IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 19, Issue 3 Ser.14 (March. 2020), PP 21-27
www.iosrjournals.org

Study of Time Elapse to Achieve Critical Gastric Volume by Serial Ultrasonography to Predict Risk of Pulmonary Aspiration among Adult Orthopaedic Trauma Patients- An Observational Study

Shah Pratibha Jain [1], Mukunda T[2], Nagaria Anisha[3], Sahare Kamalkishore[4]

1. *Professor, Department of Anaesthesiology and Critical Care, Pt. Jawaharlal Nehru Memorial Medical College, Raipur, Chhattisgarh.*
2. *Resident Doctor, Department of Anaesthesiology and Critical Care, Pt. Jawaharlal Nehru Memorial Medical College, Raipur, Chhattisgarh.*
3. *Assistant Professor, Department of Anaesthesiology and Critical Care, Pt. Jawaharlal Nehru Memorial Medical College, Raipur, Chhattisgarh.*
4. *Professor, Department of Anaesthesiology & Critical Care, Pt JNM Medical College, Raipur (C.G.).*

Abstract

Background: *Pulmonary aspiration of gastric contents is a dreaded perioperative complication leading to significant morbidity and mortality. Traumatised patients often have full stomach secondary to stress and pain. Incidence of pulmonary aspiration was noted in up to 38% of trauma victims who require surgery. Sequential antral USG helps in assessing rate of gastric emptying and time to achieve critical gastric volume, which helps in preventing unnecessary delay in emergent unplanned surgery.*

Aim: *To measure gastric emptying time to achieve critical gastric volume by serial ultrasonography to predict risk of pulmonary aspiration among adult orthopaedic trauma patients.*

Method*: After approval from Institutional Scientific and Ethics Committee, this prospective study was done in 75 adult orthopaedic trauma patients. Hourly serial antral USG was done and anticipated gastric volume was calculated using the mathematical formula i.e. Stomach volume (mL) = 27+14.6×CSA (cm^2) - 1.28×age(yrs). The time elapse to achieve critical gastric volume (1.5ml/kg) and rate of gastric emptying were recorded.*

Results*: Mean time to achieve critical gastric volume was 4.89±1.01 hours with a mean time of NPO to last meal prior to trauma of 1.286±0.595 hours and a mean time for 1st USG from time of trauma was 1.26±0.634 hours. Mean rate of gastric emptying was 3.325±0.456 ml/min.*

Conclusion*: Serial ultrasonography is a useful tool to assess the time elapse to achieve critical gastric volume and rate of gastric emptying in trauma patients that is helpful for better peri-operative management to reduce the risk of pulmonary aspiration, especially in unplanned emergent surgeries.*

Keywords*: Serial ultrasonography, Gastric antrum, Pulmonary aspiration, Orthopaedic trauma patients, Critical gastric volume, Gastric emptying rate.*

Date of Submission: 12-03-2020 Date of Acceptance: 27-03-2020

I. Introduction

Pulmonary aspiration is defined as the inhalation of oro-pharyngeal or gastric contents into the larynx and the respiratory tract. Mendelson elaborated on the consequences of abolished airway reflexes under anaesthesia and the resultant aspiration of gastric contents.[1] Pulmonary aspiration of gastric contents is a major anaesthesia related complication which may result in serious morbidity and mortality.[2] The severity of pulmonary aspiration is not only dependent on volume but also on the nature and pH of aspirated material. Prevention from aspiration remains the cornerstone of general anaesthesia. The complication rate ranges from 1:900 to 1:10,000.[3] The mortality following aspiration pneumonia is as high as 5% that accounts for about 9% of all anaesthesia-related deaths.[4-6]

Aspiration of solid matter can cause physical obstruction and lead to hypoxia. Aspiration of gastric fluid which is acidic in nature causes cytokine-mediated parenchymal reactions and develops chemical pneumonitis that is manifested as progressive dyspnoea, hypoxia, bronchial wheeze and patchy collapse.[7] Although current recommended fasting duration is the most relied preventive strategy for pulmonary aspiration but it can't be used as a measure of gastric volume.[8,9] To minimize the risk of perioperative pulmonary aspiration of gastric contents, the anaesthesiologist should consider the volume and caloric value of the last

ingested meal, medications administered and the level of pain associated with trauma. Even a tolerable pain can reduce gastric fundal accommodation and gastric motility.[10]

From the recent past studies, it was considered that the presence of solid particles or a volume of >1.5mL/kg of gastric content is a risk factor and lesser than this value is safe.[11] Many studies were conducted in healthy volunteers and surgical patients in recent past to study the pH, volume and nature of gastric contents in order to reduce the risk of pulmonary aspiration using various medicines & techniques which are invasive.[11-15] The first non-invasive imaging tool which was validated to provide information about the nature and volume of gastric contents at the bedside was gastric ultrasound.[2,5,11,14,16]

Though a standardised measurement of antral CSA would be able to discriminate a fasting stomach from a non-fasting one; sequential antral USG can be helpful to know the gastric emptying and thereby, the time at which critical gastric volume is achieved.

II. Material and Methods

After seeking the permission from the Institutional Scientific & Ethics Committee, CTRI registration was obtained. It was an observational and prospective cohort study conducted in Department of Anaesthesiology and Critical Care at Pt. Jawaharlal Nehru Medical College and Dr. Bhimrao Ambedkar Hospital, Raipur, Chhattisgarh. A total of 75 adult orthopaedic trauma patients aged 16-40 years, ASA grades I-II and BMI <30 Kg/m^2 who had presented to casualty and trauma centre of our hospital were included.

Study Design: Prospective observational cohort study

Study Location: This is a tertiary care teaching hospital based study done in Department of Anaesthesiology, at Dr Bhim Rao Ambedkar Hospital, Raipur, Chhattisgarh

Study Duration: April 2018 to July 2019 (1year 3months)

Sample Size: 75 patients.

Sample Size calculation: Calculated based on the prevalence of orthopaedic trauma patients in the casualty and trauma centre in Dr BRAM Hospital, Raipur (C.G) in the month of December 2017.

Total no of patients came to casualty and trauma centre = 1199

No of orthopedic trauma patients = 314

Prevalence (p) = a/b; where a = No of orthopaedic trauma patient

b =Total no of patients came to casualty and trauma centre

Sample size (n) = $4pq/L^2$

q = 1-p

L = error (desired precision)

n = 4×0.2618×0.7382/0.01 = 75

Taking prevalence in to consideration with confidence level 95% and allowable error of 10%, minimum 75 samples are required for this study.

Inclusion Criteria:

1. Aged 16 to 40 years
2. Traumatic orthopaedic injury
3. BMI <30 kg/m^2
4. ASAI&II
5. Those who had significant gastric volume at the time of 1^{st} antral USG.

Exclusion Criteria:

1. Patient refusal
2. Patients with ryles tube in situ
3. Gastroparesis
4. Autonomic disorders
5. Diabetes Mellitus
6. Pregnancy
7. Gastrointestinal diseases such as hiatus hernia, tumors.
8. Injury to abdomen & chest
9. Medication which alters gastric emptying like calcium channel blockers, anticholinergics, opioid analgesic, progesterone and prokinetic medications like metoclopramide, cisapride etc.

Procedure Methodology: All the patients were made to lie on the bed, with due care of the fractured site after obtaining a well-informed written consent. The preliminary data and vital signs such as heart rate (HR), blood

pressure (BP), respiratory rate (RR) and saturation (SpO_2) were noted. The weight of the patient was calculated using the formula given by Robito et al, i.e. weight = 0.5759 × {arm circumference (cm)} + 0.5263 × {abdominal circumference (cm)} + 1.2452 × {calf circumference (cm)} – 4.8689 × {sex (male=1, female=2)} – 32.9241; the arm circumference, abdominal circumference & calf circumference were measured using the measuring tape.[17,18]

The patients were scanned in the right lateral decubitus position (RLDP) with constant care to the fractured site using the curvilinear transducer. The antrum & gastric body were scanned by moving the probe from right to left to obtain the qualitative view of the cavity and gastric contents.[19] The antral cross-sectional area (CSA) was used for quantitative analysis evaluating the outer wall of the stomach, which was described by Bolondi and later by Perlas et al. It was done in the RLDP using two perpendicular diameters of the antrum from serosa to serosa, the longitudinal or craniocaudal (CC) & the anteroposterior (AP) diameter using the ellipse formula developed by Bolondi et al[11]; CSA = (CC×AP×π)/4 where the value of π = 3.14. After calculating the CSA, the total volume of the stomach (anticipated volume) was estimated in each patient using mathematical formula, i.e. stomach volume (mL) = 27+14.6 × CSA (cm^2) – 1.28×age (years).[20] The rate of gastric emptying was calculated by subtracting the final measured gastric volume (near to critical gastric volume) from the initial gastric volume [measured at 1^{st} USG (0^{th} hour)], divided by the time taken to achieve critical gastric volume.

Serial ultrasonography for qualitative and quantitative assessment of gastric antrum was done in RLDP, every hour in all the patients till the critical gastric volume i.e. 1.5 ml/kg was achieved. Data were collected and analysed.

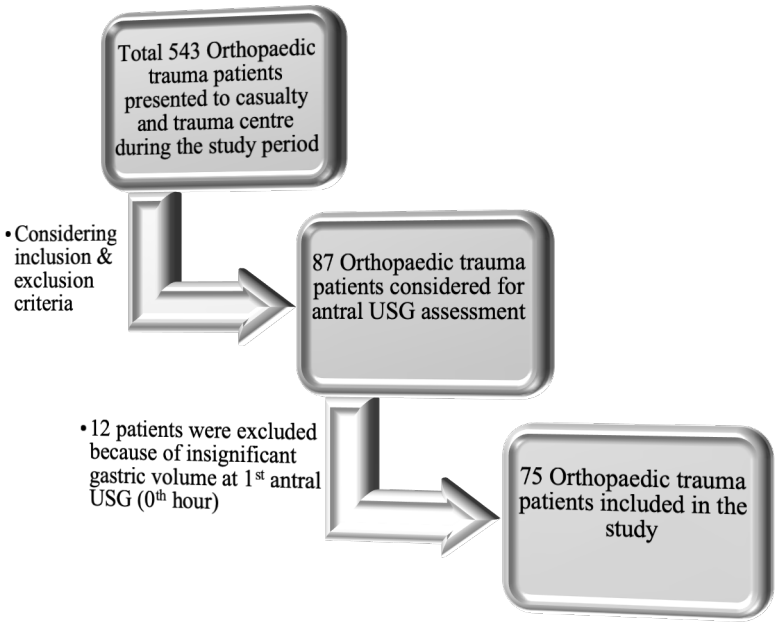
Statistical analysis

All the data were calculated with the help of Graph-Pad in stat software. The numerical data were summarized by descriptive statistics (mean and standard deviation) and categorical data was summarized in terms of percentage. p-value >0.05 was considered as not significant and p- value <0.001 and <0.05 was considered as highly significant and significant respectively.

III. Results

Among a total of 543 orthopaedic trauma patients during study period, 87 patients meeting inclusion and exclusion criteria were selected for antral USG assessment and finally 75 patients were included in the study after excluding 12 patients, who did not have significant gastric volume at initial antral sonography.

Enrolment:



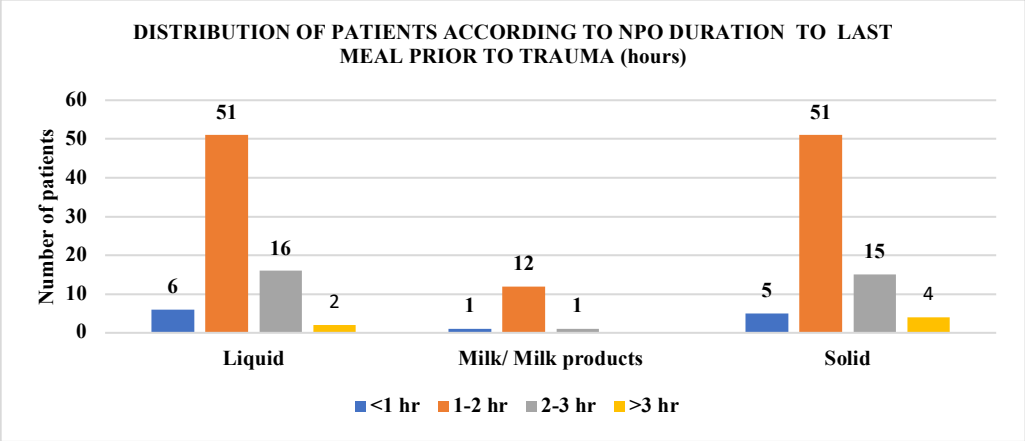
The data were analysed by descriptive statistical methods. The demographic data such as age, sex & ASA distribution, weight, height and BMI of 75 patients is depicted below in the table. (Table 1).

Table 1. Demographic profile

Age (years)	**31.73 ± 6.685**
Male: Female	**45:30**
ASA I: ASA II	**27:48**
Weight (kg)	**62.38 ± 6.78**
Height (m)	**1.66 ± 0.056**
BMI (kg/m^2)	**22.568**

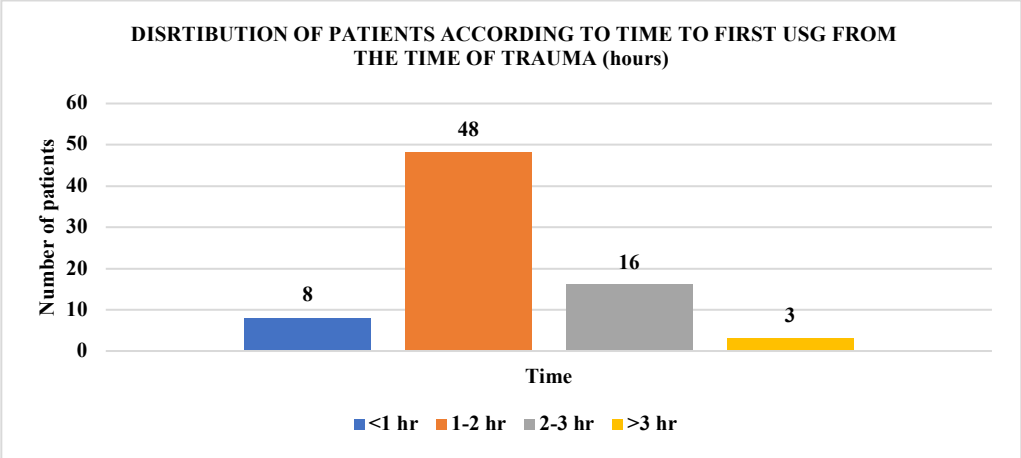
The majority of the patients were nil per oral between 1-2 hours for liquid, milk, and solids with a maximum and minimum values for NPO to liquids, milk/milk products & solids of 3 hours & 0.5 hours, 2 hours & 0.5 hours and 3 hours & 0.5 hours; respectively. (Graph 1).

Graph-1 : Distribution of patients according to NPO duration to last meal prior to trauma (hours)



The majority of the patients had their USG between 1-2 hours with maximum and minimum time elapse to USG of 4 hours and 0.5 hours, respectively. (Graph 2).

Graph-2: Distribution of patients according to time to first USG from the time of trauma (hours)



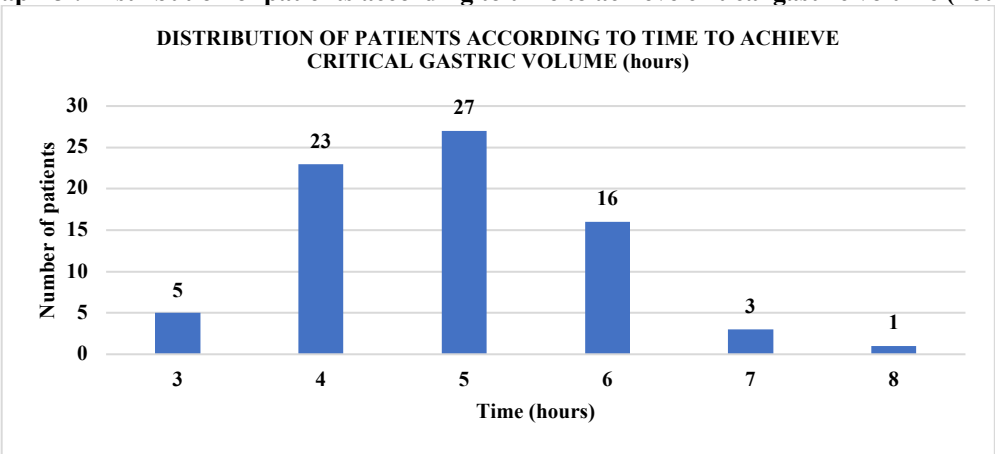
The antral cross-sectional area (CSA) and the anticipated gastric volume of the 75 patients were given in table. (Table 2).

Table 2 : Antral cross-sectional area (cm^2) and anticipated gastric volume (ml)

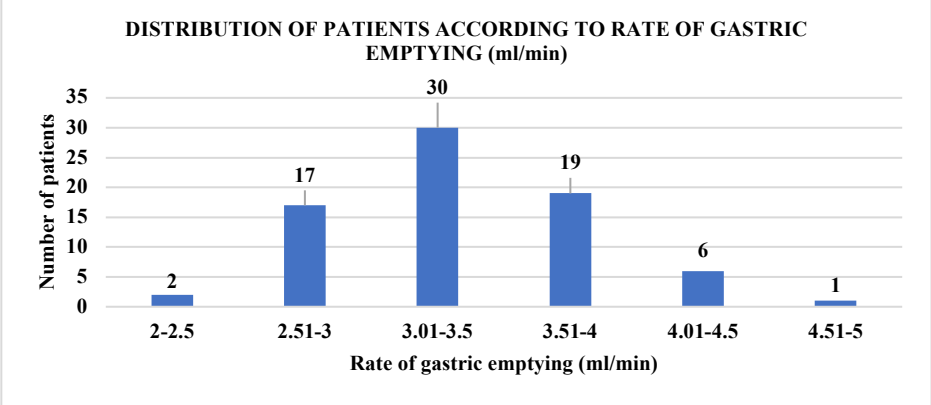
Time interval (hours)	Number of patients	Mean antral cross-sectional area (cm^2)	p-value	Mean anticipated gastric volume (ml)	p-value
0	75	18.17±3.1		247.9±45	
1	75	15.97±3.25	<0.0001	214.4±46.4	<0.0001
2	75	13.51±3.24	<0.0001	178.3±44.3	<0.0001
3	75	11.24±3.23	<0.0001	145.3±43	<0.0001
4	70	9.414±2.7	=0.0003	118±37.7	=0.0001
5	47	8.446±2.19	=0.0430	104.9±28.6	=0.0455
6	20	8.15±2.33	=0.6210	104.8±27.4	=0.9895
7	4	9.25±0.83	=0.3624	112.6±5.58	=0.5829
8	1	7±0		79.28±0	

The observed mean time to achieve critical gastric volume and the rate of gastric emptying of the 75 subjects were given in graphs. (Graph 3 & 4, respectively).

Graph-3 : Distribution of patients according to time to achieve critical gastric volume (hours)



Graph-4 : Distribution of patients according to rate of gastric emptying (ml/min)



The primary outcome was gastric emptying time to achieve critical gastric volume, which was 4.89 ± 1.01 hours and the secondary outcome was rate of gastric emptying, which was 3.325 ± 0.456 ml/min.

IV. Discussion

Trauma is very common in subtropical countries, which could be due to factors such as low socio-economic status and the low education level.[21] Orthopaedic trauma constitutes a major portion of trauma. Trauma patients often have full stomach due to decreased gastrointestinal motility secondary to stress, pain & anxiety. Trauma victims have to be considered as full stomach like any emergency case or pregnant women

undergoing caesarean section.[22] Trauma patients have impaired airway reflexes, because of either intoxication or injuries. Therefore, these patients are prone to aspiration when they nauseate or vomit, which is more likely to occur with a full stomach, which may be exaggerated with general anaesthesia and sedation due to depression of both the upper airway protective reflexes and tone of lower oesophageal sphincter.[23] Pulmonary aspiration of gastric contents was noted in up to 38% of trauma victims who require surgery.[5]

So, the present study was done in orthopaedic trauma patients to predict the risk of pulmonary aspiration through antral USG. The need of the study was to know the trend in gastric emptying and the time at which a trauma victim achieves a critical gastric volume, i.e. the volume below which the risk of aspiration is low or minimal. Therefore, by knowing the gastric emptying time, the undue delay in the surgical treatment can be avoided. To the best of our knowledge, no study has been done to study the gastric emptying rate in traumatised patients.

The higher prevalence of young males in our study could be due to food habitus and risk-taking behaviour. In India, two-thirds of road traffic injury (RTI) deaths are reported in the age group 15–44 years.[24] We had considered ASA physical status grades I-II and BMI <30 kg/m^2 as the higher ASA grades and BMI would result in false results due to impaired gastric emptying. Due to the presence of underlying medical conditions, certain patients can have significant gastric contents at the time of anaesthesia induction, despite the appropriate period of fasting intervals. As the study was conducted in orthopaedic trauma patients in the emergency department, the nil per oral status prior to trauma and the time at which they had their first USG screening following trauma varied from patient to patient and the majority of the patients had it between 1-2 hours. The mean duration of nil per oral prior to trauma and time to first USG following trauma were 1.286±0.595 hours and 1.26±0.634 hours, respectively.

In our study, the antral cross-sectional area and the anticipated gastric volume were highly significant till 4th hour ($p<0.001$), significant at 5th hour ($p<0.05$) and statistically insignificant thereafter from the time of commencement of 1st USG (0th hour) following trauma.

Few studies were conducted in labouring women to know the gastric emptying. Bataille A et al (2014)[25] had done a sonographic study to know the effect of epidural anaesthesia on gastric emptying and observed a median antral CSA of 319 mm^2 (158-469) at epidural insertion and 203 mm^2 at full cervical dilatation and the median change in antral CSA was 51 mm^2 with a median interval of 188 mins between the two measurements. ($p=2\times10^{-7}$), which suggested that the gastric motility in labour was preserved under epidural anaesthesia. Epidural anaesthesia interferes with the stress & pain associated with labour that delay the gastric emptying. These findings were statistically highly significant and comparable with our study until 4th hour from the commencement of 1st antral USG. ($p<0.001$). In the study of Zieleskiewicz L et al (2016)[26] the antral area in the supine position at 1st and 2nd ultrasound examination was 382 (315-446) mm^2 & 643 (516-758) mm^2 ($p=0.0001$) respectively. The antral area in the RLD position at 1st and 2nd ultrasound examination was 483 (303-582) mm^2 & 900 (695-1106) mm^2 respectively. ($p=0.0001$). These findings were statistically significant but not comparable with our study as they did 2nd ultrasound examination after 15 mins of giving fluids, whereas the gastric antrum was scanned hourly in our study.

None of the patients had taken more than 8 hours to achieve the critical gastric volume, the majority of them achieved it within 5 hours with a mean of 4.89 ± 1.01 hours. The difference in the time taken to achieve critical gastric volume is attributable to many factors viz. the type & quantity of food, the magnitude of stress & pain due to trauma and disproportionate gender distribution. The rate of gastric emptying varies with the type of food- fastest for fluids and slower for solids. The majority of the patients had a gastric emptying rate between 3.01-4 ml/min with a mean of 3.325 ± 0.456 ml/min.

The mean time to achieve critical gastric volume was 4.89 ± 1.01 hours with a mean time of NPO to last meal of 1.286 ± 0.595 hours and a mean time for 1st USG from time of trauma of 1.26 ± 0.634 hours. So, from these figures, it is of the inference that the time required to achieve the critical gastric volume is more than six hours which is considered as a safe time limit of fasting for solids. However, gastric emptying prior to trauma in these trauma victims was unknown, so one has to explore that and it is one of the limitations of our study.

Limitations & Future Scope: Our study had a few limitations viz.The type and quantity of the food were not taken into consideration as they varied from patient to patient, the time elapsed from the time of food intake to time of trauma and time elapse for the first USG scan from the time of trauma varied, gender distribution was not equal, the patients were not monitored up to grade 0 antrum and Subsequently, the incidence of pulmonary aspiration was not monitored; these factors might have influenced the results.

In future, the study can be extended in various aspects such as: A large sample size to validate the results, antral USG at 15 min interval or frequently to know the exact time to achieve critical gastric volume, gastric emptying of different types of food, time taken to reach grade 0 antrum and study can be extended up to perioperative period to correlate the anticipated gastric volume and incidence of perioperative pulmonary aspiration (supported by radiological imaging).

V. Conclusion

It can be concluded that besides the qualitative and quantitative ultrasonic assessment of gastric contents, serial ultrasonography is a useful tool to assess the time elapsed to achieve critical gastric volume and rate of gastric emptying in trauma patients that will be helpful for better peri-operative management to reduce the risk of pulmonary aspiration, especially in unplanned emergent surgeries.

Financial support and sponsorship- Nil

Conflicts of interest- There are no conflicts of interest.

References

[1]. Mendelson CL. The aspiration of stomach contents into the lungs during obstetric anaesthesia. Am I Obs Gynaecol 1946; 52: 191-205.
[2]. Perlas A, Mitsakakis N, Liu L, Cino M, Haldipur N, Davis L et al. Validation of a mathematical model for ultrasound assessment of gastric volume by gastroscopic examination. Anaesth Analg 2013; 116: 357–63.
[3]. Robinson M, Davidson A. Aspiration under anaesthesia: risk assessment and decision-making. Cont Edu Anaesth, Crit Care & Pain 2014; 14(4): 171-5.
[4]. Cubillos J, Tse C, Chan VWS, Perlas A. Bedside ultrasound assessment of gastric content: an observational study: J Can Anaesth/Can J Anaesth 2012; 59: 416–23.
[5]. Perlas A, Davis L, Khan M, Mitsakakis N, Chan VWS. Gastric sonography in the fasted surgical patient: a prospective descriptive study. Anaesth Analg 2011; 113: 93– 7.
[6]. Putte PVD, Perlas A. Ultrasound assessment of gastric content and volume. BJA 2014; 113(1): 12–22.
[7]. Chestnut DH, Wong CA, Tsen LC, NganKee WD, Beilin Y, Mhyre JM. Obstetric anaesthesia: principles and practice, 5th ed. Elsevier Saunders 2014; 665-78.
[8]. Song IK, Kim HJ, Lee JH, Kim EH, Kim JT, Kim HS. Ultrasound assessment of gastric volume in children after drinking carbohydrate-containing fluids. BJA 2016; 116(4): 513–7.
[9]. Dupont G, Gavor J, Lambert J, Tsekouras N, Barbe N, Presles E et al. Ultrasonographic gastric volume before unplanned surgery. The Asso of Anaesth of Great Britain and Ireland 2017; 72: 1112-16.
[10]. Hasuo H, Kusunoki H, Kanbara K, Abe T, Yunoki N, Haruma K et al. Tolerable pain reduces gastric fundal accommodation and gastric motility in healthy subjects: a crossover ultrasonographic study. Bio Psy Soc Med 2017; 11: 4.
[11]. Bisinotto FMB, Pansani PL, Silveira LAMD, Naves ADA, Peixoto ACA, Lima HMD et al. Qualitative and quantitative ultrasound assessment of gastric content. Rev Assoc Med Bras 2017; 63(2): 134-41.
[12]. Andersen J, Naesdal J, Strom M. Identical 24-hour gastric pH profiles when using intragastric antimony or glass electrodes or aspirated gastric juice. Scand J Gastroenterology 1988; 23: 375-9.
[13]. Bonten MJM, Gaillard CA, Stockbrigger RW, Tiel FHV, Geest SVD, Stobberingh EE. Assessment of gastric acidity in intensive care patients: intermittent pH registration cannot replace continuous pH monitoring. Int Care Med 1996; 22: 220-5.
[14]. Bouvet L, Mazoit JX, Chassard D, Allaouchiche B, Bosellie, Benhamou D. Clinical assessment of the ultrasonographic measurement of antral area for estimating pre-operative gastric content and volume. Anaesth 2011; 114: 1086–92.
[15]. More DG, Boutagy J, Shenfield GM. pH testing paper for measurement of intragastric acidity: an assessment. Anaesth Int Care 1983; 11: 147-50.
[16]. Perlas A, Chan VW, Lupu CM, Mitsakakis N, Hanbidge A. Ultrasound assessment of gastric content and volume. Anaesth 2009; 111(1): 82-9.
[17]. Estela IR, Gabriela BV, Vivian MMS, Laercio LCN, Julio SM: Weight and height prediction in immobilised patients. Rev Nutr Campinas 2006; 19(6): 655-61.
[18]. Melo APF, Salles RK de, Vieira FGK, Ferreira MG. Methods for estimating body weight and height in hospitalized adults: a comparative analysis. Rev Bras Cin Des Hum 2014; 16(4): 475-84.
[19]. Alakkad H, Kruisselbrink R, Chin JK, Niazi AU, Abbas S, Chan VWS et al. Point-of care ultrasound defines gastric content and changes the anaesthetic management of elective surgical patients who have not followed fasting instructions: a prospective case series. Can J Anaesth/J Can Anaesth 2015; 62: 1188–9.
[20]. Arzola C, Perlas A, Siddiqui NT, Carvalho JCA. Bedside gastric ultrasonography in term pregnant women before elective caesarean delivery: a prospective cohort study. Anesth Analg 2015; 121: 752–8.
[21]. Sami A, Moafian G, Najafi A, Aghabeigi MR, Yamini N et al. Educational level and age as contributing factors to road traffic accidents.Chin J Traumatol. 2013; 16(5): 281-5.
[22]. Ivashkov Y, Bhananker SM. Perioperative management of paediatric trauma patients. Int J Crit Ill n Inj Sci. 2012; 2(3): 143–148.
[23]. Yeung L, Miraflor E, Strumwasser A, Sadeghi P, Victorino GP. Does gastric volume in trauma patients identify a population at risk for developing pneumonia and poor outcomes? J Surg Res 2012; 178: 874-8.
[24]. Pal R, Ghosh A, Kumar R, Galwankar S, Paul SK, Pal S et al. Public health crisis of road traffic accidents in India: Risk factor assessment and recommendations on prevention on the behalf of the Academy of Family Physicians of India. J Family Med Prim Care 2019; 8: 775-83.
[25]. Bataille A, Rousset J, Marret E, Bonnet F. Ultrasonographic evaluation of gastric content during labour under epidural analgesia: a prospective cohort study. BJA 2014; 112(4): 703-7.
[26]. Zieleskiewicz L, Boghossian MC, Delmas AC et al. Ultrasonographic measurement of antral area for estimating gastric fluid volume in parturients. BJA 2016; 117(2): 198–20.

Shah Pratibha Jain, et al. "Study of Time Elapse to Achieve Critical Gastric Volume by Serial Ultrasonography to Predict Risk of Pulmonary Aspiration Among Adult Orthopaedic Trauma Patients- An Observational Study." *IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)*, 19(3), 2020, pp. 21-27.