ORIGINAL ARTICLE

Prevalence of Aspiration Risk due to a Full Stomach Assessed by Gastric Ultrasonography in Diabetic Patients Undergoing Non-Emergency Surgery

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Background: Pulmonary aspiration causes severe complications and high mortality, especially in diabetic patients during the perioperative period. Gastric ultrasonography is able to detect a patient with full stomach that poses high risk of pulmonary aspiration. However, in Thailand, there is no previous prevalence study.

Objective: To study the prevalence of aspiration risk resulting from full stomach in diabetic patients during non-emergency surgery and to identify related risk factors using gastric ultrasonography.

Materials and Methods: One hundred nineteen diabetic patients were enrolled between July 2021 and January 2022. A preoperative ultrasound examination of gastric content was performed in the right lateral decubitus position. Aspiration risk due to full stomach was defined as having solid contents or fluid volume more than 1.5 mL/kg. The associated risk factors were analyzed using multiple logistic regression models.

Results: The prevalence of aspiration risk due to "full stomach" was 18.49% (22 out of 119 patients). Age between 65 and 84 years old (adjusted OR 015, 95% CI 0.04 to 0.54) and blood urea nitrogen (BUN) levels (adjusted OR 1.04, 95% CI 1.00 to 1.08) were statistically significantly associated risk factors ($p<0.05$). There was no incidence of pulmonary aspiration during the study period.

Conclusion: While diabetic patients were advised to follow standard fasting guidelines, the risk of pulmonary aspiration persisted. Implementing an anesthetic plan as though the patient belonged to the "full stomach" group helped ensure the patient's safety. Additionally, preoperative gastric ultrasound assessment is able to detect "full stomach" condition, thereby, further reducing the incidence of pulmonary aspiration.

Keywords: Prevalence; Diabetes mellitus; High risk pulmonary aspiration; Gastric ultrasound assessment; Diabetic gastroparesis; Full stomach

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Pulmonary aspiration, the entry of food or gastric contents into the lungs, is a severe complication that can occur during anesthesia. It is a significant cause of mortality in patients undergoing sedation[1,2]. It can lead to a severe form of lung infection called aspiration pneumonia, with a mortality rate of 5%[3,4]. In Thailand, the prevalence is 1.36 per 10,000 population[5].

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Patients with type 2 diabetes mellitus develop due to insulin insensitivity, resulting in excessively high blood sugar levels. This condition disrupts the normal functioning of nerve signaling, affecting both the sensory and autonomic nervous systems. As a consequence, there is a reduction in the contraction of the digestive tract, called diabetes gastroparesis, leading to increased accumulation of substances in the stomach. Individuals with diabetes may experience symptoms such as abdominal pain, bloating, nausea, vomiting, and easy satiety. In some cases, patients may also have impaired sensory nerve function, contributing to the manifestation of these symptoms. In type 2 diabetes patients, the prevalence of diabetic gastroparesis was found to be 9.8%[6].

Risk factors contributing to full stomach include the volume and type of gastric contents[7,8], as well as other factors such as diabetes[9-12], chronic kidney disease[9,10], obesity[10,12], poor controlled diabetes[13], hyperglycemia[13], long duration of diabetes[13],

history of co-morbid conditions[13], history of oral hypoglycemic drug used[14], diabetes-related eye disease[15], emergency surgery[12], preoperative consumption of opiates[12], and patients with higher American Society of Anesthesiologists (ASA) status[16,17].

Ultrasound examination, a widely available and non-invasive diagnostic tool, can be used to detect gastric residue. It is highly specific and accurate[18,19] and can determine the type and quantity of food present in the stomach. This examination can be performed by well-trained medical professionals[20]. Ultrasound allowed for the qualitative assessment of gastric content by examining in the supine and the right lateral positions and categorizing into grades. If gastric content was detected in both positions (Perlas grade 2), it indicated a full stomach[21,22]. The quantitative assessment involved using ultrasound to measure the cross-sectional area (CSA) in the antrum region during the right lateral position, enabling the calculation of the volume of gastric content. The term 'full stomach' was determined through gastric ultrasound, which identified the presence of solid contents or fluid volume exceeding 1.5 mL/kg, posing a high risk of pulmonary aspiration[21,22]. Both qualitative and quantitative evaluations demonstrated high sensitivity and specificity in identifying or excluding a full stomach[22].

The use of ultrasound for the aforementioned purpose enabled the identification of high-risk patients for pulmonary aspiration caused by gastric residue. This facilitated appropriate and safer management of diabetic patients. The primary objective of the present study was to establish the prevalence of aspiration risk resulting from full stomach in diabetic patients during non-emergency surgery. This was achieved by utilizing ultrasound examination in diabetic patients adhering to the fasting guidelines before undergoing non-emergency surgery.

Materials and Methods

Study population

The prospective cross-sectional study, which had received approval from the Human Research Ethics Committee of Srinakharinwirot University, certification number SWUEC/F-025/2564, was carried out between July 2021 and January 2022. All participants in the present research were provided with comprehensive information sheets and gave their informed consent.

The inclusion criteria were patients aged 18 years or older, had been diagnosed with type 2 diabetes for a minimum of three months, and were scheduled to undergo non-emergency surgery while adhering to fasting guidelines.

The exclusion criteria were individuals who could not adhere to standard fasting guidelines or were scheduled for emergency surgery, patients with COVID-19, type 1 diabetes, presenting as diabetic ketoacidosis, and hyperosmolar hyperglycemic syndrome. Additionally, patients with abnormal gastrointestinal anatomy, gastrointestinal disorders such as acute gastrointestinal bleeding, bowel obstruction, gastric ulcers, duodenal ulcers, liver tumors, small and large bowel tumors, history of gastrointestinal surgery, large abdominal mass exceeding 20 weeks of gestation, patients undergoing peritoneal dialysis, pregnant individuals, patients with nasogastric or orogastric tubes in place prior to surgery, patients on specific medications affecting gastric acid secretion within two hours of surgery, including prokinetic drugs, H2-blockers, tricyclic antidepressants, and glucagon-like peptide (GLP)-1 agonists either orally or intravenously, patients who refused to participate in the research project, patients with mental health issues, or those unable to provide information about their fasting status. Furthermore, patients were excluded if researchers were unable to visualize the antrum via ultrasound due to positional restrictions, abdominal wall thickness impeding visibility, and other factors that could lead to bowel ileus, such as hypokalemia, hyponatremia, hypomagnesemia, and sepsis.

Calculation of sample size

According to the research conducted by Ohashi et al.[11], they discovered the prevalence of high-risk diabetic patients for aspiration pneumonia was 6.7%. To determine the required sample size for their study with a 95% confidence level, a margin of error of 0.05, and accounting for a 20% dropout rate, they calculated that 120 patients would be needed.

All patients who met the selection criteria and agreed to participate in the present study that included the standard fasting, which included a minimum of two hours of fasting for water, six hours for milk or clear fluids, and eight hours for fried food, fatty foods, or meat before surgery, were enrolled. The researchers collected various data, including age, weight, height, ASA physical status, duration of fasting, last meal consumed, blood glucose levels, diabetes-related complications, medication history for diabetes, creatinine level for calculate renal function, blood urea nitrogen (BUN), other comorbidities, methods

of anesthesia, and postoperative complications. In cases where fingertip blood glucose levels exceeded six hours before surgery, patients received another fingerstick test just before ultrasound examination.

Patients underwent ultrasound examinations using the Sonosite X-Porte machine with a curved probe of 5-2 MHz. The examinations were conducted by trained physicians in abdominal ultrasound in the right lateral decubitus position to assess the type and quantity of residual gastric contents. The volume of residual gastric contents was calculated from three ultrasound images to determine the average width and length of the antrum. Subsequently, the CSA of the gastric antrum was calculated. This value was then substituted into the aforementioned equation to obtain the gastric volume.

For patients at high risk of aspiration of gastric contents, the researchers informed the attending physicians to consider the appropriate method of anesthesia to manage the risk.

Quantitative assessment was performed using the formula developed by Perlas et al.[20] to calculate the CSA of the gastric antrum. The measurements were conducted in the right lateral decubitus position, specifically measuring the widest part of the antrum, which is the distance between the outermost layer of the gastric wall, or serosa. This measurement was taken three times to determine the average value, which was then used to calculate the volume of residual gastric contents using the formula CSA (cm^2) = ($\pi \times D1 \times D2$)/4, where π=3.14, D1 represented the longitudinal diameter of the antrum (cm), and D2 represented the anteroposterior diameter of the antrum, in cm (Figure 1).

The calculated CSA value was used to estimate the volume of residual gastric contents in the stomach using the following formula:

Gastric volume (mL) = 27 + (14.6 × CSA) – (1.28 × age)

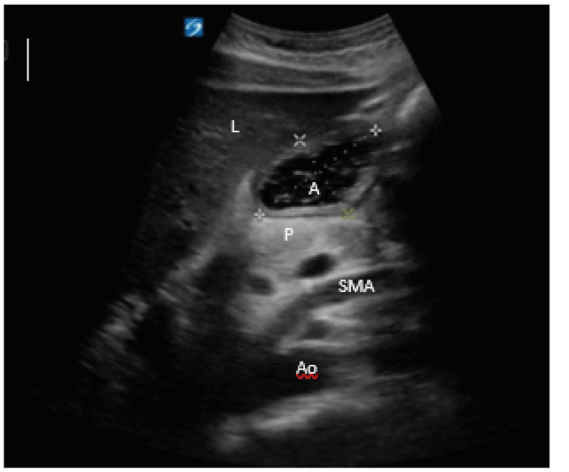

Figure 1. Shows the gastric ultrasonography to measure gastric volume: serosa-serosa.

L=liver, P=pancrease, Ao=aorta, SMA=superior mesenteric artery, A=gastric antrum

The high risk of aspiration of gastric content into the lungs was indicated by the presence of solid contents or fluid volume exceeding 1.5 mL/kg in the right lateral decubitus position in an ultrasound scan[21,22] (Figure 2).

Statistical analysis

Statistical analysis was employed to analyze the basic data using inferential statistics. For continuous variables, the distribution of the data was tested using the Shapiro-Wilk test. If the data followed a normal distribution, the report included the mean and standard deviation (SD). If the data did not follow a normal distribution, the report included the median and interquartile range. For categorical variables, the report included the frequency and percentage of each category. Univariate analysis was utilized for analyzing risk factors with binary logistic regression. If a relationship was found, further analysis was conducted using multiple logistic

Figure 2. Sonographic image of the gastric antrum (A) empty stomach, (B) the gastric antrum containing clear fluid, (C) the gastric antrum containing solid content.

Table 1. Demographic data

Variables	High risk (n=22)	Low risk (n=97)	Total (n=119)
Age (years); mean [SD]	57.64 [9.43]	65.69 [10.77]	64.02 [11.077]
Sex; n (%)			
Male	13 (59.09)	39 (40.21)	52 (43.70)
Female	9 (40.91)	58 (59.79)	67 (56.30)
BMI (kg/m^2); n (%)			
<30	17 (77.20)	80 (82.47)	97 (81.51)
30 to 39.9	4 (18.18)	15 (15.46)	19 (15.97)
40 to 44.9	1 (4.55)	1 (1.03)	2 (1.68)
≥45	0 (0.00)	1 (1.03)	1 (0.84)
Mean [SD]	27.32 [5.88]	25.31 [6.27]	25.69 [6.23]
Weight (kg); mean [SD]	69.59 [13.63]	63.70 [14.13]	64.70 [14.17]
Height (cm); mean [SD]	160.36 [12.56]	159.05 [9.65]	159.20 [10.20]
DM time (years); median (IQR)	6 (3,10)	7 (3,15)	7 (3,13)
Diabetes nephropathy; n (%)	3 (13.64)	5 (5.15)	8 (6.72)
Diabetes retinopathy; n (%)	6 (24.27)	11 (11.34)	17 (14.29)
Peripheral neuropathy; n (%)	11(50.00)	30 (30.93)	41 (34.45)
Diabetes gastropathy; n (%)	2 (9.09)	21 (21.65)	23 (19.33)
ASA; n (%)			
2	7 (31.82)	46 (47.42)	53 (44.54)
3	15 (68.18)	50 (51.55)	65 (54.62)
4	0 (0.00)	1(1.03)	1(0.84)
Insulin usage; n (%)	8 (36.36)	18 (17.56)	26 (21.85)
Oral hypoglycemic drug; n (%)	15 (68.18)	84 (86.60)	99 (83.19)
CKD stage; n (%)			
I	13 (59.09)	37 (38.54)	50 (42.37)
II	4 (18.18)	35 (36.46)	39 (33.05)
IIIA	0 (0.00)	10 (10.42)	10 (8.47)
IIIB	0 (0.00)	10 (10.42)	10 (8.47)
IV	0 (0.00)	4 (4.17)	4 (3.39)
V	5 (22.73)	0 (0.00)	5 (4.24)
BUN (mg/dL); median (IQR)	15.85 (9.9,26.2)	14.40 (10.9,18.6)	14.90 (10.8,18.7)
DTX (mg/dL); mean [SD]	147.41 [39.50]	134.88 [31.497]	137.19 [33.29]

BMI=body mass index; DM=diabetes mellitus; ASA=American Society of Anesthesiologists; CKD=chronic kidney disease; BUN=blood urea nitrogen; SD=standard deviation; IQR=interquartile range

regression. A statistically significant difference was considered when the p-value was less than 0.05, and a 95% confidence interval (CI) was used. The Stata Statistical Software, version 17 (StataCorp LLC, College Station, TX, USA) was used for these analyses.

Results

In the present study, 126 individuals were initially selected. However, six individuals were excluded. Four of them did not meet the inclusion criteria, and two were unable to undergo ultrasound examination of the stomach. Thus, 120 individuals had gastric ultrasound, and one person was found to have a gastric mass after the ultrasound examination. Therefore, the final participants were 119 patients (Figure 3).

The baseline characteristics of the participants are presented in Table 1. The population had an average age of 64 years. There were 52 males (43.70%) and 67 females (56.30%). The average body mass index (BMI) was 25.69, and 97 patients (81.51%) had a BMI of less than 30, indicating they were not obese. Nineteen patients (15.97%) were classified as having obesity (BMI 30 to 39.9). The median duration of diabetes was seven years. The number of patients with complications from diabetes was divided according to Table 1.

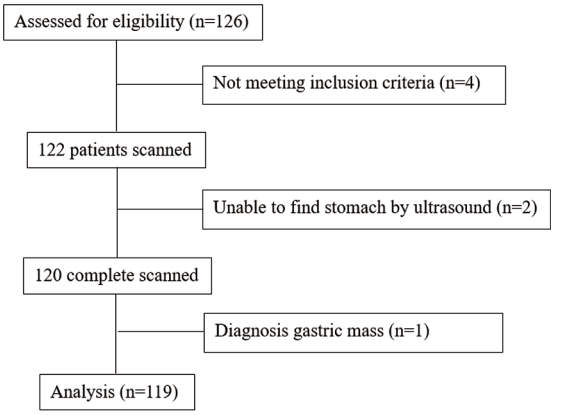

Figure 3. The study flow.

Table 2. Result of gastric ultrasound assessments

	Total (n=119)
High risk	22 (18.49)
Solid; n (%)	3 (13.60)
Liquid >1.5 mL/kg; n (%)	19 (86.40)
Gastric volume* (mL/kg); mean [SD]	2.25 [0.69]
CSA† (cm^2); mean [SD]	12.82 [3.28]
Low risk	97 (81.51)
Empty; n (%)	22 (22.70)
Liquid ≤1.5 mL/kg; n (%)	75 (77.30)
Gastric volume* (mL/kg)*; mean [SD]	0.78 [0.47]
CSA† (cm^2)†; mean [SD]	7.37 [1.87]

CSA=cross-sectional area; SD=standard deviation

* Gastric volume per body weight was calculated only for liquid content, † CSA was calculated for liquid and solid content, empty stomach was excluded

One hundred nineteen diabetic patients who underwent non-emergency surgery were included. The prevalence of high-risk pulmonary aspiration due to "full stomach" was 18.49% (22 patients). Out of these, three patients had solid content in their stomachs, and 19 patients had liquid content. The average gastric volume for the high-risk group and low-risk group for pulmonary aspiration was 2.25 (0.69) mL/kg and 0.78 (0.47) mL/kg, respectively (Table 2).

The factors associated with a high risk of aspiration of gastric content into the lungs, as analyzed by univariate analysis, included age, which was 65 to 84 years, the use of medications to reduce blood sugar levels, and BUN levels. Those risk factors were statistically significant. However, when analyzed using multivariate analysis, only age, which was 65 to 84 years, and BUN levels were statistically significant, with adjusted odds ratio (OR) of 0.15 (95% CI 0.04 to 0.54) and 1.04 (95% CI 1.00 to 1.08), respectively (Table 3).

Discussion

In the present study, 119 diabetic patients undergoing non-emergency surgery received gastric ultrasound examinations to identify gastric contents. The results showed that 22 of these patients (18.49%) had solid contents or fluid volume more than 1.5 mL/kg. This condition signifies a full stomach and is associated with a heightened risk of pulmonary aspiration of fluids and food.

In a study by Bouvet et al.[12], they observed that the prevalence of a full stomach condition among patients undergoing elective surgery, as assessed through ultrasound in both supine and right lateral decubitus positions, was 5% (95% CI 2 to 9). When retained gastric content was identified in both the supine and right lateral decubitus positions, which is classified as Perlas Grade 2, it was associated with a full stomach condition, albeit at a lower rate compared to the findings in the present study. These disparities can be attributed to variations in patient demographics and assessment methods. It was important to note that this investigation specifically focused on diabetes patients, who commonly exhibit delayed gastric emptying, leading to a higher prevalence of the condition compared to the study by Bouvet et al[12].

The studies by Bouvet et al.[12] and Inphum et al.[23] found that the prevalence of a full stomach condition in patients undergoing emergency surgery was 56% and 46.6%, respectively. It should be noted that the prevalence of this condition was significantly higher than in the current study. This difference is attributed to the fact that these studies were conducted on critically ill patients, who are independent variables. This factor leads to delayed gastric emptying, which may result in a higher volume of food in the stomach.

A study conducted by Zhou et al.[15] found that the prevalence of full stomach in diabetic patients was 48.10%. The study also found that diabetic retinopathy was a statistically significant risk factor (OR 4.83, p=0.01), indicating a higher prevalence of full stomach compared to the current study. Zhou et al.[15] utilized the Perlas qualitative grading scale to assess full stomach, specifically in the supine high head and right lateral decubitus positions, as Perlas Grade 2, which was associated with full stomach. Additionally, the study reported a 36.53% incidence of diabetic retinopathy, higher than the 17% observed

Table 3. Factor associated with high risk for increased volume of gastric content

Factors	Univariate analysis OR (95% CI)	p-value	Multivariate analysis adjusted OR (95% CI)	p-value
Age (years)				
<65	1	-	1	-
65 to 84	0.13 (0.04 to 0.46)	0.002*	0.15 (0.04 to 0.54)	0.004*
≥85	-†	0.99		
BMI (kg/m^2)				
<30	1	-		
30 to 39.9	1.25 (0.37 to 4.25)	0.72		
40 to 44.9	4.70 (0.28 to 78.99)	0.28		
≥45	-†	0.99		
DM time (years)	0.98 (0.93 to 1.04)	0.52		
Diabetes nephropathy	2.90 (0.64 to 13.21)	0.17		
Diabetes retinopathy	2.93 (0.95 to 9.07)	0.06		
Peripheral neuropathy	2.23 (0.87 to 5.72)	0.09		
Diabetes gastropathy	0.36 (0.08 to 1.67)	0.19		
ASA				
2	1	-		
3	1.97 (0.74 to 5.27)	0.18		
4	-†	0.10		
Insulin use	2.66 (0.96 to 7.32)	0.06		
Oral hypoglycemic drug	0.33 (0.11 to 0.97)	0.04		
CKD stage				
I	1	-		
II	0.325 (0.096 to 1.093)	0.069		
IIIA	-†	0.995		
IIIB	-†	0.995		
IV	-†	0.997		
V	-†	0.999		
BUN	1.05 (1.01 to 1.08)	0.01*	1.04 (1.00 to 1.08)	0.03*
NPO duration	1.02 (0.94 to 1.10)	0.72		
Ultrasonography gastric content				
Empty	1	-		
Liquid	-†	0.99		
Solid	-†	1.00		
DTX	1.01 (1.00 to 1.02)	0.12		

BMI=body mass index; DM=diabetes mellitus; ASA=American Society of Anesthesiologists; CKD=chronic kidney disease; BUN=blood urea nitrogen; OR=odds ratio; CI=confidence interval

* $p<0.05$, statistical significance, † Odds ratio is omitted due to rare event

in the current study, which may contribute to a higher prevalence of full stomach.

The present study found that two significant factors increased the risk for increased volume of gastric content, being aged 65 to 84 years and having an elevated BUN, with statistically significant adjusted OR of 0.15 (95% CI 0.04 to 0.54) and 1.04 (95% CI 1.00 to 1.08), respectively. These results are in line with the research by Soenen et al.[24], which demonstrated that elderly patients with both Parkinson's disease and diabetes tend to experience delayed gastric emptying. Similarly, the study by Sendzischew et al.[25] showed that elderly patients over the age of 65 often undergo physiological changes in gastrointestinal motility, leading to delayed gastric emptying, which is consistent with the findings of the present study. This study also noted that older patients had a higher prevalence of retained material and a greater stomach volume compared to patients under the age of 65.

Furthermore, a study by De Schoenmakere et al.[26] demonstrated that patients with chronic kidney disease undergoing hemodialysis had a longer gastric emptying time of more than 30 minutes

compared to the normal group. This was attributed to biochemical changes such as altered blood levels of albumin and pre-albumin. However, it should be noted that the current study differed from De Schoenmakere et al.[26], as the researchers focused on diabetic patients rather than those with chronic kidney disease undergoing hemodialysis, which could lead to different results.

In a study conducted by Wang et al.[27], BUN, is a nitrogenous end product of protein metabolism. An increase in BUN may result from a decline in kidney function, leading to the accumulation of uremic toxins. Among these toxins, indoxyl sulfate and hippuric acid have been identified as causative factors for gastrointestinal injury. Additionally, elevated BUN levels, which are excreted through the kidneys and gastrointestinal tract, may contribute to gastrointestinal complications. The elimination of BUN through the digestive system relies on bacterial breakdown, causing inflammation and erosion of the intestinal lining. Furthermore, high BUN levels lead to the production of uremic toxins, contributing to gastrointestinal motor dysfunction. This dysfunction manifests as increased transit time and reduced motility, further impairing smooth muscle contractility in the gut. Therefore, the present study suggests that elevated BUN levels may be a risk factor for diminishing intestinal function, leading to increased risk of full stomach.

The limitations of the present research are that it focused only on a group of patients with diabetes who underwent non-emergency surgery for studying the occurrence of delayed gastric emptying. This approach may exclude patients who underwent urgent surgery from this group, potentially resulting in a lower incidence of delayed gastric emptying compared to other studies conducted in patients with diabetes. Additionally, other risk factors that may contribute to an increased incidence of delayed gastric emptying in diabetic patients, such as neuropathy in various parts of the body, were not considered. Therefore, it may be advisable to conduct studies on diabetic patients undergoing both emergency and non-emergency surgeries and to increase the sample size to identify other risk factors that may contribute to delayed gastric emptying and a gastric volume greater than 1.5 mL/kg, which are associated with an increased risk of aspiration of food and fluids into the lungs.

Conclusion

The prevalence of aspiration risk due to a full stomach assessed by gastric ultrasonography, characterized by retained solid contents or fluid volume more than 1.5 mL/kg, in diabetic patients undergoing non-emergency surgery, was found to be 18.49%. Significant risk factors associated with this condition were age 65 to 84 years and high BUN with adjusted OR of 0.15 (95% CI 0.04 to 0.54) and 1.04 (95% CI 1.00 to 1.08), respectively. However, the present study did not have any cases of aspiration during surgery during the study period.

What is already known on this topic?

Patients with diabetes can experience delayed gastric emptying time, leading to increased gastric retention and an elevated risk of aspiration of food into the lungs.

What does this study add?

The use of ultrasound can detect retained gastric contents and help identify diabetic patients at a high risk of aspiration of food into the lungs. This can assist in selecting appropriate sedation methods and reducing the risk of aspiration.

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Conflicts of interest

The authors declare no conflict of interest.

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