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Original Research Article

ORIGINAL RESEARCH ARTICLE

Impact of fasting on the gastric volume of critically ill patients before extubation: a prospective observational study using gastric ultrasound

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Abstract

Background: A period of fasting before tracheal extubation of ventilated patients in the ICU is common practice, aiming to reduce gastric volume and aspiration risk. As the volume of gastric content is unknown at the time of extubation, the efficacy of this practice is uncertain.

Methods: A prospective, observational study using gastric ultrasound was undertaken. Images were obtained at four time points: (i) at baseline, with gastric feeds running; (ii) after suctioning of gastric contents through a gastric tube; (iii) after a 4 h period with no gastric feed running; and (iv) after both a 4 h fasting period and gastric tube suctioning. The primary outcome was the proportion of patients classed as low risk of aspiration with each intervention, using qualitative and quantitative gastric ultrasound.

Results: Fifty-four patients in the ICU were enrolled. Forty-four (81%) subjects had images that were suitable for analysis. Suctioning of stomach content through a gastric tube and fasting were equivalent with 39/44 (88.6%) and 5/44 (11.4%) subjects classified as low risk and at risk of aspiration, respectively. A period of fasting followed by suction resulted in 41/44 (93.2%) patients being at low risk.

Conclusions: Suctioning of stomach contents through the gastric tube and a 4 h fasting period appear equivalent at reducing gastric volume below a safe threshold. A small percentage did not reach the threshold despite all interventions.

Keywords: aspiration; enteral feed; extubation; fasting; gastric ultrasound; intensive care

Critically ill patients are at high risk of pulmonary aspiration and its resultant consequences. The period after tracheal extubation may be especially high risk because of the residual effects of sedation, altered conscious state, swallowing dysfunction from altered airway sensitivity, or laryngeal dysfunction secondary to a prolonged period of tracheal intubation.[1] Re-intubation, if required, may have a risk of pulmonary aspiration similar to patients undergoing emergency anaesthesia. For these reasons, a period of fasting before and immediately after extubation of the patient in critical care is common practice. The time required to reduce the gastric residual volume to a 'safe' level is not uniformly accepted. A survey of 176 ICUs in the UK reported 67–72% of units recommend a fasting period of 4–6 h before planned extubation.[2] Both sites participating in this study have guidelines recommending a minimum of a 4 h fasting period before extubation.

The considerations regarding the value of a fasting period are (i) baseline gastric volumes of critically ill patients are unknown; (ii) the fasting time required to produce a stomach volume considered to be associated with a low risk for aspiration is unknown; and (iii) the volume of stomach content

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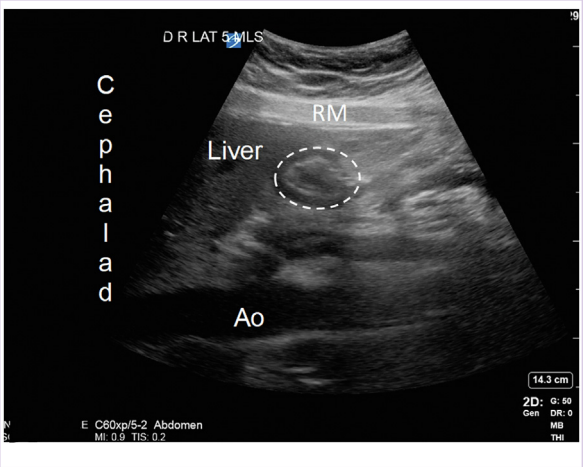

Fig 1. Ultrasound image of patient in right lateral decubitus position, after fasting, before extubation. Ao, aorta; gastric antrum, dotted line; liver, left lobe of liver; RM, rectus muscle.

considered to be associated with a high risk for aspiration is not well defined.

Gastric ultrasound is a valid technique to assess stomach content qualitatively and quantitatively, and it may be useful to answer some of these uncertainties.[3,4] Mathematical models have been developed to estimate gastric volume based on ultrasound assessment of the gastric antrum.[5,6] These methods have impacted clinical anaesthetic practice by identifying patients unsuitable for general anaesthesia because of large gastric residual volumes and at high risk for aspiration events.[7]

In this study, we used gastric ultrasound to investigate the effect on stomach content and volume of the following management strategies: (i) suctioning stomach contents through the gastric tube, (ii) a 4 h minimum fasting period, and (iii) a 4 h minimum fasting period plus suctioning of the gastric tube in patients in the ICU for whom tracheal extubation was planned.

Methods

A prospective, observational cohort study was carried out in ventilated, enterally fed patients for whom tracheal extubation was planned, in the ICUs at the Royal Brisbane and Women's Hospital and the Sunshine Coast University Hospital in Queensland, Australia, between February 2017 and July 2020.

The project was approved by the institutional human ethics committee (HREC/16/QRBW/263) with written consent obtained from a qualified substitute. Patients were eligible for inclusion if their tracheae were intubated, and they were receiving mechanical ventilation of the lungs in the ICU, age >18 yr, receiving enteral feeds *via* a gastric feeding tube, and had a planned tracheal extubation within 4–24 h after enrolment.

Subjects were excluded for recent upper abdominal surgery, pregnancy, known pathology (such as gastric tumour), large hiatus hernia, and uncleared spinal injuries that precluded positioning for the study. Suitable subjects were identified by a research nurse and included if consented, and an investigator was available to perform the ultrasound examinations. A Sonosite X-Porte (Sonosite Inc., Bothell, WA, USA) machine with a low frequency (2–5 MHz) curvilinear probe was used. The ultrasound examinations were performed by one of three investigators who were dual qualified in anaesthesia and intensive care medicine and competent in performing gastric ultrasound.

Enteral feed formulations used in this study were Nutrison® Protein Plus Multi Fibre or Nutrison® concentrate (Nutricia, Macquaire Park, NSW, Australia). Feeds were administered through a 14 or 16 Fr Salem Sump™ (Covidien, Mansfield, MA, USA) gastric tube with multiple side holes. Feeds were administered at a rate of 0.5–1.0 ml kg^{-1} h^{-1} determined by estimated caloric requirement or need for fluid restriction. In total, four ultrasound examinations were completed as follows: (i) the first ultrasound was performed at baseline with gastric feeds running *via* a gastric feeding tube. The patient was initially supine and subsequently repositioned to the right lateral decubitus position where an image was obtained, including gastric antrum, left lobe of liver, and aorta, if possible (Fig. 1). Video images were saved as 10 s video clips, and measurements were performed later. (ii) The gastric tube was then suctioned, and the volume withdrawn was recorded. A second gastric ultrasound was then performed immediately, following the same technique as outlined previously. Upon completion of the examination, the suctioned volume of feed was returned to the stomach, as per unit feeding guidelines for managing gastric residual volumes. (iii) A third ultrasound examination was performed in the same sequence, after at least a 4 h fasting period, during which no feeds were running. Usually, this was overnight, in preparation for extubation the following day. (iv) The fourth and final ultrasound was obtained after both the 4 h fasting period and

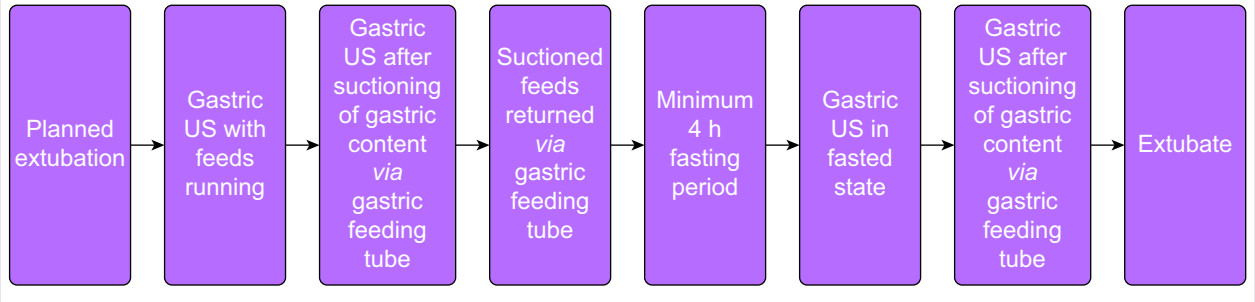

Fig 2. Timeline sequence of gastric ultrasound (US) examinations leading to extubation.

nasogastric tube suctioning. On this occasion, the gastric aspirate was discarded. Upon completion of the final ultrasound examination, the patient proceeded to extubation at the discretion of the treating intensivist, who was unaware of the ultrasound findings (Fig. 2). The person performing the ultrasound was not blinded to the time point at which they were obtaining an image.

Evaluation of the images occurred later. Qualitative and quantitative assessments were performed in all studies. Quantitative estimation of gastric volumes based on the cross-sectional area (CSA) of the gastric antrum was performed on images, where the stomach was identified as containing clear fluid. The cross-sectional area of the antrum was measured with the patient in the right lateral decubitus position between peristaltic contractions, using the free-trace method and including the gastric wall, as described previously. Two investigators (SDOD and JMP) independently made measurements of the antral CSA, and the area was used to estimate the gastric volume, using previously published formulae as follows[5,8]:

Formula 1: volume (ml)=27+(14.6 × right lateral CSA [cm^2]−1.28 × age])

Formula 2: volume (ml)=79.38+13.32 × right lateral CSA (cm^2).

Images were considered suitable for measurement if >80% of the outline of the gastric antrum was traceable. Images deemed unsuitable were excluded from both qualitative and quantitative analyses. The investigators were not blinded and made measurements on images in the time sequence at which the images were taken.

Patients were categorised as low risk (stomach empty using qualitative assessment or gastric volume less than 1.5 ml kg^{-1} quantitatively) or at risk (thick fluid with qualitative assessment or gastric volume greater than 1.5 ml kg^{-1} quantitatively) for aspiration.

Sample size and statistical analysis

The number of patients recruited represents a convenience sample. At the time of study design, no comparable published studies reporting gastric volumes in enterally fed patients in the ICU were found. Therefore, a sample size of 50 participants was selected based upon estimated recruitment rates and time frames for study completion. Clinical and patient variables were described with means and standard deviations for continuous variables, and frequencies with percentages for categorical variables. Median and inter-quartile range were used for non-normally distributed data. Groups were categorised as low risk (stomach empty or estimated gastric volume less than 1.5 ml kg^{-1}) or at risk (thick fluid in the stomach or greater than 1.5 ml kg^{-1} estimated gastric volume). Normally distributed data were analysed using a two-tailed paired *t*-test. Non-normally distributed data were analysed using the unpaired Wilcoxon rank-sum test. Statistical analysis used Stata software (16.1; StataCorp LLC, College Station, TX, USA).

Results

Fifty-four subjects were enrolled in this study. Images suitable for measurement were obtained in 44/54 (81%) subjects. CNS disorder (stroke, traumatic brain injury, subarachnoid haemorrhage, or encephalopathy) was the most common ICU admission diagnosis (21/54), followed by respiratory failure (pneumonia, asthma, chronic obstructive pulmonary disease, or upper airway obstruction) (17/54). The remainder had a metabolic, trauma, or cardiac cause for admission. The mean number of ventilated days was 4.9 (range: 2–17) days. Eight out of 54 (15%) patients were receiving one or more prokinetic agents (metoclopramide or erythromycin) at the time of entry into the study. Fifty-one out of 54 (94%) were receiving enteral feeds at their estimated target rate. Participant characteristics of weight, BMI and number of ventilated days were not significantly different between those where an image suitable for analysis was obtained and those where it was not. The most common reason for failure to obtain a suitable image was bowel gas obscuring the view (Table 1).

The first ultrasound examination with enteral feeds running demonstrated that 14/44 (32%) of stomachs were empty, 16/44 (36%) contained thick fluid, and 14/44 (36%) contained clear fluid. After quantitative assessment, 21/44 (48%) would be low risk (stomach empty or less than 1.5 ml kg^{-1}) and 23/44 (52%) would be at risk (stomach contained thick fluid or volume greater than 1.5 ml kg^{-1}). Images obtained, after suctioning of gastric content *via* the nasogastric tube, showed 31/44 (70.4%) stomachs to be empty and 2/44 (4.5%) contained thick fluid; after quantitative assessment, 39/44 (88.6%) and 5/44 (11.4%) were low risk or at risk, respectively. Images obtained after at least a 4 h period of fasting showed 36/44 (82%) stomachs were empty and 2/44 (4%) contained thick fluid. Therefore, 39/44 (88.6%) and 5/44 (11.4%) would be low risk or at risk, respectively (Table 2). Finally, after fasting and a final suction of the gastric tube, 2/44 (4%) of patients had thick fluid in the stomach, 2/44 (4%) had clear fluid, and the rest remained empty: 41/44 (93.2%) were low risk and 3/44 (6.8%) were at risk. In summary, 52% of patients at

Table 1 Patient characteristics.

Variable	Image obtained	No image obtained	*P*-value	All
n (%)	44 (81)	10 (19)		54
Age, mean (SD)	60.8 (13.9)	47.9 (23.8)	0.03	59.0 (16.7)
Male sex, *n* (%)				33 (61)
Weight, mean (SD) (kg)	80.1 (18.7)	79.7 (12.2)	0.96	80 (17)
BMI, mean (SD) (kg m^{-2})	27.3 (5.2)	27.4 (4.0)	0.99	27.3 (4.9)
Ventilated days (median; IQR)	4.0 (3.0–5.5)	4.0 (3.0–5.0)	0.98	4.9 (3.1)
Aspirate previous 24 h (median; IQR) (ml)	98 (35–196)	152 (116–307)	0.19	116 (25–210)
Feeds at goal rate (*n*, %)	42/44 (95)	9/10 (90)	0.35	51/55 (93)

Table 2 Patient grouping according to aspiration risk assessment. Low risk: qualitative assessment: empty stomach or quantitative assessment: <1.5 ml kg^{-1}. At risk: qualitative assessment: thick fluid or quantitative assessment: >1.5 ml kg^{-1}.

Characteristic	Baseline		Gastric tube suctioned		Period of fasting	
	Low risk	At risk	Low risk	At risk	Low risk	At risk
Qualitative						
Empty	14		31		36	
Thick fluid		16		2		2
Quantitative						
<1.5 ml kg^{-1}	7		8		3	
>1.5 ml kg^{-1}		7		3		3
Total	21/44	23/44	39/44	5/44	39/44	5/44

baseline were at risk of aspiration, which reduced to 11.4% after gastric tube suctioning. After fasting, 11.4% were at risk, which reduced to 6.8% with suctioning.

Using Formula 2, all patients identified with clear fluid in the stomach after gastric tube suction and fasting had greater than 1.5 ml kg^{-1} with quantitative assessment. Whilst there are 5/44 patients in both groups (suctioned gastric tube or fasted) that failed to achieve low aspiration risk, there was a total of nine patients that were classified as at risk on at least one occasion. After suctioning of the gastric tube on the first occasion, no patient characteristics were identified that significantly differed between those classified as at risk and those classified as low risk of aspiration (Table 3).

No patient had a documented pulmonary aspiration event or required re-intubation within 24 h of extubation.

Discussion

Ultrasound assessment of the gastric antrum is a validated technique to assess aspiration risk, as it provides information about the type and volume of gastric content. In anaesthesia, gastric ultrasound may alter clinical decision-making,[7] but its role in critical care remains uncertain.

In the present study, we used validated gastric ultrasound techniques in an intubated patient cohort in the ICU to assess aspiration risk. Patients were categorised as low risk (stomach empty qualitatively or gastric volume less than 1.5 ml kg^{-1} quantitatively) or at risk (thick fluid qualitatively or gastric volume greater than 1.5 ml kg^{-1} quantitatively) of aspiration, before and after interventions, to reduce gastric content and volume.

We found that it is possible to obtain an image deemed suitable for analysis in 44/54 (81%) of subjects in this setting. Our findings relating to the feasibility of gastric ultrasound as a tool for imaging are similar to a previous study. Comparing gastric ultrasound with CT for assessing gastric antral area in 55 patients in the ICU, image acquisition was good in 36/55 (65%), poor in 16/55 (29%), and impossible in 3/55 (6%).[9]

The most notable finding was that both suctioning gastric contents *via* a nasogastric tube and a period of fasting of at least 4 h are equivalent in achieving a low aspiration risk classification. A combination of fasting plus nasogastric tube suctioning was the most effective in ensuring a low residual volume. Whilst 5/44 patients were classified as at risk after gastric tube suctioning or fasting, a total of 9/44 patients were classified as at risk on at least one occasion. This finding suggests that risk is dynamic; some patients will become low risk with fasting either by qualitative or quantitative assessment, whilst others will change into the at-risk group. The study design, whereby patients received enteral feeds for a period (after initial suctioning of the gastric tube and before the fasting period began) may account for some patients becoming at risk over this period.

Bedside gastric ultrasound may be useful in clinical practice to identify those patients that do not achieve a low residual volume after suctioning of the gastric tube if planned to extubate before a fasting period. Furthermore, bedside gastric ultrasound may identify those that, after fasting, may benefit from additional suctioning through the nasogastric tube.

There is no wide consensus in critical care practice as to the best management of enteral feeds before planned extubation. The composition of feeds used across ICUs may vary. However, feed preparations commonly contain plant and milk protein, vegetable and fish oils, and dietary fibres. These enteral feed preparations are not clear fluids, and if considered similar to non-human milk, a 6 h fasting period would be recommended if using perioperative fasting guidelines derived from the elective anaesthesia literature.[10] The implication of following such fasting guidelines in the ICU setting is that extubation postponement or delays for several

Table 3 Characteristics of patients classified as low risk of aspiration compared with those classified as at risk of aspiration after suctioning of the gastric feeding tube.

Characteristic	Low aspiration risk	At risk of aspiration	P-value
n, (%)	39 (88.6)	5 (11.4)	-
Age, mean (Range)	61.4 (22-85 yrs)	56.4 (52-63 yrs)	0.458
Weight, mean (SD) (kg)	80.3 (19.0)	79.2 (16.0)	0.902
BMI, mean (SD) (kg m^{-2})	27.5 (5.5)	26.4 (1.8)	0.662
Ventilated days, median (IQR)	4 (3–5)	6 (4–7)	0.114
Total aspirate volume 24 h, median (IQR) (ml)	85 (30–185)	129 (120–260)	0.219
Feeds at target rate, number (%)	37/39 (95)	4/5 (80)	0.100

reasons may result in unnecessarily prolonged fasting periods.

The gastric volume considered to be associated with a high risk of aspiration in humans is uncertain. Historically, it was not possible to evaluate gastric volumes easily in a noninvasive manner. Since the recent introduction of gastric ultrasound, the literature on gastric volume and its implications for aspiration risk has increased significantly, but a threshold over which aspiration risk increases is still the subject of controversy.

Some research groups have adopted 1.5 ml kg^{-1} as a cut-off for aspiration risk, accepting that it may in fact be higher. Furthermore, some authors use residual gastric volumes as a surrogate marker of aspiration risk.[11] Accepting these limitations, we adopted a value of 1.5 ml kg^{-1} of actual body weight using a quantitative method as the volume threshold for 'at risk' of aspiration, given that this is based on human data and widely used in recent literature.

There are few previous studies that have examined the effect of fasting on gastric volumes before extubation in ICU settings. Nguyen and colleagues[12] found 26/100 (26%) were estimated to have a full stomach, defined as the presence of gastric content (qualitative) or gastric volume >1.5 ml kg^{-1} (quantitative). Fasting for greater than or less than 6 h had no effect on the number of patients assessed as having a full stomach. Ultrasound examinations were performed in a half-seated position and used a formula published by Bouvet and colleagues[13] to estimate gastric volume, which was different from our method. Ten subjects were assessed using the quantitative method, with nine classified as having an empty stomach and one as having a full stomach (>1.5 ml kg^{-1}). Further differences are that only 56/100 (56%) patients received enteral nutrition in the 48 h before assessment, and only 5/56 (9%) were receiving prokinetics. In our study, 51/54 (94%) were receiving enteral feeds at the target rate, suggesting a high degree of feed tolerance, and 8/54 (15%) were receiving one or more prokinetic agents. These differences limit direct comparisons between these two studies.

The present study has some limitations. Recruitment was much slower than anticipated. Patients were identified by a research nurse during weekday business hours; obtaining consent and availability of an investigator to perform ultrasound scans on consecutive days in addition to clinical duties were the limiting factors. The mean duration of mechanical ventilation was relatively short at 4.9 days (range: 2–17 days) but does reflect the units in which this study was conducted, which have a combined mean duration of invasive ventilation of 81 h. This may limit the generalisability of these results to patients who are ventilated for longer periods of time. The numbers of patients in the subgroups are small with only 11/44 and 6/44 patients undergoing quantitative assessment after suctioning and fasting, respectively. This likely reflects that those patients approaching extubation are less critically ill, and therefore tolerating enteral feeds. The investigators were unblinded to the time points when performing ultrasound examinations. This could bias results in that the intervention to reduce stomach volume was known to investigators. A further limitation is that all 44 subjects were assessed at the four different time points. In general, when a cohort of subjects is examined multiple times, there will be less variability found in the results compared with examining different groups of patients allocated to different strategies, and one must consider this effect on the results. No patients required re-intubation or had documented aspiration events. Given that the incidence of pulmonary aspiration events is relatively low in this setting and that most patients were extubated with a low volume of gastric content, no conclusions can be derived from this study on the relationship between gastric volume and aspiration risk.

In conclusion, the results from this preliminary observational study suggest that suctioning through the gastric feeding tube reduces gastric volume as effectively as a period of at least 4 h of fasting. A small group benefitted from both fasting and gastric tube suctioning. This study may provide good pilot data to compare these strategies in a future RCT.

Authors' contributions

Conceptualisation: SDOD.
Collection/verification of historical facts: JMP, GKFP, CMA, RER, AP, AVZ.
Drafting of article: JMP, GKFP, CMA, RER, AP, AVZ.
Writing/review of article: JMP, GKFP, CMA, RER, AP, AVZ.
Final approval of article: JMP, GKFP, CMA, RER, AP, AVZ.

Declarations of interest

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