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Ultrasound assessment of gastric volume in severely obese individuals: a validation study

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Abstract

Background. Point-of-care gastric ultrasound is an emerging tool to assess gastric content and volume at the bedside. The examination includes both a qualitative and a quantitative component. The aim of this study was to evaluate the performance of an existing model for predicting gastric volume in severely obese subjects (BMI >35 kg m^{-2}).
Methods. This observer-blinded experimental study compared the gastric volume predicted based on a sonographically measured cross-sectional area of the gastric antrum with the gastric volume measured by suctioning under gastroscopic guidance in a cohort of severely obese subjects. Volumes between 0 and 400 ml, in 100 ml increments, were studied. Allocation was randomized, and all study observations were blinded to group allocation. The correlation and the level of agreement between predicted and observed volumes were studied.
Results. Data from 38 subjects suggested that the gastric volume predicted by sonographic assessment correlated strongly with that measured by gastric suctioning (concordance correlation coefficient of 0.82 and Pearson's correlation coefficient of 0.86). In addition, Bland–Altman analysis suggested a high level of agreement between the calculated and suctioned volumes, with a mean difference of 35 ml, and 95% limits of agreement similar (within 30%) to those observed in the non-obese population.
Conclusions. Our results suggest that the existing mathematical model to determine gastric fluid volume based on sonographic assessment performs well in severely obese individuals.

Key words: gastric emptying; obesity; respiratory aspiration of gastric contents; ultrasonography

Point-of care ultrasound applications are rapidly expanding in the perioperative setting. Ultrasound is increasingly used as a supplement to the history and physical examination to guide clinical decision-making at the bedside.[1] Growing evidence demonstrates the positive impact of point-of-care ultrasonography on patient care.[2 3]

Pulmonary aspiration of gastric contents continues to be a leading cause of anaesthesia mortality and is often related to inadequate assessment of aspiration risk.[4] Morbidly obese individuals are considered to be at increased risk for this perioperative complication.[5–7] To date, rigorous application of the ASA fasting guidelines has been the primary method to

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Editor's key points

- Ultrasonography may be useful in assessing the volume of gastric contents, but its efficacy in severely obese subjects is not clear.
- In 38 severely obese subjects, the gastric volume estimated by ultrasound was compared with the volume measured by the conventional suction method.
- There was a good agreement in the gastric volume between the conventional and ultrasound methods.

prevent aspiration by ensuring an empty stomach before anaesthetic induction.[8 9] However, there remain many situations where fasting guidelines do not apply; these include urgent or emergency situations and medical conditions associated with delayed gastric emptying.

Gastric ultrasound can objectively assess perioperative gastric content and volume at the bedside.[10–12] A complete gastric ultrasound examination includes both qualitative and quantitative assessment. A qualitative assessment can detect the following: (i) a completely empty stomach [no content in the gastric antrum in both the supine and right lateral decubitus (RLD) positions]; (ii) clear fluid content (distended antrum with hypoechoic content); and (iii) thick fluid or solid content (distended antrum with hyperechoic or heterogeneous content).[12 13] Additionally, in the presence of clear fluid, a quantitative volume assessment can help to differentiate a negligible volume compatible with baseline gastric secretions (<1.5 ml kg^{-1}) from a higher volume consistent with a 'full stomach' state (>1.5 ml kg^{-1}).[13–15]

We previously reported a mathematical model to measure gastric fluid volume based on a cross-sectional area (CSA) of the gastric antrum, as follows:

$$\text{Volume} = 27.0 + 14.6 \times \text{Right-lat CSA} - 1.28 \times \text{age}$$[14] where Right-lat CSA is the antral CSA measured in the RLD.

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This model was validated for non-pregnant adults with a BMI ≤ 40 kg m^{-2}.[14] The aim of the present study was to evaluate the performance of our model for predicting gastric volume in severely obese subjects (BMI >35 kg m^{-2}).

Methods

After obtaining approval from the University Health Network Research Ethics Board, we conducted this randomized blinded study in collaboration with the bariatric surgical programme at Toronto Western Hospital. Patients undergoing upper gastrointestinal endoscopy screening in preparation for bariatric surgery were invited to participate in the study. Inclusion criteria were as follows: BMI >35 kg m^{-2}; age 18–80 yr; ASA physical status I–III; height ≥ 150 cm; who were to undergo elective gastroscopy; and had the ability to understand the rationale of the study and provide informed consent. Exclusion criteria were as follows: pregnancy; recent upper gastrointestinal bleed (within the preceding 1 month); previous gastric or lower oesophageal surgery; and documented abnormalities of the upper gastrointestinal tract, such as hiatal hernias and gastric tumours. Written informed consent was obtained from all subjects.

According to standard institutional practice, all patients were fasted for 8 h without fluids or solids before elective gastroscopy. A baseline gastric ultrasound examination was first performed to confirm an empty stomach before randomization. All ultrasound examinations were performed by either a sonographer or a staff anaesthetist with a minimum of 3 yr previous experience and at least 100 previous gastric ultrasound examinations.

Patients were then randomized to ingest one of five predetermined volumes of apple juice (0, 100, 200, 300, or 400 ml) according to a computer-generated randomization list. Group allocation was concealed in sealed opaque envelopes that were opened only after recruitment. Both the sonographer and the surgeon performing the gastroscopy were blinded to group allocation until after all data collection was complete. Two minutes after ingestion, a second ultrasound scan was performed according to a standardized protocol in both the supine and RLD positions.[14] The antrum was identified in a sagittal plane between the liver cephalad and anteriorly, and the pancreas and aorta posteriorly. Care was taken to obtain a true transverse view of the antrum, avoiding oblique views from excessive probe rotation that could overestimate the antral size. All images were obtained between peristaltic contractions with the antrum at rest, to avoid underestimating the antral area. Three consecutive images of the antrum were stored and labelled.

Ultrasound examinations were completed using a Philips CX50 system with image compounding technology and a low-frequency (2–5 MHz) curvilinear array probe. For the qualitative assessment, the antrum was classified using a three-point grading system, as follows: grade 0, no fluid appreciable in either supine or RLD position; grade 1, clear fluid appreciable in the RLD only; and grade 2, clear fluid appreciable in both supine and RLD positions. For the quantitative assessment, a CSA of the gastric antrum was measured in the RLD position using free-tracing callipers.[14 15] The full thickness of the gastric wall was included in the measurement. The mean of three measurements from three consecutive images was used. Immediately after the second ultrasound scan, i.v. sedation was administered according to standard institutional practice (midazolam 1–2 mg and fentanyl 50–100 μg) to achieve anxiolysis. Gastroscopy was performed by a staff general surgeon using an Olympus gastroscope. All gastric fluid was thoroughly suctioned through a side-port and its volume measured to the nearest millilitre.

We conducted and reported our investigation according to the Guidelines for Reporting Reliability and Agreement studies.[16]

Sample size estimate and statistical analysis

Based on the original data from the study that developed the mathematical model,[14] the 95% limits of agreement (LOA) of the difference between the predicted volume *vs* the observed volume was a mean of 126.1 ml (upper 95% LOA 132.4 ml and lower 95% LOA −119.74 ml) with a standard deviation of 64.5 ml. In severely obese subjects, we considered it reasonable to expect a 30% increase in this difference ($\leq$163.93 ml) and in the standard deviation ($\leq$83.63 ml). We estimated that 39 patients would be required to prove our hypothesis for this specific population with a Type 1 error <0.05 and a power of 80%. Descriptive statistical methods were used to describe the study population. A Bland–Altman analysis was performed to evaluate the difference between the calculated volumes based on antral CSA and the suctioned volumes, and to place the magnitudes of these differences in a clinical context.[17 18] In addition, we estimated the upper and lower 95% LOA for the differences, which represent the differences likely to arise between the two measurements with a 95% probability. The assumption of normal distribution of the differences was verified with the