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Impact of Bedside Gastric Ultrasonography in the Daily Routine of Anesthesiology: An Observational Study

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ABSTRACT

Background: *Pulmonary aspiration is a serious complication of anesthesia. For prevention, fasting guidelines have been made, but they do not apply to acute patients or patients with certain conditions. In addition to known prevention, gastric ultrasonography is believed to help to quantify the amount of gastric content and predict the risk for pulmonary aspiration. In this study, changes in anesthesia procedure after gastric ultrasound were investigated.*

Aims: *To investigate if the use of preoperative gastric ultrasound in the normal daily routine has consequences for how we anesthetise our patients. To contribute to creating recommendations for indications of gastric ultrasound.*

Methods: *In an observational study 96 pre- and postoperative patients were gastric ultrasound scanned in order to evaluate their gastric content before urgent and elective surgery and before transfer from the Recovery Unit to the General Ward. On a standardised sheet, the amount and texture of the gastric content was registered and the risk for pulmonary aspiration was predicted. Every change in anesthesia strategy was documented.*

Results: *The examination found 16 patients (18%) with an amount of gastric content corresponding to a high risk of pulmonary aspiration even in elective, non-risk patients. The anesthetic management for 23 patients (25%) was changed after gastric ultrasound. None of the investigated patients had pulmonary aspiration.*

Conclusion: *Gastric ultrasound may be a valuable tool to help to investigate aspiration risk in order to plan the best anesthetic management for every patient.*

Keywords

Ultrasonography, Respiratory Aspiration Gastric Contents, Fasting, Anesthesia, General, Safety Management.

Introduction

Pulmonary aspiration is defined as “the inspiratory sucking into the airways of fluid or foreign body, as of vomitus” [1]. To prevent perioperative pulmonary aspiration, the European Society of Anesthesiology (ESA) has provided perioperative fasting guidelines for healthy, elective, adult patients, which recommend not to eat solid food less than six hours before surgery and not to drink clear fluids less than two hours before surgery [2]. However, these guidelines cannot be used for acute patients or patients with certain conditions such as gastric retention or sub-ileus.

The incidence of pulmonary aspiration of gastric content during anesthesia oscillates between 0.0029% and 0.005% [3-5]. Kozlow et al. described a prevalence of up to 19.1% for pulmonary aspiration after surgical procedure [6]. The large range in incidences is due to a lack of a uniform definition, differences in different populations and no specific or sensitive test for pulmonary aspiration [7]. Aspiration of acidic, bacterial and particle content from the stomach to the lungs can lead to cyanosis, arrhythmia, shock, pneumonia, pneumonitis, adult respiratory distress syndrome (ARDS) and ultimately death. The findings of van de Putte et al. indicate that perioperative pulmonary aspiration is involved in up to 9% of all anesthesia related deaths [8]. Olsson et al. described a mortality of 0.2 per 10,000 anesthetics due to aspiration during anesthesia [5]. Sakai et al. described a mortality of 1 per 99,441 after perioperative pulmonary aspiration [7].

Risk factors that contribute to pulmonary aspiration are a full stomach, intraabdominal pathology (intestinal obstruction, inflammation, and gastric paresis), oesophageal disease (symptomatic reflux, motility disorders, neuromuscular disorders and sphincter disorders), hiatus hernia, pregnancy, obesity, trauma, drug intake and uncertainty about intake of food or drink [9-11]. Furthermore, endotracheal intubation, laparoscopic operation, relaxation of the lower oesophageal sphincter and upper airway reflexes increase the risk of pulmonary aspiration. A well-placed nasogastric tube can be used to reduce the volume of gastric contents and is indicated in patients with gastrointestinal obstruction [10]. It is however not recommended as a standard practice [11]. Rapid-Sequence-Induction (RSI) is also used to reduce the likelihood of perioperative pulmonary aspiration [10]. Medical pre-treatment to enhance gastrointestinal motility can also be used, but is only recommended in patients with particular conditions [11]. Endotracheal intubation is the most used procedure to prevent pulmonary aspiration.

Ultrasound examination is a non-invasive tool which has received an increasing amount of attention in the modern point-of-care patient examinations. Gastric ultrasonography (GUS) is a rather new method to quantify gastric content in order to envisage the risk of pulmonary aspiration. With GUS it is possible to differentiate between clear fluid and solid content. Furthermore, it is possible via a formula to estimate an almost exact volume of gastric residual volume. Afterwards the actual gastric volume can be compared to the basic gastric secretion. As GUS is a new method, a few case reports have been published, but only few studies on the use of GUS in the daily routine can be found [12-14].

The aims of this study were: 1) To investigate if the use of preoperative GUS in the normal daily routine has consequences for how we anesthetise our patients. 2) To contribute to creating recommendations for indications of GUS.

Material and Methods

This was an observational study of preoperative and postoperative patients who were scanned in order to evaluate their gastric content before urgent and elective surgery and before transfer from the Recovery Unit to the General Ward if the patients were considered to be at higher than basic risk of aspiration. Data were collected continuously prospective and analysed retrospectively at the end of all observations.

The aim of the project was to reflect the use of GUS in a hospital setting in the normal daily routine, so apart from kids, pregnant patients or morbidly obese patients, all patients could be included in the study. Two senior anesthesiologists had a special interest in preventing pulmonary aspiration with the use of ultrasonography and started to scan patients consecutively from 2017 to 2019 and documented their findings for later research. The study took place in a hospital with 14,498 anesthesias in 2018.

We used the ultrasound devices SonoSite X-Porte with the probe C60xp and SonoSite M-Turbo with the probe C60xi from FUJIFILM SonoSite, Bothell, Washington.

The physician who scanned 79% of the participants, supervised the remaining 21%, and was responsible for a possible change in anesthetic management, was a senior anesthesiologist, who was trained in ultrasound and had access to discuss findings with a radiographer with speciality in ultrasonography at the same hospital.

We used a standardised gastric ultrasound report form to gather all relevant information about the patients including date, time, age, weight, gender, planned procedure, planned anesthesia, aspiration risk factors, fasting status, ultrasonic landmarks, gastric content type, antral area, estimated volume, graduation and comments [15].

We scanned the patients in the right lateral decubitus (RLD) position (Figure 1d), identified ultrasonic landmarks such as the liver (Figure 1) and measured the cross-sectional area of the antrum (CSA) from serosa to serosa with the antrum at rest between peristaltic contractions in order to estimate the gastric volume via the model: "Gastric volume in ml = 27.0 + 14.6 x right-lateral CSA – 1.28 x age" [16]. Afterwards the results were compared to the baseline gastric secretion of 1.5ml/kg and graded 0-2 in order to predict the pulmonary aspiration risk, Grade 0-1 predicting low risk for pulmonary aspiration and Grade 2 predicting high risk [16]. We did exclusively scan the patients in the RLD position, because the CSA in the RLD position was needed to estimate gastric volume with the above shown model and Perlas et al. suggested that particularly gastric volume measured in the RLD position correlates well with the CSA [8].

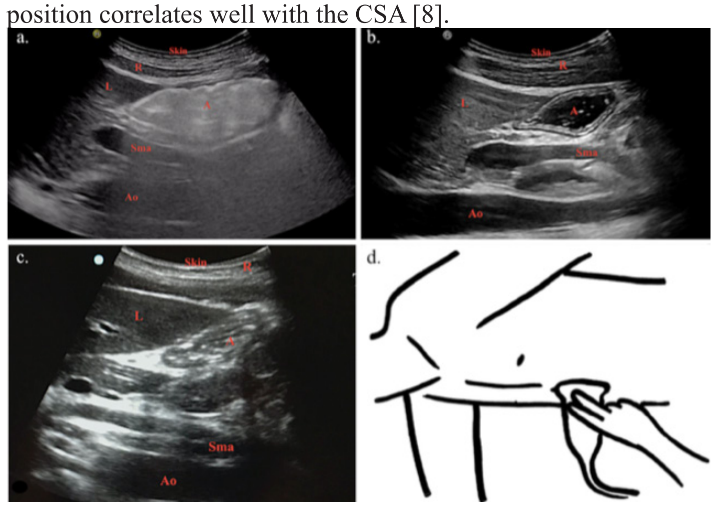

Figure 1: Gastric ultrasonography of an early solid stage stomach (a), fluid filled stomach with air bubbles (b), empty stomach (c) and a schematic illustration of the right lateral decubitus scanning position on a patient (d). A: Antrum; Ao: Aorta; L: Liver; R: Rectus abdominal muscle; Sma: Superior mesenteric artery.

We used the above model from Perlas et al. due to its accuracy in non-pregnant adults with a body mass index (BMI) under 40 kg/m^2. Its mean difference is stated to be 6 ml between the predicted and measured gastric volumes. It is easy to use, requires only the patient's age and predicts volumes up to 500 ml [16]. Our results were registered in an electronic database (SurveyXact) [17].

Analyses

The data were analysed with descriptive statistics and presented as n/% or mean/range according to the data.

Ethics

According to Danish law, the study did not need (and therefore could not obtain) approval from the Regional Committee on Health Research Ethics for Southern Denmark. A waiver for patient consent was obtained from the Directorship of Lillebaelt Hospital, University Hospital of Southern Denmark, and the study was registered with the Danish Data Protection Agency.

Results

Table 1 presents patient characteristics of the overall population and is subdivided into Grade 0-2. A total of 96 patients were GUS scanned. Five patients were excluded due to inclusive GUS results. The majority (64%) were scanned before abdominal surgery. Furthermore, 51% were scanned before elective surgery. The majority of the patients (79%) were fasting. In most of the examinations, antrum and regional landmarks were visualised (>95%).

Table 2 presents all the consequences of GUS, corresponding to each grade. In 25% of all anesthesias, the anesthetic management was changed after GUS and 6% received a nasogastric tube as a response to GUS.

A total of 16 patients (18%) of the investigated population had solid gastric content or a clear fluid volume that exceeded baseline gastric secretion, thus grading them as Grade 2 and suggesting a high risk of pulmonary aspiration. In a total of 63% these cases the anesthetic management changed.

A total of 24 patients (26%) were graded as Grade 1 and thus had clear gastric fluid, which did not exceed baseline gastric secretion. The consequences of those findings were a change in anesthetic management in 42%.

		Total		**Grade 0[1]**		**Grade 1[1]**		**Grade 2[1]**	
		n=91[2]		**n=51[2]**		**n=24[2]**		**n=16[2]**	
Age (mean/SD)		65	16	66	14	63	16	64	22
Gender (male; (n/%)		44	(48)	26	(51)	10	(42)	8	(50)
Weight, kg (mean/SD)		75	19	71	19	81	20	74	18
Surgery procedure (n/%)	Abdominal surgery	58	(64)	39	(76)	11	(46)	10	(62,5)
	Other	26	(29)	8	(16)	10	(42)	6	(37,5)
Procedure (n/%)	Acute	23	(25)	15	(29)	13	(54)	7	(44)
	Elective	46	(51)	35	(69)	5	(21)	6	(38)
Anesthesia (n/%)	Acute RSI[1]	24	(26)	5	(10)	7	(29)	12	(75)
	Elective	55	(60)	43	(84)	12	(50)	0	
Fasting (n/%)	Yes	72	(79)	49	(96)	15	(63)	8	(50)
	No	17	(19)	2	(4)	7	(29)	8	(50)
Antrum defined (n/%)	Yes	86	(95)	47	(92)	24	(100)	15	(94)
	No	3	(3)	2	(4)	0		1	(6)
Regional landmarks (n/%)	Liver	87	(96)	47	(92)	24	(100)	16	(100)
	Other	50	(55)	33	(65)	9	(38)	8	(50)
Gastric content (n/%)	Empty	51	(56)	51	(100)	0		0	
	Clear fluid	35	(38)	0		24	(100)	11	(69)
	Solid	5	(6)	0		0		5	(31)
	Est. volume clear fluid ml (mean/SD)	114	100	0		72	40	206	131
Graduation (n/%)	0	51	(56)	51	(100)	0		0	
	1	24	(26)	0		24	(100)	0	
	2	16	(18)	0		0		16	(100)
Nasogastric tube after GUS1 (n/%)		5	(6)	0		1	(4)	4	(25)
Change in anesthetic management (n/%)		23	(25)	3	(6)	10	(42)	10	(63)

Table 1: Patient characteristics.

[1]Grade 0: No gastric content detected when gastric ultrasound scanning. Grade 1: Gastric fluid which did not exceed baseline gastric secretion detected by gastric ultrasound. Grade 2: Solid gastric content or a clear fluid volume that exceeds baseline gastric secretion detected by gastric ultrasound. RSI: Rapid-Sequence-Induction. GUS: Gastric ultrasonography.

[2]Different n for the specific variables due to missing data.

	Grade 0[1]	Grade 1[1]	Grade 2[1]
	n=51	n=24	n=16
No change in anesthetic management (n)	48	14	6
Change in anesthetic management (n)	3	10	10
Airway management by another of the team	2		1
Nasogastric tube		1	4
No nasogastric tube		1	
Elective to RSI[1]		1	2
Elective to cRSI[1]		1	
RSI to cRSI	1	2	1
RSI to elective		3	
Delay of the operation			1
Change of patient position			1
No intubation despite GCS[1] 3		1	

Table 2: Change in anesthetic management as a response of gastric ultrasonography.

[1]Grade 0: No gastric content detected when gastric ultrasound scanning. Grade 1: Gastric fluid which did not exceed baseline gastric secretion detected by gastric ultrasound. Grade 2: Solid gastric content or a clear fluid volume that exceeds baseline gastric secretion detected by gastric ultrasound. RSI: Rapid-Sequence-Induction. cRSI: controlled RSI with gentle facemask ventilation. GCS: Glasgow Coma Scale.

A total of 51 patients (56%) were graded as Grade 0 and thus had no gastric fluids detected on GUS and were defined as low pulmonary aspiration risk.

The consequences of those findings were a change in airway management in two cases and a change in induction strategy in one case. The anesthetic management of 6% of these cases changed. In a total of five cases, the patients had a RSI or cRSI (controlled RSI with gentle facemask ventilation) even though they had an empty stomach. In the very beginning of the study, the anesthesia team had to trust their findings with regards to GUS and were restrained to change airway management drastically in acute patients.

This project resulted also in a more secure feeling of the anesthesia team and thus creating more learning opportunities for junior physicians or anesthesiology nurses to intubate safely in a situation with low pulmonary aspiration risk.

Furthermore, the change from a RSI to an elective induction could retain the cardio-pulmonary stability of the most vulnerable patients.

Discussion

To our knowledge, our study is one of few to present the impact of GUS on daily routine: how GUS changes planned anesthetic management, triggers precautions and contributes to a greater feeling of safety among the anesthesiology team.

Koenig et al. described an incidence of 16% patients prior to urgent endotracheal intubation who had sufficient gastric fluid (200-1000 ml) to justify gastric tube insertion [13]. Ohashi et al. described an incidence of 2.7% for gastric residual volume >1.5ml/kg using bedside GUS in a population of 222 fasting patients before non-emergency surgery [18].

We found an incidence of 16/91 (18%) in high risk for pulmonary aspiration grading them Grade 2 in our study.

In the study of van de Putte el al. about the use of GUS in elective surgical patients, non-compliant to fasting guidelines they described a change in aspiration risk stratification and anesthetic management in 24/37 (64,9%) patients and in 13,5% of the cases, the anesthetic technique was modified [14]. Alakkad et al. described a change in timing and/or the anesthetic technique in 27/38 (71%) of cases in a similar population [12].

In our study the anesthetic management for 23 patients (25%) was changed after GUS. None in the investigated population had pulmonary aspiration during the operation or after being transferred to the General Ward from the Recovery Unit.

Preventing only one patient from pulmonary aspiration would possibly have a great advantage for this single patient, considering the severe complications of pulmonary aspiration. It could furthermore shorten the patient's hospital stay, and in that way lower the costs for society. Another possible advantage of GUS is the possibility to determine if a patient is fasting or not and thereby to streamline the surgery schedule. In our study GUS made it possible to delegate inductions from senior anesthesiologists to anesthesiology nurses or junior physicians with the purpose of training.

To GUS scan every patient before surgery seems impossible; however, even so we found two fasting patients without pulmonary aspiration risk factors with Grade 2 gastric content and thus at high risk for pulmonary aspiration. Thus, it is important to create recommendations for indications of GUS to scan the most vulnerable patients. Van de Putte and Perlas have suggested indications for GUS on their homepage gastricultrasound.org e.g. the known risk factors such as diabetes, pregnancy or neuromuscular disorders, but also language barriers, severe kidney or liver dysfunction or miscommunication [15].

Challenges we face with GUS are abnormal gastric anatomy (e.g. gastric bypass), a significant amount of air in the intestines that camouflages the ultrasound picture, as well as obese patients with a great distance between skin and the stomach. In our study, five patients were excluded due to excessive subcutaneous fat, air in colon and an excessively solid filled colon.

A GUS examination takes only a couple of minutes for a trained physician. It only took the senior anesthesiologist in our study approximately five minutes to scan and evaluate one patient. Arzola et al. conclude that it takes 33 examinations to achieve a 95% success rate in bedside GUS for an anesthesiologist with appropriate training and supervision [19].

The largest limitation of this study is the design. Being an observational study with no inclusion criteria apart from the considerations of a senior anesthesiologist, we are only able to show that GUS has made a difference in handling 23 of our patients.

That the same anesthesiologist selected and scanned the patient and afterwards decided whether to change the anesthetic management or not might possibly have led to bias. Furthermore, the fact that the anesthesia team in the beginning of the study was restrained to change anesthetic management as a response of their GUS findings is a possible limitation of the study. The study included only 91 patients in two years in a hospital with approximately 14,000 anesthesias annually. This was partly due to the GUS being conducted by only a few anesthesiologists and the composition of all anesthesias. The main part of these anesthesias were elective and with overall healthy patients. Only a minor part was urgent or with patients considered to be at higher risk of pulmonary aspiration. Only approximately 300 of all anesthesias were in relation to abdominal surgery.

Conclusion

GUS can visualise the nature of gastric content and quantify it to predict the risk of pulmonary aspiration. In this study, the use of GUS contributed to a substantial change in anesthesia management, including airway management. This study also shows that even if the patients have been fasting according to the current recommendations and do not present any pulmonary aspiration risk factors, GUS can find gastric content corresponding to Grade 2 with high risk of pulmonary aspiration, complicating clear indications for GUS to decrease the risk for pulmonary aspiration, and this study thus cannot contribute to further recommendations. Furthermore, GUS is a tool to help the anesthesiologist to decide which anesthetic management is the safest, but the decision has to be made based on a total assessment.

In ten cases the anesthesiology team described feeling more secure during airway management, knowing the patient had low pulmonary aspiration risk.

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