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Ultrasound Assessment of Gastric Contents and Volume in Paediatric Surgical Patients: A Clinical Audit

Tejesh C. Anandaswamy*, Pooja and Prathima P. Thammanna

Department of Anaesthesiology, MS Ramaiah Medical College, Bengaluru – 560054, Karnataka, India; drtejeshca@yahoo.com

Abstract

Background: Perioperative pulmonary aspiration of gastric contents is a rare event in the clinical practice of paediatric anaesthesia. The volume of the gastric content is one of the predisposing factors for pulmonary aspiration. The present clinical audit aimed to detect "at-risk stomach" by ultrasound visualisation of solid gastric contents and/or by quantification of gastric volume>1.25mL/kg body weight in children scheduled for elective surgery. **Materials and Methods:** Children aged 1 to 18 years scheduled for elective surgery were subjected to preoperative gastric ultrasound examination in supine and right lateral decubitus positions after obtaining parental consent. Gastric contents were qualitatively graded and the gastric volume was quantified by a previously validated formula. Statistical analysis was done using Microsoft Excel (2013). **Results:** Fifty-one children were scheduled for elective surgery during the one month of the audit. In five children antrum could not be visualised due to excessive air and hence were excluded and 46 children were included for data analysis. None of the children had solid gastric contents. The mean calculated gastric volume was16.6±13.8 mL and the mean gastric volume/kg was 0.68±0.4 mL/kg. Three children had gastric volume >1.25mL/kg signifying "at-risk stomach". Three children had Grade 2 stomach as assessed qualitatively. **Conclusion:** Ultrasound assessment of gastric contents and residual volume is a good preoperative tool in the paediatric population to detect children at risk of pulmonary aspiration of gastric contents.

Keywords: Elective Paediatric Surgical Patients, Gastric Ultrasound, Paediatric Anaesthesia, Pulmonary Aspiration

1. Introduction

The incidence of pulmonary aspiration of gastric contents in paediatric anaesthesia ranges from 0.02% to 0.1%[1-4]. Despite being rare it can have adverse perioperative consequences requiring intensive care unit admission and ventilation. Pulmonary aspiration is more common in children presenting for emergency surgery and those with certain comorbidities. However, it can occur in healthy children presenting for elective surgery without any obvious recognisable risk factors[1,3,4]. Increased residual gastric volume is one of the contributing factors for regurgitation of gastric contents and pulmonary aspiration. Gastric ultrasound has recently emerged as a reliable point-of-care preoperative tool for the evaluation of gastric content and volume in both adults and children[5,6].

The present clinical audit aimed to assess the "at-risk stomach" in children scheduled for elective surgery during a one-month study period, as defined by the ultrasound visualisation of any solid content and/or by a calculated gastric residual volume>1.25mL/kg body weight.

*Author for correspondence

2. Materials and Methods

The present prospective observational study was conducted as an internal clinical audit after approval from the Institutional Ethics Committee. All children aged 1 to 18 years scheduled to undergo elective surgery during one month were consecutively included after obtaining parental consent. Children with a history of previous upper gastrointestinal surgery, previous upper abdominal surgery, gastrointestinal disorders (hiatal hernia, GERD, gastritis) and parental refusal were excluded from the study. All children were advised to fast as per the ASA fasting guidelines (clear fluids 2h; breast milk 4h; infant formula 6h; solids and nonhuman milk 6h; fried food, fatty food and meat 8h)[7].

All ultrasound examinations of the gastric antrum were performed by an investigator experienced in performing more than 50 gastric ultrasound examinations and were blinded to the clinical history of the patient and the duration of fasting. Ultrasound examinations were performed before induction of anaesthesia in the preoperative room in parental presence. Sedation with fentanyl 2mcg/kg intravenously was employed in children who were uncooperative for an ultrasound examination. Examinations were performed with children lying in the supine and Right Lateral Decubitus (RLD) positions using the SonoSite M-turbo machine (FUJIFILM SonoSite Inc., Bothell, Washington, USA) with a linear high-frequency 10-13 MHz or a curvilinear 2-5 MHz transducer depending on the age of the child.

The gastric antrum was identified in the epigastrium in a sagittal plane including the left lobe of the liver and aortic pulsations posteriorly as previously described[8,9]. Gastric antrum cross-sectional area was measured in both supine and right lateral decubitus positions with the free hand tool of the SonoSite machine in between peristaltic contractions. The final Cross-Sectional Area (CSA) was taken as an average of three readings. Qualitative assessment of the antral contents was done as clear, particulate, or solid depending on the ultrasonographic appearance as previously described[8]. Qualitative grading of the antrum was done as per Perlas grading[5]: Grade 0 – no fluid visible in the antrum in either the supine or RLD position; Grade 1 – antral fluid visualised only in the RLD position; Grade 2 – antral fluid visualised in both supine and RLD position. Quantitative assessment of the gastric volume was done by applying the formula as described by Spencer AO in their study for the paediatric population [Volume (mL) = -7.8 + (3.5xRLD-CSA in cm^2) + (0.127x age in months)][8]. All children who had particulate or solid content on qualitative assessment and volume>1.25mL/kg body weight were considered at risk for aspiration. The primary outcome was to find the gastric contents at risk of aspiration in children scheduled for elective surgical procedures. Statistical analysis was done using Microsoft Excel (2013).

3. Results

During the one month of audit, 51 children aged between 1 to 18 years who were scheduled for elective surgery were recruited into the study. Twelve of these children required sedation to facilitate gastric ultrasound examination. In 5 children gastric antrum could not be visualised due to air shadows and were excluded from analysis of gastric ultrasound parameters. The demographic profile and the duration of fasting are depicted in Table 1. The mean duration of fasting for clear fluids, solids and breast milk was found to be longer than what was advised to their parents and ward staff. None of the children were on infant formula and only five children were breastfed. The mean antral cross-sectional area was larger in the right lateral decubitus position (3.77±2.4 cm^2) compared to the supine position (1.95±0.8 cm^2). None of the children had solid as the antral content. Three children had gastric antrum Grade 2 and calculated gastric volume > 1.25mL/kg signifying "at-risk stomach" (Table 2). This gives an incidence of 6.5% for both Grade 2 antrum and a gastric volume of >1.25mL/kg.

Table 1. Demographic variables and fasting duration

Variable	
Age (years)*	7.02±4.5
Gender (M/F)†	37/14
Weight (kg)*	21.05±12.3
Height (cm)*	113.88±24.9
Duration of fasting (hr) Clear fluids* Solids* Breast milk*(n=5) Infant formula	 11.5±2.5 12.4±2.1 7.8±1.6 None

Data presented as * Mean±SD and † number

Table 2. Gastric ultrasound parameters

Variable (n = 46)	
Antral CSA in the supine position (cm^2)*	1.95±0.8
Antral CSA in right lateral decubitus position (cm^2)*	3.77±2.4
Qualitative grading of gastric antrum (Grade 0/Grade 1/Grade 2) †	26/17/3
Calculated gastric volume (mL)*	16.6±13.8
Gastric volume (mL/kg body weight)*	0.68±0.4

Data presented as * Mean±SD and † number

4. Discussion

Preoperative fasting aims to ensure an empty stomach to reduce the risk of pulmonary aspiration of gastric contents. The reported incidence of anaesthesia-related pulmonary aspiration in the paediatric population in various studies ranges from 0.02-0.1%[1-4]. The recent APRICOT study, a multicentre prospective observational study in children to assess the incidence of severe critical events under general anaesthesia, found the incidence of aspiration of 0.1% or 9.3 per 10000 elective or emergency procedures[2]. None of the studies have reported any mortality related to pulmonary aspiration in children. The related morbidity is most often relatively mild in the form of unanticipated hospital admission, cancellation of surgery, and intubation with or without ventilation[1,2].

The majority of the fasting guidelines advocate the so-called 6-4-2 rule. The need for a strict 2h clear fluid fast in children has been challenged by a few with the introduction of the 6-4-0 rule, wherein children are allowed to take clear fluids until they are called to the operating suite[10-12]. The study found no increase in the rate of aspiration compared to traditional fasting duration[12]. In a joint consensus statement, the Association of Paediatric Anaesthetists of Great Britain and Ireland, the European Society for Paediatric Anaesthesiology, and L'Association Des Anesthésistes-Réanimateurs Pédiatriques d'Expression Française have recommended for all children to allow clear fluids up to 1 h before elective surgery, unless a clear contraindication exists[13]. Shorter fasting duration not only improves the perioperative experience of parents and children but also results in the reduction of side effects like hypoglycaemia, dehydration, metabolic acidosis, cardiovascular instability, discomfort, hunger, thirst and irritability in children[14].

Children fasting for the prescribed duration are presumed to have an empty stomach, however, it does not guarantee any specific outcome[7]. Though pulmonary aspiration risk is known to be multifactorial, gastric residual volume remains an important risk factor. Prior information about a patient's gastric residual volume may improve decision-making and impact anaesthetic management. Gastric ultrasound has recently emerged as a very reliable tool for evaluating gastric content and volume. It is easy to learn and perform, non-invasive, reproducible, and free of ionizing radiation with good intra- and inter-rater reliability[15].

In children, a gastric residual volume of >1.25mL/kg has been suggested by various studies as the volume that may predispose to regurgitation of the gastric contents and hence in the present study similar volume has been considered to identify "at-risk stomach"[8,16,17].

The antrum may be difficult to demonstrate by ultrasound in 2-3% of adults either due to anatomical variation or due to the presence of a significant amount of gas in the stomach and nearby bowel[18,19]. In the present study in 5 children (9.8%), antrum could not be visualised due to air shadows. These children were inconsolably crying which may have led to aerophagy and may thus explain the higher rate of inconclusive ultrasound examinations.

The mean calculated gastric fluid volume in the present study (0.68±0.4 mL/kg), was similar to that reported by Spencer AO *et al.,* (0.63±0.47 mL/kg)[8]. They also reported the incidence of Grade 2 antrum

to be 9%. In the present study, the incidence of Grade 2 antrum was 6.5%. This slightly higher incidence may be due to the inclusion of children with gastrointestinal problems in their study[8]. Bouvet L *et al.,* in their study found the prevalence of "at-risk stomach" (gastric fluid volume>1.25mL/kg) in children scheduled for elective surgery as 1% (95% confidence interval: 0.2-3.9%) and Grade 2 antrum as 3%. Their study found the qualitative grading to be imprecise in discriminating between "at-risk" and "empty" stomach in children[17]. However, in the present study, all children with Grade 2 antrum had their calculated gastric volume >1.25mL/kg. Given the low incidence of a full stomach, the present study is not powered to correlate this incidence with any specific risk factors in children presenting for elective surgery.

The actual duration of preoperative fasting in the present study was much longer than that advised during the preoperative evaluation and may be a limitation. However, several studies have shown that fasting times longer than that prescribed by the existing guidelines is common in children[10,14,20-23]. The practical difficulties of ensuring that this does not happen by ensuring that every child on the elective surgery list stops taking orally at the right time is very evident for any busy paediatric anaesthetist. The reasons attributed are many, including miscommunication, organisational delays, not waking up for a morning drink, change in the surgical schedule, inaccuracy in predicting the timing of the operation during a busy schedule, and sometimes ward staff not complying with the fasting orders[20,23-25].

It is evident from various studies in literature and the present one, that a very small proportion of children presenting for elective surgery may have a full stomach as assessed by gastric ultrasound despite the recommended or sometimes even after a much-prolonged duration of fasting. Does this justify a gastric ultrasound examination in every child presenting for surgery? At present, it does not seem so. Similar to other tests, gastric ultrasound may have false positives and false negatives, which are still not clearly defined. Future research needs to better define the diagnostic value of gastric ultrasound so that it becomes a part of the preoperative assessment tool for the anesthesiologist. Until then the clinical situations wherein gastric ultrasound may be useful are emergency surgery, nonadherence to fasting guidelines, and unreliable history. It has been suggested that preoperative gastric ultrasound should be performed in patients with diabetes mellitus, obesity, chronic opioid therapy, and in those who are noncompliant with fasting instructions[26]. These conditions, except noncompliance with fasting instructions, are however not commonly encountered in children and risk factors that predispose children to increased gastric residual volume are not known. Future research to determine these risk factors may help target preoperative gastric ultrasound specifically to such paediatric populations so that its use can be most efficient.

The number of participants in the present study is too small due to the very short duration of the audit period (one month) to draw any meaningful statistical conclusion and in addition, being from a single centre may be subjected to a variety of biases. Studies with larger sample sizes involving multiple centres to access the gastric content and residual volume by ultrasound in future may help better define the role of preoperative gastric ultrasound in the paediatric population and thus influence clinical decision-making.

5. References

1. Borland LM, Sereika SM, Woelfel SK, Saitz EW, Carrillo PA, Lupin JL, *et al.* Pulmonary aspiration in pediatric patients during general anesthesia: Incidence and outcome. J Clin Anesth. 1998; 10:95-102. https://doi.org/10.1016/S0952-8180(97)00250-X
2. Habre W, Disma N, Virag K, Becke K, Hansen TG, Jöhr M, *et al.* Incidence of severe critical events in paediatric anaesthesia (APRICOT): A prospective multicentre observational study in 261 hospitals in Europe. Lancet Respir Med. 2017; 5:412-25.
3. Tan Z, Lee SY. Pulmonary aspiration under GA: A 13-year audit in a tertiary pediatric unit. Pediatr Anesth. 2016; 26:547-52. https://doi.org/10.1111/pan.12877
4. Walker RW. Pulmonary aspiration in pediatric anesthetic practice in the UK: A prospective survey of specialist pediatric centers over a one-year period. Pediatr Anesth. 2013; 23:702-11. https://doi.org/10.1111/pan.12207
5. Perlas A, Davis L, Khan M, Mitsakakis N, Chan VWS. Gastric sonography in the fasted surgical patient: A prospective descriptive study. Anesth

Analg. 2011; 113:93-7. https://doi.org/10.1213/ANE.0b013e31821b98c0
6. Schmitz A, Schmidt AR, Buehler PK, Schraner T, Frühauf M, Weiss M, *et al*. Gastric ultrasound as a preoperative bedside test for residual gastric contents volume in children. Pediatr Anesth. 2016; 26:1157-64. https://doi.org/10.1111/pan.12993
7. Practice guidelines for preoperative fasting and the use of pharmacologic agents to reduce the risk of pulmonary aspiration: Application to healthy patients undergoing elective procedures: An updated report by the American Society of Anesthesiologists Task Force on preoperative fasting and the use of pharmacologic agents to reduce the risk of pulmonary aspiration. Anesthesiol. 2017; 126:376-93. https://doi.org/10.1097/ALN.0000000000001452
8. Spencer AO, Walker AM, Yeung AK, Lardner DR, Yee K, Mulvey JM, *et al*. Ultrasound assessment of gastric volume in the fasted pediatric patient undergoing upper gastrointestinal endoscopy: Development of a predictive model using endoscopically suctioned volumes. Pediatr Anesth. 2015; 25:301-8. https://doi.org/10.1111/pan.12581
9. Schmitz A, Thomas S, Melanie F, Rabia L, Klaghofer R, Weiss M, *et al*. Ultrasonographic gastric antral area and gastric contents volume in children. Pediatr Anesth. 2012; 22:144-9. https://doi.org/10.1111/j.1460-9592.2011.03718.x
10. Brunet-Wood K, Simons M, Evasiuk A, Mazurak V, Dicken B, Ridley D, *et al*. Surgical fasting guidelines in children: Are we putting them into practice? J Pediatr Surg. 2016; 51:1298-302. https://doi.org/10.1016/j.jpedsurg.2016.04.006
11. Andersson H, Hellstrom PM, Frykholm P. Introducing the 6-4-0 fasting regimen and the incidence of prolonged preoperative fasting in children. Pediatr Anesth. 2018; 28:46-52. https://doi.org/10.1111/pan.13282
12. Andersson H, Zarén B, Frykholm P. Low incidence of pulmonary aspiration in children allowed intake of clear fluids until called to the operating suite. Paediatr Anaesth. 2015; 25:770-7. https://doi.org/10.1111/pan.12667
13. Thomas M, Morrison C, Newton R, Schindler E. Consensus statement on clear fluids fasting for elective pediatric general anesthesia. Pediatr Anesth. 2018; 28:411-14. https://doi.org/10.1111/pan.13370
14. Frykholm P, Schindler E, Sumpelmann R, Walker R, Weiss M. Preoperative fasting in children: Review of existing guidelines and recent developments. Br J Anaesth. 2018; 120:469-74. https://doi.org/10.1016/j.bja.2017.11.080
15. Kruisselbrink R, Arzola C, Endersby R, Tse C, Chan V, Perlas A. Intra- and interrater reliability of ultrasound assessment of gastric volume. Anesthesiol. 2014; 121:46-51. https://doi.org/10.1097/ALN.0000000000000193
16. Cook-Sather SD, Liacouras CA, Previte JP, Markakis DA, Schreiner MS. Gastric fluid measurement by blind aspiration in paediatric patients: a gastroscopic evaluation. Can J Anaesth. 1997; 44:168-72. https://doi.org/10.1007/BF03013006
17. Bouvet L, Bellier N, Gagey-Riegel A-C, Desgranges F-P, Chassard D, De Queiroz Siqueira M. Ultrasound assessment of the prevalence of increased gastric contents and volume in elective pediatric patients: A prospective cohort study. Pediatr Anesth. 2018; 28:906-13. https://doi.org/10.1111/pan.13472
18. Bouvet L, Mazoit J-X, Chassard D, Allaouchiche B, Boselli E, Benhamou D. Clinical assessment of the ultrasonographic measurement of antral area for estimating preoperative gastric content and volume. Anesthesiol. 2011; 114:1086-92. https://doi.org/10.1097/ALN.0b013e31820dee48
19. El-Boghdadly K, Wojcikiewicz T, Perlas A. Perioperative point-of-care gastric ultrasound. BJA Educ. 2019; 19:219-26. https://doi.org/10.1016/j.bjae.2019.03.003
20. Engelhardt T, Wilson G, Horne L, Weiss M, Schmitz A. Are you hungry? Are you thirsty? - Fasting times in elective outpatient pediatric patients. Paediatr Anaesth. 2011; 21:964-8. https://doi.org/10.1111/j.1460-9592.2011.03573.x
21. Buller Y, Sims C. Prolonged fasting of children before anaesthesia is common in private practice. Anaesth Intensive Care. 2016; 44:107-10. https://doi.org/10.1177/0310057X1604400116
22. Agegnehu W, Rukewe A, Bekele NA, Stoffel M, Nicoh M, Zeberga J. Preoperative fasting times in elective surgical patients at a referral hospital in Botswana.

Pan Afr Med J. 2016; 23:102. https://doi.org/10.11604/pamj.2016.23.102.8863

23. Beck CE, Rudolp D, Becke-Jakob K, Schindler E, Etspüler A, Trapp A, *et al*. Real fasting times and incidence of pulmonary aspiration in children: Results of a German prospective multicenter observational study. Pediatr Anesth. 2019; 29:1040-5. https://doi.org/10.1111/pan.13725
24. Schmidt AR, Buehler P, Seglias L, Stark T, Brotschi B, Renner T, *et al*. Gastric pH and residual volume after 1 and 2 h fasting time for clear fluids in children. Br J Anaesth. 2015; 114:477-82. https://doi.org/10.1093/bja/aeu399
25. Arun BG, Korula G. Preoperative fasting in children: an audit and its implications in a tertiary care hospital. J Anaesthesiol Clin Pharmacol. 2013; 29:88-91. https://doi.org/10.4103/0970-9185.105810
26. Bouvet L, Desgranges FP, Aubergy C, Boselli E, Dupont G, Allaouchiche B, *et al*. Prevalence and factors predictive of full stomach in elective and emergency surgical patients: A prospective cohort study. Br J Anaesth. 2017; 118:372-9. https://doi.org/10.1093/bja/aew462