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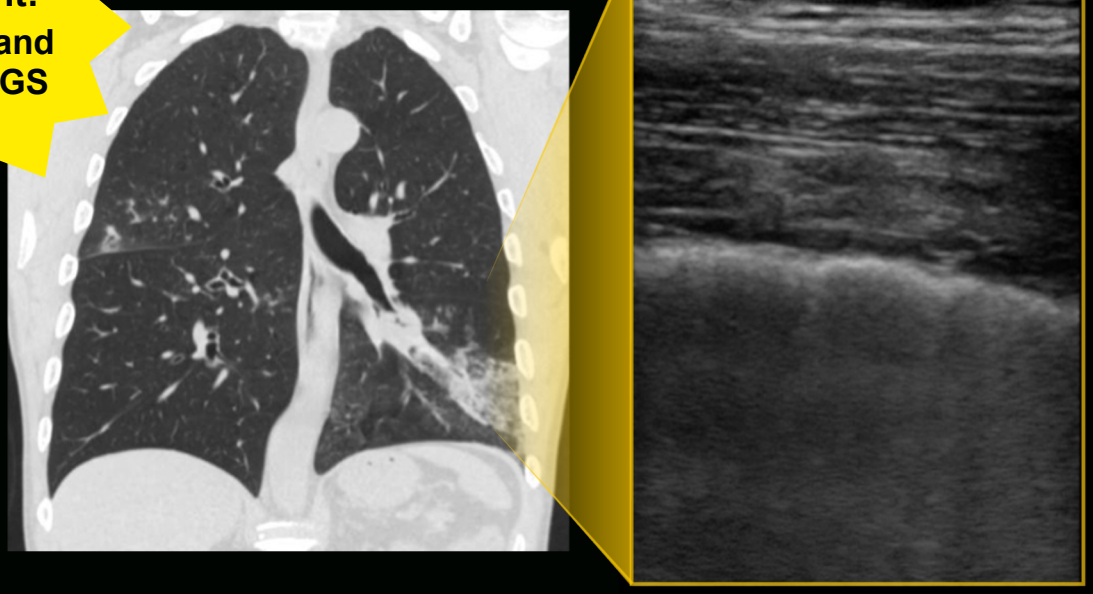

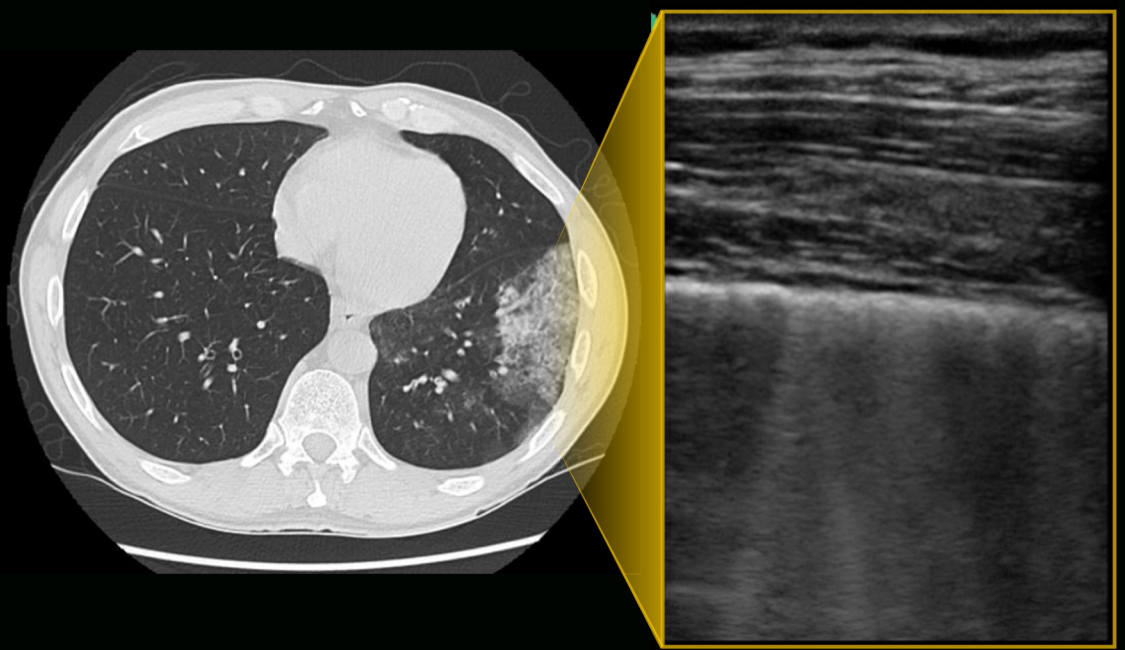

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Use of hand held ultrasound to guide therapeutic and diagnostic thoracentesis in the pleural space clinic

by Michael Fitzpatrick, MD, FRCPC,

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Case 1

Mr. P was a 75 year old gentleman with a history of splenic marginal zone lymphoma. His cancer was complicated by development of a pleural effusion and ascites. He was admitted to hospital due to abdominal discomfort but following discharge developed dyspnea. He was referred to the Pleural Space Clinic by his oncologist for worsening dyspnea and consideration of thoracentesis.

Ultrasound of the lung bases was conducted to assess for effusion by the consultant Respirologist using a Vscan device. There was no fluid present in the patient's right pleural space. A moderate sized pleural effusion (Figure 1) was seen on the left side. The ultrasound of the left lung based was used to guide the thoracentesis (online Video 1). The site of catheter insertion was landmarked at the 8th intercostal space, roughly 10 cm from the spine. Lidocaine was used to anesthetize down to the pleura. The catheter was introduced along the same location and angle, and a total 1.5 litres of serosanguinous fluid was collected. The procedure was well tolerated without complications. Ultrasound following the procedure showed a very small amount of remaining fluid. Sliding lung/pleura could be seen as well. The patient experienced relief of symptoms following the procedure.

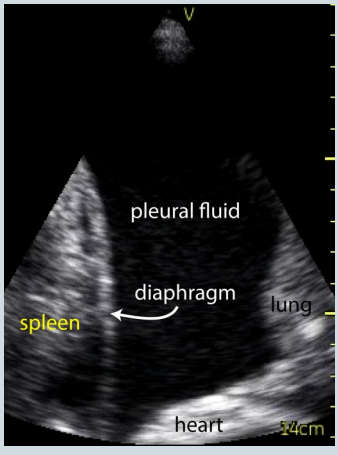

Figure 1. Left lung base. Acquired by GE Healthcare Vscan.

Case 2

Mr. M is a 58 year old man, with a prior history of non-small cell lung cancer and recurrent pleural effusions of unclear etiology noted on chest x-ray. The patient was referred to the Pleural Space Clinic due to increasing dyspnea on exertion.

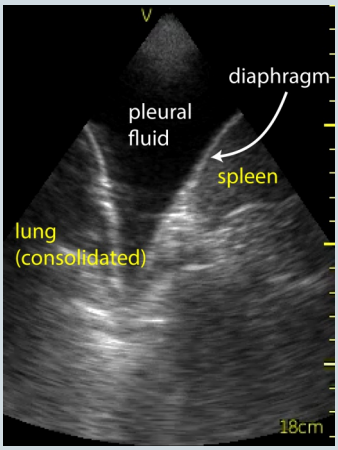

Figure 2. Direct thoracic view of the left lung base. Acquired by GE Healthcare Vscan.

Ultrasound of the lung conducted by the Respirologist using a VScan device revealed a small amount of right pleural effusion and a moderate sized left pleural effusion. The ultrasound was used to landmark the site of needle insertion for thoracentesis (Figure 2, online Video 2), at the 8th intercostal space, roughly 10 cm from the spine. Following anesthesia with lidocaine, the thoracentesis catheter was inserted along the same angle. A total of 500 ml was drained from the pleural space. The procedure was terminated as the patient began to experience some chest discomfort. Following thoracentesis, ultrasound was repeated and there was no significant remaining fluid. Sliding lung/pleura was visualized. The procedure was otherwise well tolerated. Fluid was sent for routine analysis, as well as cytology, flow cytometry, and cultures.

Case 3

Mr. V was a 69 year old man initially referred to the Lung Diagnostic Assessment Program Clinic for a small right sided pleural effusion and incidental lung thickening noted on a CT scan conducted several weeks prior during a bout of pneumonia. Given the appearance of the CT scan the decision was made to investigate for malignancy, especially in the presence of bilateral calcified pleural plaques in the absence of exposure to asbestos. He was referred to the Pleural Space Clinic for diagnostic thoracentesis.

The patient's right pleural space was assessed by the consultant Respirologist using a VScan device. A small amount of fluid in the right pleural space was noted to be gelatinous in appearance and loculated. Adjustment of the probe to the 6th intercostal space, roughly 10 cm from the spine helped to localize the largest fluid loculation in order to conduct the diagnostic thoracentesis (online Figure S3, Video 3). Following informed written consent, and lidocaine anesthesia in a sterile fashion, an angiocather was introduced guided by the ultrasound location of the largest pocket of fluid. Approximately 70 ml of bloody fluid was collected. The patient tolerated the procedure well without complication. Ultrasound post procedure persistence of fluid with several loculations remaining. The collected fluid was sent for routine analysis, cytology, flow cytometry, and culture.

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Hemoptysis localization - hearing with your eyes

by Barry Chan, MD

Queen's University, Internal Medicine

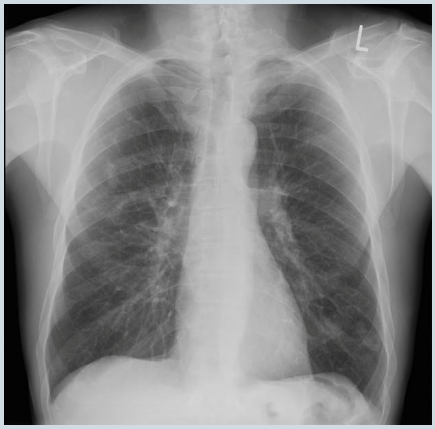

Figure 1. Chest X-ray appears normal.

Clinical Vignette: 45 year old was transferred from a peripheral facility for acute massive hemoptysis though maintained sufficient airway patency with no evidence of hemodynamic instability or respiratory failure. Thoracic auscultation revealed vesicular breathing with no adventitious sound. CXR from the peripheral site was normal (see Figure 1).

Indication: Localization (and lateralization) of the bleed to (1) optimize positioning via lateral decubitus; (2) facilitate emergent endobronchial blocking if needed. CT scan would be the most ideal imaging modality though it may not be feasible in a timely fashion due to a multitude of reasons, therefore PoCUS would rapidly provide the answer to the targeted clinical questions.

Multiple studies have demonstrated the superiority of thoracic PoCUS in identifying interstitial syndrome compared to conventional chest x-ray. In this particular case, the CXR was essentially normal though PoCUS demonstrated otherwise.

Image Acquisition: Bilateral four zone thoracic imaging acquisition. One can perform an extended scan if the posterior thorax can be accessed for Zone 5 and 6. (To scan Zone 5, displace the scapula by having the patient "hug" him/herself). See Supplemental Figure S2 for graphical representation of the four zones imaged with the borders for each zone demarcated.

Image Interpretation: A-lines are seen in all zones barring LZ4 (Left Zone 4) which revealed > 3 B-lines between two-rib space (see Figure 2).

In this case, A-lines are seen at the right and left thorax barring LZ4 which showed multiple B-lines.

B-lines are vertical artefacts indicating "something" is in the interstitium and/or alveoli – water, pus, blood, scar, or mass – with >3B-lines seen between 2 rib-space designated as a significant scan. The diagnostic term for such a positive scan is called "Interstitial Syndrome" in the PoCUS realm.

In this particular case, significant number of B-lines was localized to the left lower lobe suggesting it as the most likely source of the hemoptysis. Nevertheless, there are several limitations to beware of.

First of all, it is not uncommon to see B-lines in the lower lobes at the most dependent regions secondary to atelectasis or gravitation of fluid. Secondly, the presence of significant

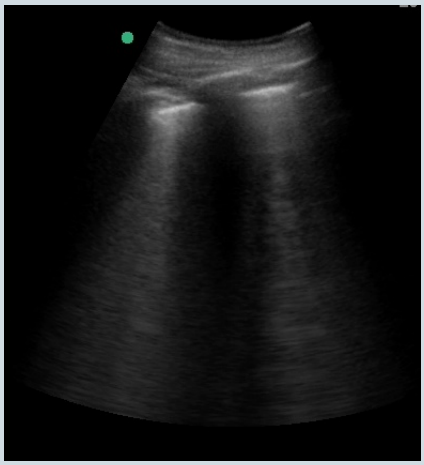

Figure 2. Left Zone 4 shows B focal lines.

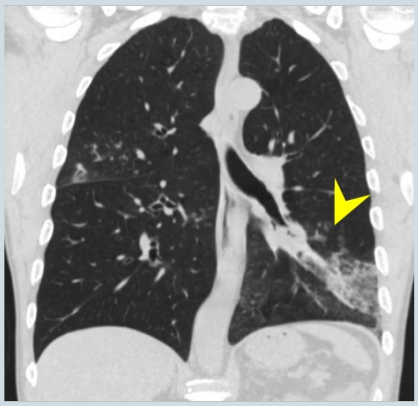

Figure 3. Chest CT shows coarse and ragged pleura (arrow).

B-lines indicates interstitial syndrome though it does not confer an etiology in-of-itself – nevertheless, the pattern and distribution of the B-lines may suggest an etiology. In addition, one cannot discern whether B-lines are acute, chronic, or acute-on-chronic. Finally, of note, if the lesion is surrounded by aerated parenchyma or a pneumothorax, the ultrasound beam will be scattered – yielding A-lines rather than B-lines. (For example, if the source of the bleed was proximal, the thoracic PoCUS would not be able to detect it.)

Clinical Synthesis: The source of the hemoptysis is likely originating from the left lower lobe.

Vignette Resolution: The patient was immediately placed on a left lateral decubitus position upon attaining the thoracic PoCUS results; and the intubation expert was notified of the findings. An emergent CT thorax without contrast demonstrated ground-glass opacity in the left lower lobe (see Figure 3).

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The use of gastric ultrasound to assess risk of pulmonary aspiration

by James Cheng, PGY-4

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Pulmonary aspiration of gastric contents is a dreaded complication of general anesthesia, as it carries significant patient morbidity and mortality (1-3). Subsequent aspiration pneumonia can lead to prolonged mechanical ventilation, and a mortality rate of up to 5% (4). To minimize the risk of pulmonary aspiration, patients are required – as per the American Society of Anesthesiology's "Practice Guidelines for Preoperative Fasting" – to fast prior to elective surgery in order to ensure that the stomach is empty prior to induction of general anesthesia. In situations where the patient is not fasted for the appropriate time period, and delay of surgery is not an option, a rapid sequence induction (RSI) is performed to minimize aspiration risk. RSI includes preoxygenation of the lungs, rapid administration of anesthetic and paralytic agents, and cricoid pressure. However, an RSI has its own risks, including the potential for hemodynamic instability given its rapidity.

Gastric ultrasound is a recently described tool that quantifies gastric contents, and gives an estimation of aspiration risk. Using it in the preoperative setting can help guide anesthetic management and potentially avoid unnecessary RSIs. We present a case where preoperative gastric ultrasound changed our anesthetic management.

Case: An 80-year-old man was scheduled for urgent decompressive thoracic laminectomy for new cauda equina syndrome. In addition to this, the patient had a full breakfast including eggs and sausage only 6 hours prior to presentation. His past medical history included hypertension and diabetes. The patient's neurologic exam revealed paraplegia and complete lack of sensation below T11 which was a dramatic change from 6 hours previous. Given the rapidity of the patient's neurologic decompensation, the neurosurgical team was eager to proceed with surgery as soon as possible.

To better quantify the patient's aspiration risk, a gastric ultrasound was done preoperatively to assess gastric volume. The patient was supine with the head of the bed elevated to approximately 45°. A curvilinear ultrasound probe (we should insert here the machine make and model) was placed in the epigastric region in the sagittal orientation. The antrum of the stomach was located (Figure 1, Online Video 1). Based on this image, the cross sectional area of the antrum was calculated to be 550mm2,which corresponded to a gastric volume that would be in keeping with low risk of aspiration (5,8).

Given this finding, the anesthesia team felt it was appropriate for the patient to proceed with his surgery as soon as possible. An arterial line was placed pre-induction along with standard CAS monitors. A titrated induction of general anesthesia was performed with lidocaine 1mg/kg, remifentanil 1mcg/kg, propofol 0.5mg/kg, and succylcholine 1mg/kg. Cricoid pressure was not applied. Gentle bag mask ventilation was performed. The patient's trachea was intubated without aspiration, and his anesthetic was otherwise uneventful.

Discussion: This case presented some challenges with regard to the anesthetic management. The combination of an unfasted state and diabetes puts the patient at a high risk for aspiration. In an elective setting, surgery should be delayed. In this case, however, delay of surgery in the setting of cauda equina syndrome would jeopardize his chance for neurologic recovery. Similarly, performing a rapid sequence induction (RSI) in a frail 80 year old could easily cause significant hypotension, which could affect spinal perfusion and subsequent neurologic recovery. Faced with this dilemma, a gastric ultrasound was performed as a way to objectively assess for aspiration risk.

Scanning technique: The goal of gastric ultrasound is to visualize the antrum of the stomach and to measure its cross sectional area (CSA). The technique was described by Perlas et al. (5) A curvilinear probe is often used, but a linear probe can be used in thin or pediatric patients. The patient is positioned in the semi-sitting position or in the right lateral decubitus position. The probe is placed over the epigastrium in the sagittal orientation and moved side to side until the antrum is visualized. The antrum is localized just caudal to the left lobe of the liver. Other landmarks which may be visualized include the pancreas, aorta, inferior vena cava, and superior mesenteric artery which are located posterior to the antrum. The antrum may be collapsed, or filled with fluid, particulate material, or a mixture. The CSA of the antrum is measured or calculated when the antrum is not contracting during peristalsis.

Interpretation of findings: The gastric ultrasound is interpreted based on the quality of the antrum contents and CSA of the antrum. Solid material in the antrum has increased echogenicity, and has a heterogeneous appearance. Solid material in the antrum indicates a high risk of aspiration. On the other hand, fluid will appear hypoechoic or anechoic, and will be uniform in appearance. Thicker fluids and milk will have increased echogenicity.6

If the antrum contains clear fluid, the next step is to calculate the CSA of the antrum. The CSA can be calculated from the diameters measured from serosa to serosa using the formula:

$$CSA = (AP \times CC \times \pi)/4$$

AP: antero-posterior diameter

CC: cranio-caudal diameter

Alternatively, a tracing tool can be used to trace the antrum to obtain the CSA. An empty antrum will be completely collapsed and is

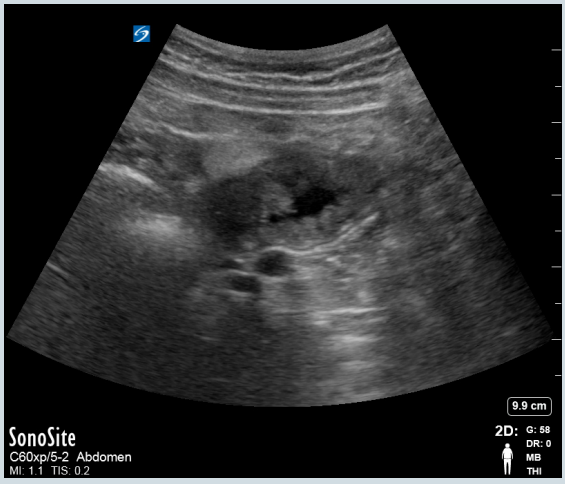

Figure 1. Gastric ultrasound with patient in a semi-sitting position. The antrum located in the middle and filled with clear fluid (anechoic). The liver is seen to the left. The pancreas and SMA are visualized posterior to the antrum.

sometimes described as having a "target-like" appearance.

From the CSA and the patient position, a gastric volume can be estimated based on various verified mathematical models. For patients scanned in the right lateral decubitus position, Perlas et al. use:

GV(mL) = 27 + 14.6×CSA – 1.28×age

This formula is applicable in non-pregnant patients with BMI less than 40. F or patients in the semi-sitting position, Bouvet et al. suggest:

GV(mL)=-215 + 57logCSA − 0.78age –
0.16ht – 0.25wt −0.8ASA +
16(in emergency cases) +
10(with preop ingestion of
100mL antacid prophylaxis)

ht: height in cm

wt: weight in kg

CSA: in mm2

This formula is also applicable only in non-pregnant patients.8

Perlas et al. also describe a grading system based on a qualitative assessment that may be quicker to use (9). Using this method, the patient is scanned first supine and then in right lateral decubitus. A grading system of 0-2 is used. If the antrum is empty in both positions, the patient is a grade 0. For grade 1, the antrum is empty supine but filled with clear fluid in RLD. Grade 2 is clear fluid in both positions. Grade 2 is associated with a gastric volume of > 1.5mL/kg and increased aspiration risk.

Gastric volume and aspiration risk:

The cut-off value for the gastric volume associated with increased risk of aspiration is still a source of controversy. After fasting overnight, the gastric residual volume can be around 25mL (10). Bouvet et al. have suggested a value of 0.8mL/kg as a cut-off based on animal studies and extrapolating the data to humans (11). On the other hand, Perlas et al. suggests that a value of 1.5mL/kg is more appropriate (12). They point to studies that have assessed gastric volume in fasted patients which show a mean volume of 20-30mL with range of 0-75mL (13-16). When converted to mL/kg, the upper limit of normal was 1.5mL/kg. Ultimately, using a gastric volume cut-off value to assess for aspiration risk is based on expert opinion and extrapolation. Further studies will be needed to better characterize the relationship between aspiration and gastric volume.

Conclusion: Preoperative gastric ultrasound is a newly developed tool used to assess for the risk of pulmonary aspiration of gastric contents following induction of general anesthesia. We present a case where gastric ultrasound was useful in guiding our anesthetic management of a patient with new cauda equine syndrome. Overall, ultrasound imaging of the antrum can be used to assess residual gastric volume. Based on current evidence and expert opinion, a cut-off value of 1.5mL/kg for gastric volume is reasonable, but more research in this area is required.

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June 10-14, 2016 – Seattle, WA, USA

Point-of-Care & General Medicine Ultrasound (AIUM)
www.aium.org/cme/events/pg2016_7/pg2016_7.aspx
July 23-14, 2016 – Portland, OR, USA

12th Winfocus World Congress on Ultrasound in Emergency & Critical Care
www.winfocus.org
September 7-10, 2016 – Ljubljana, Slovenia

Fourth Annual World Congress Ultrasound in Medical Education
www.wcume.org
September 23-25, 2016 – Lubbock, TX, USA

EuroEcho-Imaging 2016, European Society of Cardiology
www.escardio.org/ESC2016
December 7-10, 2016 – Leipzig, Germany

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