the left kidney.
- The probe is placed in long axis to the body, and then turned to short axis once all planes in longitudinal have been assessed with fanning the probe.
- Sometimes it is easier to find the spleen first, and then slide the probe caudally until the left kidney is found.

5. Umbilical (modified 5th) view:

- Key structures assess at this site include 1) the gravity dependent body wall, 2) intestines, 3) spleen and regions between these structures.
- The Umbilical view is recommended to ensure localization of gravity dependent abdominal effusion by placing the probe at the umbilicus.
- The probe is placed at roughly a 45-degree angle with the head of the probe directed towards the table top. The probe should then be rocked and fanned.
- Assessing the umbilical site before sliding the probe under the patient to assess the gravity dependent kidney increases the chances of detecting smaller quantities of free abdominal fluid that might otherwise be displaced to either side of the probe.

LIMITATIONS OF ABDOMINAL VPOCUS

- Initial hypovolemia or severe dehydration could limit detection of effusion; important to reassess after adequate resuscitation (serial VPOCUS exams)
- Difficult to confirm rupture of the urinary bladder with ultrasound (some indirect evidence that should put rupture on the list, but often need radiographic contrast studies to confirm)
- A negative abdominal VPOCUS does not rule out injury

POTENTIAL PITFALLS

- Hepatic vessels and the gall bladder can sometimes be mistaken for fluid.
- It is important to remember that ultrasound is a dynamic imaging modality and therefore by fanning, rocking, sliding, changing the depth, and rotating the probe (longitudinal to transverse and vice versa) we can determine if these areas are vessels (by moving the probe it will be easier to see that these structures form vessels).
- Edge shadowing is where the ultrasound beams create dark shadows on the edges of an organ, which can be mistaken for fluid. It can cause the wall of a structure to disappear, which should not be confused for rupture of an organ (e.g. don't confuse edge artifact for rupture of the urinary bladder or fluid around the gallbladder).
- Intestinal and stomach walls can also be mistaken for abnormal fluid or structures, and once again by moving the probe it will be easier to determine if the structure is intestine or stomach.
- Mirror image artifact of the gall bladder, or hepatic vessels, which are often distorted, can be confused for pleural effusion.
- Highly cellular effusion such as acute hemorrhage or septic exudates can sometimes mimic soft tissue structures or stomach contents and can be difficult to identify as fluid.
- Probe manipulations can sometime create "swirling" which may help differentiate cellular effusion from tissues.

- Fanning will also often identify “structures” within the fluid and can find sharp angles to help differentiate cellular fluid from soft tissue structures.

SERIAL VPOCUS EXAMS

- Serial VPOCUS exams are recommended to: 1) monitor progression/resolution of intra-cavitary fluid in fluid positive patients, and 2) to re-assess fluid negative patients, particularly those that are unstable, and/or have received significant quantities of intravascular fluids.
- The frequency the abdominal VPOCUS exam is repeated depends on the patient. It should be repeated as often as required to identify the reason a patient is unstable if no identifiable cause is evident on ancillary diagnostic tests, or to determine why a patient changes from stable to unstable.
- If the patient is stable and the goal is to simply follow resolution or progression of underlying pathology, the VPOCUS scan can be repeated every 4 hours.

WHAT DOES FREE ABDOMINAL FLUID LOOK LIKE?

- Free fluid in the abdomen typically appears as dark (anechoic or hypoechoic) triangles/sharp angles between organs and structures, commonly visualized at the apex of the bladder, between the bladder and the body wall, at the poles of the kidneys, between the spleen and left kidney, between liver lobes, between the liver and diaphragm, between the liver and right kidney, and/or surrounding small intestinal loops.

SPECIFIC BINARY QUESTIONS TO ANSWER WHEN PERFORMING ABDOMINAL VPOCUS

1. Does the patient have abdominal effusion at any of the sites described above Y/N?

- How many sites? Serial changes to the amount of fluid or number of positive sites?

2. *Is there free abdominal air in the abdomen Y/N?*

There are 3 key steps that can be followed to help detect pneumoperitoneum:

I. The peritoneal lining must be identified. This is essential so as not to confuse free air within the GI tract for free air in the abdomen. Identifying the peritoneal lining can be achieved by placing the patient in lateral recumbency and identifying structures in contact with the peritoneal lining of the non-gravity dependent body wall, such as the stomach, liver or spleen. Leaving the animal in lateral for a few minutes to allow air to rise to the non-gravity dependent body wall is recommended. It is also possible to follow the peritoneal lining caudally from the curtain sign (see notes on pleural and lung ultrasound for more information on the curtain sign). Free air can be detected between organs or within the wall of some structures, although this is more technically challenging to confirm.

II. Identify the presence of reverberation artifact that originates at the peritoneal lining. This is very important to differentiate from reverberation artifact contained within the GI tract, which again, emphasizes the importance of clearly identifying the peritoneal lining.

III. Identify the enhanced peritoneal stripe sign. This sonographic finding occurs when free abdominal air comes in contact with the peritoneal lining. At the point where free abdominal air comes in contact with the peritoneal lining it will cause the peritoneal lining to become more hyper-echoic. This is the enhanced peritoneal lining. Reverberation artifact, if it is the result of free abdominal air will originate from the enhanced peritoneal stripe sign.

3. *Does the patient have Ileus Y/N? Is the stomach distended and fluid filled Y/N?*

- Ileus is defined as a transient cessation of gastrointestinal (GI) motility or an abnormal pattern of GI motility.
- GI motility varies throughout the intestinal tract. However, the mean number of peristaltic contractions of the stomach and proximal duodenum are 4 to 5 contractions per minute. These tend to be the easiest sites to evaluate in general when it comes to identifying post-operative ileus and are part of the VPOCUS sites.
- It should be kept in mind that focal ileus, particularly when present with localized GI conditions (i.e. GI foreign bodies) may not result in ileus at the level of the stomach or duodenum.
- To measure the number of contractions per minute the total number of contractions is recorded over 3-minutes and divide by 3 (to give the number of contractions/minute). In the interest of time, the number of contractions is often simply calculated over 1 minute. If there are no contractions noted a diagnosis of ileus can be made.
- Food within the GI tract is a strong stimulus for GI motility, and a diagnosis of ileus can be made with greater confidence if food is noted within the GI lumen and there is an absence of GI contractions.
- Given the stomach is easily identified at the subxiphoid location of the abdominal VPOCUS exam, and the duodenum is in close proximity to the right kidney on of the right paralumbar site of the abdominal VPOCUS exam, it is very easy to identify these structures during abdominal VPOCUS scanning and assess the GI tract for motility.
- Other areas of the small intestines can be evaluated but the number of contractions is less in these regions and identifying specific areas or small intestine can be challenging.
- Gastric fluid retention should also be assessed (and can be measured using a similar formula as the urinary bladder volume calculation if the stomach is fluid filled) as removal of gastric fluid contents may make patients more comfortable and reduce the risk of regurgitation and aspiration pneumonia.

4. *Is the animal producing urine Y/N?*

- It is sometimes difficult to quantitatively measure urine output in small animals due to technical challenges in placing urinary catheters, risks of urinary tract infections and/or financial constraints of owners. Although not 100% accurate, point of care ultrasound can be used to estimate urinary volume and urine production over time.
- To measure the urine volume the bladder should be fanned through its entirety in the longitudinal orientation and measurements taken at the widest part of the bladder. The probe is then rotated 90 degrees, so the bladder is scanned in transverse orientation, again fanning through its entirety and taking measurements at its widest point. The formula length x width x height (averaged) x 0.625 is used to estimate urinary volume in milliliters.
- Indications to measure urine production include acute kidney injury, anuric and oliguric renal failure, and monitoring of fluid therapy (Atalan G et al 1998).

5. *Does the patient have a gall bladder halo sign Y/N?*

- A study by (Quantz et al 2009) demonstrated that patients with acute anaphylaxis often have a halo (double rimmed gall bladder wall) sign (the gall bladder wall is normally very thin or not easily visualized on ultrasound), and this can be seen during abdominal VPOCUS (Figure 1.11). A thicker gallbladder wall (often due to edema with or without surrounding fluid) can be seen with a “halo” effect.
- However, this is not specific for anaphylaxis and can be seen in patients with a number of conditions (anything that causes edema). However, with unstable patients presenting for collapse, the finding of a “halo” sign should prompt consideration of anaphylaxis, right-sided heart failure, pericardial effusion, fluid overload or changes to vascular permeability and sepsis.

- The most common cause of the halo sign varies by geographical area. In Canada and Belgium, pericardial effusion is the most likely cause in a collapsed unstable patient, while in the Southern United States anaphylaxis is probably the most common cause.

SUMMARY ABDOMINAL VPOCUS

- Abdominal VPOCUS was initially developed for the detection of free abdominal fluid in trauma cases using A-FAST, but it has now evolved into a triage tool for any patient: Trauma, acute abdomen, post-surgical, critically ill, etc. Done patient-side at the same time as IV catheter, minimum emergency database, auscultation, oxygen, sedation. Helps track progression, guides abdominocentesis and further diagnostics and interventions, is non-invasive, repeatable, and rapid. Allows assessment of free abdominal fluid or air, ileus, halo sign, and urine production. Binary questions help avoid errors, answer the most important clinically relevant questions first and sequentially build skill levels by mastering one question at a time.

References/Suggested Reading: Available upon request