The use of gastric ultrasound to assess risk of pulmonary aspiration

by James Cheng, PGY-4

Queen's University, Kingston General Hospital, Department of Anesthesiology

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 succinylocholine 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 epigastrum 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.

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
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:

\[ GV(\text{mL}) = 27 + 14.6 \times \text{CSA} - 1.28 \times \text{age} \]

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:

\[ GV(\text{mL}) = -215 + 57 \log \text{CSA} - 0.78 \text{age} - 0.16 \text{ht} - 0.25 \text{wt} - 0.8 \text{ASA} + 16 \times (\text{in emergency cases}) + 10 \times \text{(with preop ingestion of 100 mL antacid prophylaxis)} \]

ht: height in cm
wt: weight in kg
CSA: in mm²

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

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.

**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.

**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.

**References:**


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