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Utility of ultrasonography for detection of gastric fluid during urgent endotracheal intubation

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Abstract *Purpose:* Aspiration of gastric contents is a dangerous complication of urgent endotracheal intubation (UEI). Left upper quadrant (LUQ) ultrasonography may have the potential to decrease this complication by identifying patients with gastric fluid content, thereby allowing the UEI team to evacuate gastric contents prior to intubation. *Methods:* This was an observational study of 80 UEIs where LUQ ultrasonography was performed in a medical intensive care unit of a tertiary care hospital. The subjects were 80 patients requiring UEI. Gastric fluid content was identified as an anechoic or hypoechoic space in the appropriate anatomic position. If potentially consequential fluid was identified, it was evacuated using a gastric tube. Repeat LUQ ultrasonography confirmed removal of gastric contents prior to induction. *Results:* A total of 80 patients had LUQ ultrasonography performed; 19 (24%) had gastric fluid content identified and 13 (16%) had sufficient gastric fluid content such that the UEI team proceeded with gastric tube insertion. Following gastric fluid removal, repeat ultrasonography showed absence of gastric fluid. Gastric fluid volume removed was 553 ± 290 ml (mean ± standard deviation, SD). None of the 80 patients had a clinically consequential aspiration event. Performance of ultrasonography took fewer than 2 min. No patient had complication related to the ultrasonography or removal of gastric contents. *Conclusions:* Ultrasonography is useful for the detection of gastric fluid. This technique may have utility in reducing risk of a clinically consequential aspiration event during UEI.

Keywords Intubation · Safety · Ultrasonography · Gastric · Aspiration · Emergency

Abbreviations

UEI	Urgent endotracheal intubation
LUQ	Left upper quadrant
NPO	Nil per os/nothing by mouth

Introduction

Aspiration of gastric contents is rare in the controlled environment of elective operating room endotracheal intubation [1, 2]. However, an uncommon but dangerous complication of urgent endotracheal intubation (UEI) is massive aspiration of gastric contents [3]. The patient with a stomach full of fluid, who must undergo UEI for a life-saving indication, may vomit during the procedure due to laryngeal stimulation and/or gastric air insufflation. When this happens, a large volume of fluid is ejected into the airway of the patient who is supine and who has

attenuated airway protective reflexes. The patient may quickly asphyxiate and die. Alternatively, a large volume of gastric contents enters the lungs resulting in acute lung injury or pneumonia. This article describes the use of left upper quadrant (LUQ) ultrasonography to identify gastric fluid collection prior to induction during UEI. In identifying major gastric fluid collection, the UEI team may then take action to empty the stomach on an emergency basis, in order to avoid a potentially lethal complication. We describe our technique and its potential ability to decrease the incidence of massive aspiration.

Materials and methods

Study setting

Long Island Jewish Medical Center is a 452-bed acute care teaching hospital with an 18-bed medical intensive care unit that is staffed by full-time attending intensivists, fellows, and house staff. The unit team performs all aspects of UEI, using a combined team approach and well-defined protocol [4]. We defined UEI as a patient requiring intubation who was not in full cardiac arrest or with such severe cardiopulmonary failure that any delay in acquiring an airway could lead to death. The primary reasons for UEI were acute respiratory failure (defined as respiratory rate greater than 34 and/or saturation of less than 90 on FIO_2 1.0 with or without non-invasive support), hypercapnia (defined as $PaCO_2$ greater than 45 mmHg in association with decline in mental status and inability of patient to protect their airway), airway protection, hypotension/sepsis (defined as systolic blood pressure less than 90 mmHg requiring intravenous vasoactive medications with severe sepsis), and pre-procedure. Critical care attendings and fellows are trained in critical care ultrasonography, including the identification of gastric fluid. Data were collected prospectively and placed in a de-identified database for purposes of quality assessment of UEI performed by the intensive care unit team. The institutional review board of Long Island Jewish Medical Center approved use of the database for this study.

Performance of ultrasonography

The ultrasound scan was performed by a qualified critical care attending during the setup for UEI using a 1.0–5.0 MHz phased-array transducer (P21x, SonoSite M-Turbo, Bothell, WA, USA). The ultrasound transducer was positioned on the mid torso in the mid-axillary line using a longitudinal scanning axis (Fig. 1). The scanner identified the spleen and left hemidiaphragm. Using these as landmarks, the ultrasonographer angled the transducer anteriorly to achieve multiple tomographic planes of the LUQ. The examiner supplemented this view with sagittal plane scanning of the LUQ from an anterior approach (Fig. 2). Stomach fluid was identified as a hypoechoic space subtended by the stomach wall. Frequently, echogenic material could be identified floating within the fluid filled stomach (Fig. 3). The ultrasonographer made no formal attempt to quantify the amount of gastric fluid. The decision to empty the stomach was made by the examiner on a qualitative basis and was followed by placement of a gastric tube. Following removal of fluid, a second ultrasound examination was performed to verify removal of stomach contents. The UEI team then proceeded with induction and insertion of the endotracheal tube.

Fig. 1 Longitudinal scanning axis. The ultrasound transducer is positioned in the left mid-axillary line. Index mark identified by *white arrow* is oriented towards patient head. Transducer can be tilted anteriorly and posteriorly along longitudinal axis in order to scan stomach

Fig. 2 Anterior approach, transverse scanning. The ultrasound transducer is positioned in LUQ, index mark identified by *white arrow* is oriented towards patient head

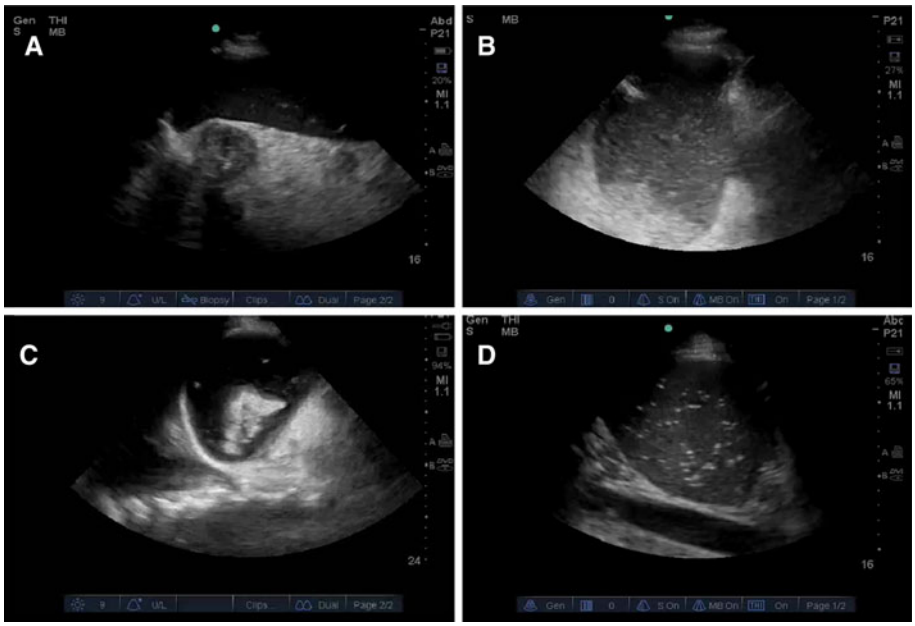

Fig. 3 Stomach ultrasound images. **a** Empty stomach. **b** Stomach with liquid and solid content. **c** Stomach with liquid and solid content. **d** Fluid filled stomach with numerous air bubbles

Data collection

As part of ongoing quality assessment, all UEIs were monitored. Immediately following the procedure, the team leader was required to fill out a standard data sheet that reported all complications including aspiration of gastric fluid. For this study, we retrospectively reviewed these data sheets. Aspiration of stomach contents was defined as visible regurgitation of stomach fluid into the oropharynx with subsequent penetration through the vocal cords during the intubation sequence.

Results

A total of 80 patients had LUQ ultrasonography; 19 (24%) had gastric fluid content identified. Patient characteristics and reasons for intubation are presented in Table 1. In 5/80 (6%) patients with gastric fluid, the examiner decided that the amount was inconsequential and no gastric tube was inserted. In 14/80 (17%) patients the examiner decided that there was sufficient fluid to warrant gastric tube insertion, and in 13/80 (16%) the tube was placed. In these 13 patients, the volume of gastric fluid removed was 553 ± 290 ml (mean ± SD) with a range of 200–1,100 ml. Repeat ultrasonography showed no residual gastric fluid. All patients tolerated gastric tube insertion without incident. The volume of fluid removed was estimated by observation of the suction canister which was divided into 100-ml gradations.

One patient had sufficient gastric fluid that the UEI team considered insertion of a gastric tube to remove the fluid. The patient was very unstable, so the team decided that establishing an airway took precedence over emptying the stomach. This patient had gastric fluid enter the oropharynx during direct laryngoscopy with minor vocal cord soiling. In anticipation of ejection of gastric fluid into the airway, the UEI team had prepared two suction catheters and positioned assigned personnel at the airway to initiate immediate suctioning when the need arose. No other patient, including the 13 patients who had gastric fluid removal, had an aspiration event during UEI. The performance of ultrasonography did not interfere with standard UEI protocol and took fewer than 2 min to perform without any associated complications. The patients who required gastric fluid removal had been nil per os for many hours before UEI, and physical examination gave no indication that they had gastric fluid present. Performance of the ultrasonography examination and gastric tube insertion did not interfere with other aspects of UEI setup.

Discussion

We describe a simple and safe technique for identifying the presence of gastric fluid during setup for UEI. In this situation, removal of the gastric fluid before induction may be indicated in order to reduce the risk of peri-intubation emesis with aspiration of gastric fluid into the airway. Based upon the observation that 16% of the present study patients had consequential gastric fluid contents that were emptied by gastric suction, we propose that ultrasonography may be useful in reducing the risk of massive aspiration during UEI. In order to avoid this complication, we now routinely perform LUQ ultrasonography as part of

Table 1 Patient characteristics ($n = 80$)

	n
Age (range)	67 (20–91)
Gender (male/female)	42/38
Primary diagnosis (%)	
Sepsis	15 (19%)
Pneumonia	14 (17.5%)
COPD/OSA/asthma	14 (17.5%)
Neurological disorder	13 (16%)
Malignancy	7 (9%)
Other respiratory disorder	5 (6%)
Pulmonary edema	4 (5%)
Gastrointestinal bleed	4 (5%)
Neuromuscular disorders	2 (2.5%)
Other	2 (2.5%)
Primary reason for UEI (%)	
Acute respiratory failure[a]	32 (40%)
Hypercapnia[b]	20 (25%)
Airway protection[c]	20 (25%)
Hypotension/sepsis[d]	5 (6%)
Pre-procedure[e]	3 (4%)

COPD chronic obstructive pulmonary disease, *OSA* obstructive sleep apnea, *UEI* urgent endotracheal intubation

[a] Acute respiratory failure defined as respiratory rate greater than 34 and/or saturation of less than 90% in the presence of severe respiratory distress on FIO_2 1.0 with or without non-invasive support

[b] Hypercapnia defined as $PaCO_2$ greater than 45 mmHg in association with decline in mental status and inability of patient to protect their airway

[c] Airway protection defined as the patient being unable to maintain a patent airway in association with alteration of mental status secondary to metabolic and/or neurological disease

[d] Hypotension/sepsis defined as systolic blood pressure less than 90 mmHg requiring intravenous vasoactive medications with severe sepsis

[e] Pre-procedure indication for emergency endotracheal intubation (EEI) defined as endotracheal intubation required for purposes of safe performance of a diagnostic procedure requiring deep sedation

standard protocol in order to identify patients at risk for this serious complication of UEI.

Ultrasonography is ideally suited to identify fluid. The physical characteristics of fluid yield typical ultrasound findings, a hypoechoic or anechoic space subtended by typical anatomic boundaries. The ultrasonographer can identify fluid collection in the stomach by using standard ultrasound scanning planes and by avoiding body elements that block ultrasound exam such as gastric air or bony structures. This proposed application of ultrasonography is a good example of the utility of the modality of point of care ultrasonography and supports the utility of having an ultrasound machine immediately available in the intensive care unit, on a full-time basis.

Our study has methodological limitations. It is not a randomized controlled trial, so we cannot conclude definitively that identification and removal of gastric fluid before endotracheal intubation reduces the risk of an aspiration event. However, common sense dictates that removal of a large volume of gastric fluid before UEI should reduce the risk of aspiration. Because the risk of massive aspiration with resultant death is so low in our experience, it would be difficult to test the hypothesis that ultrasonography reduced this risk using a controlled-trial approach. A very large number of subjects would be required, and there might be ethical objections to such a study.

The decision to empty the stomach by the attending at bedside was made on a quick qualitative basis given the instability of the clinical situation. This is a weakness of the study. Unfortunately, we are not able to give specific recommendation as to what constitutes a significant quantity of gastric fluid visualized with ultrasonography. This requires further study. We are aware that the amount of fluid removed by gastric suctioning was not highly accurate given that the suction canister had gradations of 100 ml. Figure 3 demonstrates some examples of what we considered to be significant gastric contents that required urgent gastric tube insertion. We would prefer to make the decision based upon a quantitative assessment of gastric fluid content using planar geometric measurements [5]; but this may not be practical, given the clinical pressures that surround UEI. The identification of stomach fluid alerts the UEI team of the risk for aspiration, but it does not mandate insertion of a gastric tube in all cases. For example, the patient may be so near death that there is no time to insert a gastric tube. In this dire circumstance, establishing an airway takes precedence. The UEI team, alerted to the presence of gastric fluid but unable to insert a gastric tube, can take extra measures to prevent aspiration. The risk of gastric tube insertion must be balanced against the risk of disrupting the esophagogastric sphincter. Insertion of a gastric tube could precipitate emesis. This did not occur in our patient population, but it remains a concern.

Another limitation is that ultrasonography was performed by intensivists who were skilled in critical care ultrasonography. It is not known what skill level is required to reliably detect gastric fluid. In our experience, it is straight forward; however the examiner must have adequate training to have confidence in the result.

Finally, we have concern about the possibility of a false-negative result of ultrasonography. This could result from operator inexperience or due to limitations of ultrasonography related to obesity, gastric or colonic air, or body dressings. A false-positive scan is of less concern. A fluid collection in the LUQ that is not gastric content, as might occur with a colonic fluid collection, may result in insertion of a gastric tube without removal of gastric fluid. This would not harm the patient.

Conclusion

A recognized, dangerous complication of UEI is massive aspiration of gastric contents. During setup for UEI, LUQ

ultrasonography allows the intensivist to identify significant gastric fluid. Removal of the fluid may reduce risk of aspiration of gastric contents during UEI.

Conflict of interest This study received no financial support from any entity. Drs. Koenig, Lakticova, and Mayo have no conflicts of interest to disclose.

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