Pulmonary aspiration is a potentially fatal anesthetic complication occurring when gastric contents enter the respiratory system. Fasting guidelines aim to decrease the risk of pulmonary aspiration by recommending a timeframe in which patients abstain from food and drink before surgery. Fasting guidelines recommended for healthy individuals fail to account for patients with type 2 diabetes mellitus (T2DM). Gastroparesis, a common condition associated with T2DM, is exacerbated during stress such as an impending surgery. This study sought to determine whether a relationship exists between stress levels and gastric contents in fasting patients with T2DM presenting for an elective surgical or diagnostic procedure. The quality and quantity of gastric contents and preoperative stress were evaluated using gastric ultrasonography and salivary α-amylase levels. No relationship existed between preoperative stress and gastric contents; however, glycated hemoglobin levels of 7% or greater were associated with increased gastric fluid, which was the most significant finding in this study. In addition, there was a significant difference between the mean gastric volume in healthy individuals and patients with T2DM. Performance of gastric ultrasonography preoperatively provides objective data that could influence the anesthetic plan and decrease the risk of pulmonary aspiration in patients with T2DM.

Keywords: Gastric contents, gastric ultrasonography, preoperative stress, pulmonary aspiration, salivary α-amylase.

patients are at an increased risk of anesthesia-related complications in the perioperative arena. One of the more serious complications is pulmonary aspiration, which accounts for 10% to 30% of anesthesia-related deaths. The incidence of pulmonary aspiration in the adult population varies greatly in the literature, anywhere from 0.1% to 19%. Even though the incidence is low, patients who experience pulmonary aspiration may experience devastating consequences, including hypoxia, pneumonitis, and death. With the exception of the most extreme outcome of pulmonary aspiration, death, other physiologic consequences often result in a prolonged length of stay (mean, 15 days) and a decreased quality of life depending on the severity of the aspiration event.

Nurse anesthetists currently gauge the presence and quality of a patient’s gastric contents before administering anesthesia by asking the patient how long they have abstained from food and drink. The subjective nature in which gastric contents are assessed before anesthesia leaves uncertainty regarding the true contents of the stomach. Eliminating the ambiguity of self-reported fasting times by implementing an objective gastric content assessment may result in a safer anesthetic. Because gastroparesis is common in patients with diabetes mellitus, the use of some form of objective measure becomes important. In addition, stressful events, such as an impending surgery, may exacerbate gastroparesis in the patient with T2DM resulting from slowed gastric emptying and activation of the stress response.

The authors hypothesized that a relationship between stress levels and gastric contents exists in fasting patients with T2DM presenting for an elective surgical or diagnostic procedure, and the aim of this study is to determine if such a relationship exists. In addition, mean gastric contents and mean salivary α-amylase (sAA) levels were compared between patients with T2DM undergoing an elective surgery or diagnostic procedure and, as described previously, healthy individuals not undergoing an elective surgical or diagnostic procedure. Also, the authors determined whether hemoglobin A1C (HbA1C) levels and age contributed to predicting gastric contents in the patient with T2DM.

Materials and Methods
This descriptive correlational study involved assessing how preoperative stress affects gastric contents in patients with T2DM. A 580-bed teaching hospital located

Type 2 Diabetes Mellitus: Relationships Between Preoperative Physiologic Stress, Gastric Content Volume and Quality, and Risk of Pulmonary Aspiration

Amy M. Reed, PhD, CRNA
Richard E. Haas, PhD, CRNA, PHRN
The primary researcher also recorded the following information from the EMR: age, gender, height, weight, body mass index (BMI), race-ethnicity, fasting blood glucose value, HbA1C, current medications regarding T2DM diagnosis, any mood-altering medications, and gastric-altering medications. The following historical data were also recorded: smoking, gastroparesis, and pulmonary aspiration.

• Data Analysis. Data were analyzed using statistical analysis software (SPSS®) to determine the presence of a relationship between T2DM and gastric contents in the presence of stress. Furthermore, the researchers sought to find whether a relationship exists between gastric contents and covariates including age, gender, BMI, fasting blood glucose value, HbA1C, and smoking history. Descriptive statistics were used to analyze demographic information. A Pearson product-moment correlation coefficient assessed the relationship between sAA levels and gastric contents. The t test was used to analyze the difference in the means of gastric contents of healthy individuals (<1.5 mL/kg) compared with patients with T2DM. Of note, the mean gastric contents of patients with T2DM in this study collected from gastric ultrasonography were compared with the mean gastric contents of healthy individuals (<1.5 mL/kg), which was already researched in the literature.³ The t test was also used to test the difference between the mean sAA in patients with diabetes not undergoing an elective surgery or diagnostic procedure (108.48 U/mL [SD, 6.37 U/mL])⁶ and the experimental group of patients with T2DM undergoing an elective surgery or diagnostic procedure. The mean sAA in individuals with diabetes not undergoing an elective surgical or diagnostic procedure was found in the literature⁸ and compared with the mean sAA collected in this study’s sample of patients with T2DM undergoing an elective surgery or diagnostic procedure. Because data already exist in the literature regarding mean gastric contents of healthy individuals and mean sAA levels of patients with diabetes not undergoing an elective surgical or diagnostic procedure, no pilot studies were necessary. A linear regression with a Durbin-Watson statistic was used to analyze the degree to which HbA1C and age were predictors of gastric contents and covariates. In addition, a χ² test was used to evaluate the relationship between HbA1C greater than 7% and the presence of fluid in the stomach.

Three missing data points were identified, as well as an extreme outlier in sAA level of the tested group. These 4 cases were excluded from analysis. Additionally, HbA1C was condensed into a categorical/dichotomous variable (HbA1C <7%/HbA1C ≥7%). Next a multiple linear regression analysis was used to determine the significance of any predictor variables of gastric fluid. The continuous variable of gastric fluid (in milliliters) was the dependent variable, and independent (predictor) variables were HbA1C (percent) as an ordinal dichotomous variable and age as a continuous variable. Assumptions regarding a linear relationship, multivariate normality,
Equation 2. Gastric Contents (mL) = 7.50 + (3.33 x HbA1C) - (2.70 x Age in years)

Results

The patients' demographic variables are shown in Table 1. Preoperative vital signs were within the reference range on average except for a mean diastolic blood pressure of 140.6 mm Hg (SD, 17.7 mm Hg).

Most patients had fluid in the stomach (60%, n=24), and of those with fluid present, the mean volume was 23.75 mL (SD, 16.42 mL). The CSA of the antrum was measured if the antrum had well-defined margins in indicating an empty stomach (n=14) or a stomach with fluid contents (n=24). Of the 11 participants who had well-defined margins of the antrum, the mean CSA was 4.15 cm$^2$ (SD, 1.80 cm$^2$). The remaining 2 participants' stomachs (5%) contained solid substances.

Of the 40 participants, the mean HbA1C and fasting glucose levels were 7.5% (SD, 1.56%) and 166.65 mg/dL (SD, 62.22 mg/dL), respectively. Most patients had HbA1C levels above 7% (55%). The mean sAA for the sample was 126.46 U/mL (SD, 131.99 U/mL).

Regarding the preoperative fasting questions that were asked each of the participants, the mean length of time abstaining from food and liquids was 21.33 hours (SD, 11.36 hours) and 6.65 hours (SD, 3.52 hours), respectively. As shown in Table 2, most participants reported that their last meal was solid (85%) and the last liquid consumed was clear (100%). In addition, 62.5% of the participants also reported that they felt hungry, and
82.5% reported that a nurse was the healthcare professional who instructed the participant on fasting guidelines. Most participants were instructed to have nothing to eat after midnight (92.5%), and 42.5% reported that they had abstained from food and drink before surgery for a reason other than aspiration. Of the 40 participants, the majority reported no history of pulmonary aspiration (87.5%), but 1 individual had experienced pulmonary aspiration in the past (2.5%). In addition, most of the sample reported no known history of gastroparesis (97.5%; see Table 2).

Hemoglobin A1C and age were the only covariates that were significant predictors of gastric contents. However, the 2 covariates explained only 17% of the variance, and neither was a significant predictor independently (Table 3). Age inversely correlated with gastric fluid, which indicated that as age increased, gastric volume decreased, similar to the inverse relationship identified by other researchers. The most pertinent finding of this study was that HbA1C levels equal to or greater than 7% significantly correlated with higher amounts of gastric fluid in the preoperative environment vs patients with T2DM whose HbA1C levels were less than 7% (Table 4).

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Not only were there no significant findings regarding the relationship between preoperative physiologic stress and gastric contents, there were no significant differences in associations between traditional biomarkers of stress (heart rate and blood pressure) and gastric contents. In addition, heart rate and blood pressure had no significant correlation with sAA levels in this sample. Patients with T2DM in this study had significantly less fluid in their stomachs compared with the “safe” amount of fluid when undergoing anesthesia. These findings indicate that the fasting instructions the patients were given before their elective surgery or diagnostic procedure corrected for any factors, such as physiologic stress and gastroparesis that may contribute to an increase in gastric contents in patients with T2DM. However, the patients in this study were not instructed to follow current fasting guidelines recommended by the ASA.

Discussion
The findings of this study demonstrate that there was no significant relationship between sAA levels and gastric contents and that patients with T2DM had significantly less fluid in their stomachs compared with the “safe” amount of fluid when undergoing anesthesia. These findings indicate that the fasting instructions the patients were given before their elective surgery or diagnostic procedure corrected for any factors, such as physiologic stress and gastroparesis that may contribute to an increase in gastric contents in patients with T2DM. However, the patients in this study were not instructed to follow current fasting guidelines recommended by the ASA. Rather, they were instructed to consume “nothing after midnight,” which conflicts with the ASA recommendations. When the patients in this study were asked about the fasting instructions they received before their elective surgery or diagnostic procedure, 92.5% reported

<table>
<thead>
<tr>
<th>Model (constant)</th>
<th>β</th>
<th>SE</th>
<th>Standardized coefficients</th>
<th>t</th>
<th>Significance</th>
</tr>
</thead>
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<td>7.50</td>
<td>23.27</td>
<td>0.322</td>
<td>.749</td>
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<tr>
<td>HbA1C</td>
<td>3.33</td>
<td>1.77</td>
<td>.301</td>
<td>1.88</td>
<td>.068</td>
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<tr>
<td>Age</td>
<td>−.279</td>
<td>.227</td>
<td>−.196</td>
<td>−1.23</td>
<td>.227</td>
</tr>
</tbody>
</table>

Table 4. Test of Independence Between Rows and Columns (Hemoglobin A1C >7%/Gastric Contents)

significantly different (Table 6).

Discussion
The findings of this study demonstrate that there was no significant relationship between sAA levels and gastric contents and that patients with T2DM had significantly less fluid in their stomachs compared with the “safe” amount of fluid when undergoing anesthesia. These findings indicate that the fasting instructions the patients were given before their elective surgery or diagnostic procedure corrected for any factors, such as physiologic stress and gastroparesis that may contribute to an increase in gastric contents in patients with T2DM. However, the patients in this study were not instructed to follow current fasting guidelines recommended by the ASA. Rather, they were instructed to consume “nothing after midnight,” which conflicts with the ASA recommendations. When the patients in this study were asked about the fasting instructions they received before their elective surgery or diagnostic procedure, 92.5% reported

<table>
<thead>
<tr>
<th>Test</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>χ² observed value</td>
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</tr>
<tr>
<td>χ² critical value</td>
<td>3.84</td>
</tr>
<tr>
<td>df</td>
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<tr>
<td>P</td>
<td>.001</td>
</tr>
<tr>
<td>α</td>
<td>.05</td>
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<tr>
<td>Fisher exact test</td>
<td>P (2-tailed)</td>
</tr>
<tr>
<td>α</td>
<td>.05</td>
</tr>
<tr>
<td>Coefficient</td>
<td>Pearson ϕ</td>
</tr>
<tr>
<td>Cramer V</td>
<td>0.53</td>
</tr>
</tbody>
</table>
they were told to eat “nothing after midnight,” which suggests the patients followed a restrictive outdated preoperative fasting regimen. Drastically long fasting times potentially explain the significant decrease in gastric contents in the study’s sample and the lack of significance between sAA levels and gastric contents.

Of note, 2 participants had solid substances in their stomach despite extremely prolonged fasting times, as they were instructed to consume “nothing after midnight.” This finding highlights the potential for complications when objective data provided by gastric ultrasonography are not used. The anesthetic plans for these 2 participants were altered, and no regurgitate events occurred.

It remains unknown whether the current fasting guideline of drinking clear liquids up to 2 hours before surgery is a safe practice for patients who have comorbidities associated with gastroparesis or if drinking clear liquids 2 hours before surgery will increase their risk of pulmonary aspiration. If nurse anesthetists are proficient in scanning the antrum of the stomach using gastric ultrasonography, the prevention of pulmonary aspiration in patients with comorbidities associated with gastroparesis is possible despite the uncertainty regarding fasting guidelines. In addition, assessing the difference between an empty, fluid-filled, and solid antral state is pretty clear, as indicated in Figures 1 through 3, which show the 3 different types of gastric states from participants in this study.

Variability of sAA levels is well documented in the literature. In addition to the potential sAA enzyme secretion dysfunction due to diabetic autonomic neuropathy, which was not assessed in this study, the wide variability of sAA levels was pertinent to the results. The sAA levels of the patients with T2DM participating in this study were measured at various times throughout the day in conjunction with their surgery and procedure times; thus, the diurnal pattern could have affected the sAA enzyme level, resulting in inconsistent levels among the sample. Despite this variability, the mean sAA level for this study was not significantly different from the mean sAA level in patients with diabetes not undergoing an elective surgery or diagnostic procedure in the study by Panchbhai et al. However, this wide range makes it difficult to decipher a mean sAA level that is relevant to the clinician.

The most pertinent finding of this study was that HbA1C levels equal to or greater than 7% significantly correlated with higher amounts of gastric fluid in the preoperative environment vs patients with T2DM with HbA1C levels less than 7%. Jellish et al demonstrated that non-insulin-dependent and insulin-dependent patients with diabetes had higher HbA1C levels compared with individuals without diabetes, and Moldovan et al explained that higher HbA1C levels were associated with delayed gastric emptying. However, the positive correlation between HbA1C and gastric contents is a new finding.

Limitations to this study included the sample size, location of the study, and the type of surgeries and diagnostic procedures the participants were undergoing. The sample size of 34 was determined to have a sufficient power to determine if a relationship exists between sAA levels and gastric contents; however, a larger sample size would have increased the generalizability of the study findings and perhaps provided more information regarding covariates. In addition, the sample consisted of mostly white men undergoing gastroenterology diagnostic procedures, which limited the generalizability of the study. The study looked only at patients with T2DM, which further limited the generalizability of the findings. In addition, survey questions were not analyzed for internal consistency, which highlights another limitation of this study.

Preoperative physiologic stress was not measured well in this study because of the wide variability of the sAA levels. Factors that may have reduced this limitation include taking sAA samples at the same time each day to avoid variability due to sAA diurnal patterns. In addition, although having patients abstain from medications that may affect sAA levels such as β-blockers and β-antagonists may have reduced the variability, discontinuing these medications is unethical because morbidity and mortality risk would increase. A visual analog scale would have been a beneficial addition to this study as a supplemental measurement of stress with which to compare gastric contents.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number</th>
<th>Mean (SD)</th>
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<tbody>
<tr>
<td>Gastric fluids (mL/kg)</td>
<td>38</td>
<td>0.146 (0.171)</td>
</tr>
<tr>
<td>Difference (measured against 1.5 mL/kg)</td>
<td>–1.354 mL/kg</td>
<td></td>
</tr>
</tbody>
</table>

Table 5. Gastric Fluid Difference Between Study Group and Literature

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elective procedure sAA</td>
<td>37</td>
<td>126.2 (134.3)</td>
</tr>
<tr>
<td>No elective procedure sAA</td>
<td>40</td>
<td>108.48 (6.37)</td>
</tr>
</tbody>
</table>

Table 6. Salivary α-Amylase (sAA) Levels Between Study Group and Literature

\[Results: t\text{(observed value)}=48.687, |t| (critical value)=2.026, df=37, P\text{(2-tailed)}<.0001, \alpha=.05.\]

\[Results: Difference=17.72, SE=22.10, 95\% CI= (−27.10 to 62.54), t \text{statistic}=0.80, df=36, \text{significance level}=.423.\]
Another limitation of this study was that the researchers could not control for numerous factors that influence stress as well as glycemic control such as diet, exercise, smoking, alcohol consumption, antidepressants, and diuretics. Controlling for such factors would be possible statistically; however, obtaining a sample population would require years of study. In addition, vital signs were entered into the EMR and collected by other individuals. These data points were treated as accurate; however, having numerous data collectors of varying skill levels may be viewed as a limitation of the study.

**Conclusion**

This study provides additional evidence in support of the growing body of knowledge regarding the utility of gastric ultrasonography by demonstrating a noninvasive, easy-to-use, rapid assessment of gastric contents to provide nurse anesthetists with objective data that can guide the anesthetic care plan of each patient. In addition, the study results provide insight on the increased amount of fluid present in patients with poorly controlled T2DM, as evidenced by a HbA1C greater than or equal to 7%. Also, the findings of this study shed light on common fasting instructions provided to patients preoperatively compared with the fasting guidelines recommended by the ASA.

This study raises far more questions than it answers, highlighting the need for more research regarding how much fluid is too much fluid, especially with the increasing use of Early Recovery After Surgery (ERAS) protocols. These study results provide a foundation for future research in patients who consume clear liquids up to 2 hours before surgery as well as the use of gastric ultrasonography in other comorbidities and conditions. This study also provides several opportunities to contribute to the understanding of preoperative physiologic stress and how it may affect the perioperative experience of patients.

**REFERENCES**


AUTHORS
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Richard E. Haas, PhD, CRNA, PHRN, is the principal of Eastern Consulting LLC, York, Pennsylvania.

DISCLOSURES
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Kathleen Louden, ELS, copy edited the manuscript.