Original Article

Volume and pH of Gastric Contents in Patients Undergoing Gynecologic Laparoscopic Surgery during Emergence from General Anesthesia: A Prospective Observational Study

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Objective: To find out the volumes and pH values of the digestive contents during emergence in patients undergoing elective gynecologic laparoscopic surgery under general anesthesia.

Materials and Methods: One hundred patients scheduled for surgery under general balanced anesthesia with standard monitoring were allocated in the present study. Gastric volumes greater than 0.4 mL/kg and pH of less than 2.5 were set as cut-off points to establish the risk of aspirated pneumonitis. Prior to insufflation of CO_2 gas into the participants' abdominal cavity and placing them in lithotomy or Trendelenburg position, anesthetists inserted an orogastric tube to deflate the patients' stomach. Then gastric volumes and pH values were measured at hourly intervals through the operation.

Results: Eighty-nine participants completed the study. The pH and gastric volumes of high-risk and non-high-risk groups showed statistically significant differences ($p<0.001$), as 1.1±0.4 and 1.1±0.8 mL/kg, and 2.8±2.2 and 0.3±0.4 mL/kg, respectively. Though their ages ($p=0.047$), body mass index (BMI) ($p=0.015$), and pre-medication drugs ($p<0.001$) showed significant differences, they were not apparent in the pre-fluid loading, fasting, and surgical time.

Conclusion: During emergence from general anesthesia, 65.2% of the patients undergoing gynecologic laparoscopic surgery were exposed to a high risk of aspirated pneumonitis. The present study showed significant association with age, BMI, and pre-medication drugs. Investigators suggested that patients with a BMI greater than 25 kg/m^2, administering H_2 receptor antagonist or a proton pump inhibitor as premedication, and having gastric content drainage prior to endotracheal tube extubation should have a low risk of pulmonary aspiration.

Keywords: Anesthesia, Gynecology, Gastric content, Laparoscopic surgery

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By and large, gastric contents compare of hydrochloric acid, potassium, and sodium chloride, form a digestive fluid in the stomach with concentrations of 140 to 160 mEq/L and a pH of 1.5 to 3.5[(1)]. The fluid digests all foodstuffs before passing through the intestinal tract. However, the regurgitation of stomach contents, with a pH lower than 2.5 and a volume greater than 0.4 mL/kg, across the lower respiratory tract can cause inflammation of the lung tissue, known as aspirated pneumonitis or Mendelson's syndrome[(2)].

Aspiration pneumonitis can occur at every stage of general anesthesia because anesthetized patients are unable to protect themselves. The situation is aggravated by increased gastric volumes and intragastric pressures, as well as decreased gastric pH values, including full stomach, delayed gastric emptying time, incompetent lower-esophageal sphincter tone, laparoscopy surgery, and patients in lithotomy or Trendelenburg position[(3)].

Thus, gastric contents dictate the severity of this detrimental event. A previous study showed an incidence of 1:900 to 1:10,000, particularly during induction (20%) and emergence (80%) of anesthesia[(4,5)]. Since patients undergoing gynecologic laparoscopic surgery, with and without premedication, are prone to gastric regurgitation, investigators would

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like to find out the volumes and pH values of digestive contents in these patients during emergence from elective, general anesthesia.

Materials and Methods

The present study was a prospective observational study approved by the Siriraj Institutional Review Board (Si-IRB), Certificate of Approval (COA): Si437/2018 and verified by ClinicalTrial.gov NCT03672734. Written informed consents were obtained from all subjects. The study was conducted at the Department of Obstetrics and Gynecology, Siriraj Hospital. The sample size was calculated from a previous observational in 10 cases as follows, standard deviation of gastric volume was equal to 24 mL and 95% confidence level with allowable error of 5 mL, then the sample size to achieve the objective was 89 (estimation for single mean)[6].

After the 10% drop-out was added, 100 patients undergoing general anesthesia for elective gynecologic laparoscopic surgery were enrolled in the study between September and December 2018. Inclusion criteria were patients aged 18 to 65, body mass index (BMI) of less than 30 kg/m^2 and American association of Anesthesiologist (ASA) classification I-II. The exclusion criterion was patients with a high risk of full stomach. Withdrawal or termination criteria were the difficulty of orogastric (OG) tube insertion and the turning of laparoscopic surgery to exploratory laparotomy.

Before the day of surgery, the project was explained in detail to all participants, particularly the insertion of the OG tube during general anesthesia. As a routine practice, premedication with omeprazole or ranitidine, or both, were freely allowed for prescription.

In the operating theatre, patients were monitored with standard anesthesia care, including non-invasive blood pressure (IBP), electrocardiography (EKG), percutaneous oxygen saturation (SpO_2), pulse rate (R), and end tidal carbon dioxide ($ETCO_2$). An anesthesiologist administered 6 LPM of oxygen for preoxygenation. Fentanyl 1 to 2 mcg/kg or morphine 0.1 to 0.2 mg/kg after propofol 1.5 to 2.5 mg/kg was given intravenously for induction. Then cisatracurium 1 to 1.5 mg/kg or atracurium 0.6 mg/kg was dispensed for intubation, and maintenance of anesthesia with sevoflurane in air and oxygen.

Prior to the surgical procedure, a no.16 OG tube was inserted. The appropriate length of the tube was determined by the distance from the epigastrium to the tragus of an ear and the angle of the mouth. A co-researcher confirmed the gastric gurgling sound with a stethoscope. In addition, the gastric contents were drawn for volumes and pH values at hourly intervals through the surgery.

Statistical analysis

Data were expressed as percentage, mean and standard deviation. Categorical and non-parametric data were analyzed with chi-square, Fisher's exact tests, odds ratio, and multivariate analysis by a forward stepwise logistic regression, respectively. Gastric volumes greater than 0.4 mL/kg and pH less than 2.5 were set as cut-off points to establish the risk of pulmonary aspiration between premedicated and non-premedicated patients. A p-value of less than 0.05 was considered statistical significance at 95% confidence interval.

Results

Eighty-nine participants were included in the study, as 11 patients dropped out, nine for turning to exploratory laparotomy and two for the difficulty of OG tube insertion.

The demographic characteristics regarding age, BMI, ASA, fasting time, pre-fluid loading, surgical time, pre-medication drugs, pH, and gastric volume were recorded (Table 1).

Fifty-eight patients (65.2%) having pH values of less than 2.5 and gastric volumes greater than 0.4 mL/kg became high-risk candidates for aspiration pneumonitis, while others were at non-high-risk conditions (Table 2).

The pH and gastric volumes of high-risk and non-high-risk groups showed statistically significant differences ($p<0.001$), as 1.1±0.4 and 1.1±0.8 mL/kg, and 2.8±2.2 and 0.3±0.4 mL/kg, respectively. Though age ($p=0.047$), BMI ($p=0.015$), and pre-medication drugs ($p<0.001$) showed significant differences, they did not appear in the pre-fluid loading ($p=0.635$), fasting ($p=0.496$), and surgical time ($p=0.822$) (Table 3).

Discussion

As pH of less than 2.5 and gastric volume of more than 0.4 mL/kg were verified as high-risk pulmonary aspiration. They showed significant correlation with age, BMI, and pre-medication drugs for some reason (Table 4).

The young were much more stressed than the elderly in terms of medical practice. Their emotional strain associated with hospital stays and surgical operation could disturb gastric motility and increase

Table 1. Demographic characteristics, pH and gastric volume of studied patients

	Number of patients; n (%)
Age (year); mean±SD	40.5±7.8
18 to 40	42 (47.2)
41 to 65	47 (52.8)
BMI (kg/m^2); mean±SD	22.2±3.4
15.0 to 25.0	69 (77.5)
25.1 to 30.0	20 (22.5)
ASA classification	
I	59 (66.3)
II	30 (33.7)
Fasting time (hour); mean±SD	13.2±2.2
≤12	35 (39.3)
>12	54 (60.7)
Pre-fluid loading (mL); mean±SD	411.8±284.7
≤500	63 (70.8)
>500	26 (29.2)
Surgical time (hour); mean±SD	3.1±1.0
≤3	52 (58.4)
>3	37 (41.6)
Premedication drugs	
No	68 (76.4)
Antacids	21 (23.6)
Gastric volume (mL/kg); mean±SD	0.8±0.8
≤0.4	26 (29.2)
>0.4	63 (70.8)
pH; mean±SD	1.7±1.5
<2.5	78 (87.6)
≥2.5	11 (12.4)

BMI=body mass index, ASA=American Society of Anesthesiology; SD=standard deviation

Table 2. Risk of pulmonary aspiration in studied patients

pH	Volume (mL/kg)	Severity	n (%)
<2.5	>0.4	High	58 (65.2)
<2.5	≤0.4	Non-high	20 (22.5)
≥2.5	>0.4	Non-high	5 (5.6)
≥2.5	≤0.4	Non-high	6 (6.7)

acid secretion[7]. This was consistent with the findings of Manchikanti et al[8], who noted that the risk of acid aspiration pneumonitis was theoretically present in all age groups, with children being at greatest risk and geriatric patients with the least risk. Thus, gastric acidity and volumes both decreased with patients' age. However, longer fasting periods augmented gastric acidity without significant effects on volumes[9].

Furthermore, Kaydu and Gokcek[7], and Perlas et al[9], pointed to reduced gastric motility at an advanced age, as the stomach walls of elderly patients were more compliant than those of younger ones. Interestingly, Phillips et al[10] confirmed that younger patients were more susceptible to chemical pneumonitis due to residual gastric contents alone. This was contrary to the reduction in the gastric emptying rate with age, as demonstrated by scintiscanning techniques. This could result from the general reduction in cellular functions.

Though, no patients were obese, with a BMI of more than 30 kg/m² in the current study, it appeared that anyone with a lower BMI was prone to the risk of aspirated pneumonitis. This seemed to agree with Harter et al[11], who found that among non-medicated obese patients, the proportion with high-volume and low-pH (HVLP) gastric contents was lower than that of lean patients. Delgado-Aros et al[12], added that increased BMIs were associated with a delayed onset of satiation and reduced fullness 30 minutes after a meal, but not with increased gastric volumes. These findings might correspond with Kaydu and Gokcek[7], on the correlation of BMIs and antral cross-sectional areas, which showed a weak positive linear relationship as illustrated by ultrasound detection. Nonetheless, according to the mathematical models of Bovet et al[13] and Perlas et al[14], gastric volumes varied with BMIs in non-pregnant adults.

Non-premedicated patients with antacids showed significantly high risks of pulmonary complications. Many studies revealed that antacids, either histamine-2 (H_2) receptor antagonist or proton pump inhibitor (PPI), played an important role in reducing gastric contents or gastric acidity.

In fact, the suppression of histamine at the stomach parietal cell deactivates its response to gastrin and acetylcholine hormones, and then decreases the secretion of acids, while PPI acts by irreversibly blocking the H^+/K^+ ATPase of the parietal cell and then directly reduces acid secretion at the terminal stage. In addition, they were insufficient to prove the lessening of emesis, reflux, or aspirated pneumonitis during the perioperative period[15,16].

As a result, some anesthesia consultants were reluctant to administer them as routine premedication, except in patients with apparent increased risks of pulmonary aspiration[17]. This was supported by Strand et al[18] and Scarpignato et al[19], who claimed that PPI was invaluable since it could lead to breakthrough symptoms in some individuals.

Table 3. Comparison of factors affecting high-risk and non-high-risk pulmonary aspiration in studied patients

Factors	High risk (n=58); n (%)	Non-high-risk (n=31); n (%)	p-value
Age (year); mean±SD	38.8±7.7	43.7±7.2	0.047*
18 to 40	32 (55.2)	10 (32.3)	
41 to 65	26 (44.8)	21 (67.7)	
BMI (kg/m^2); mean±SD	21.7±3.2	23.2±3.7	0.015*
15.0 to 25.0	50 (86.2)	19 (61.3)	
25.1 to 30.0	8 (13.8)	12 (38.7)	
Fasting time (hour); mean±SD	13.4±2.1	12.7±2.1	0.496
≤12	21 (36.2)	14 (45.2)	
>12	37 (63.8)	17 (54.8)	
Pre-fluid loading (mL); mean±SD	424.1±275.5	388.7±304.6	0.635
≤500	42 (72.4)	21 (67.7)	
>500	16 (27.6)	10 (32.3)	
Surgical time (hour); mean±SD	3.0±1.1	2.9±0.9	0.822
≤3	33 (56.9)	19 (61.3)	
>3	25 (43.1)	12 (38.7)	
Premedication drugs			<0.001*
No	53 (91.4)	15 (48.4)	
Antacids	5 (8.6)	16 (51.6)	
Gastric volume (mL/kg); mean±SD	1.1±0.8	0.3±0.4	<0.001*
≤0.4	0 (0.0)	26 (83.9)	
>0.4	58 (100)	5 (16.1)	
pH; mean±SD	1.1±0.4	2.8±2.2	<0.001*
<2.5	58 (100)	20 (64.5)	
≥2.5	0 (0.0)	11 (35.5)	

BMI=body mass index; SD=standard deviation

* p<0.05 significance

Table 4. Crude and adjusted odds ratio with 95% confidence interval from logistic regression analysis identifying associations selected characteristics in studied patients

Characteristic	Crude odds ratio (95% CI)	p-value	Adjusted odds ratio (95% CI)	p-value
Age (year)				
18 to 40	2.58 (1.04 to 6.45)	0.047*	-	0.097*
41 to 65	1.0			
BMI (kg/m^2)				
15.0 to 25.0	3.95 (1.40 to 11.16)	0.015*	4.65 (1.43 to 15.17)	0.017*
25.1 to 30.0	1.0		1.0	
Premedication drugs				
No	11.31 (3.56 to 35.93)	<0.001*	12.52 (3.71 to 42.27)	<0.001*
Antacids	1.0		1.0	

BMI=body mass index; CI=confidence interval

* p<0.05 significance

Moreover, Penston and Wormsley[20], and de la Coba et al[21], mentioned that H2 antagonist and PPI had potential toxic plasma concentrations of some therapeutic agents.

The operation time and pre-fluid loading showed no effect on gastric contents and acidity possibly because the surgical strain and stress of patients were suppressed during general anesthesia[22]. Furthermore, Boscan et al[23], found that anesthesia decreased gastric motility, prolonged gastric emptying time, but did not change the pH. Their findings were supported by Biswas et al[24], who insisted that the mere duration of anesthesia had an insignificant effect on gastric pH.

In addition, anesthetized patients were closely monitored by anesthesia personnel, and fluid administration was performed under the Holliday and Segar principle[25]. Therefore, this minimized the problem of peri-operative volume derangement. Additionally, Enoki et al, confirmed that preoperative administration of fluids had no influence on patients at risk for aspiration of gastric contents[26].

Generally, six hours of fasting was widely accepted as a routine practice in anesthesia, as it could decrease the risk of intra-operative pulmonary aspiration[17]. Accordingly, fasting of 12 hours showed no effect on this matter. This was confirmed by Kaydu and Gokcek[7], who proved that in patients with at least eight hours of fasting, the stomach antrum area and its contents decreased as the starving period increased.

Conclusion

During emergence from general anesthesia, 65% of patients undergoing gynecologic laparoscopic surgery produced gastric volume greater than 0.4 mL/kg and a pH of less than 2.5. The present study showed significant association with age, BMI, and pre-medication drugs.

What is already known on this topic?

Currently, elective laparoscopic gynecologic surgeries are performed in patients under general balanced anesthesia. Very few patients are premedicated with a H2 receptor antagonist or a PPI, or both. Since they are normally placed in lithotomy and Trendelenburg position, prior to insufflation of CO_2 gas into the abdominal cavity, an anesthetist inserts an OG tube to deflate the stomach. Though the risk of pulmonary aspiration is defined as gastric volumes of more than 0.4 mL/kg and a pH of less than 2.5, with a high prevalence in patients with increased intra-abdominal pressure and during emergence from anesthesia, intraoperative gastric contents between non-premedication and premedication with antacids have never been verified.

What this study adds?

The gastric contents of elective laparoscopic gynecologic patients during emergence from general anesthesia showed significant association with age, BMI, and pre-medication drugs.

The gastric contents proved lower in non-obese patients with a BMI of less than 25 kg/m^2.

Premedication with a H_2 receptor antagonist or a PPI, or both, could reduce gastric contents.

At the end of surgery and prior to extubation of the endotracheal tube, the gastric contents should be drained out as much as possible via the OG tube.

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Conflicts of interest

The authors declare no conflict of interest.

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