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Routine Evaluation with Gastric Ultrasound to Reduce Gastric Aspiration (REGURGA)

Joel Jackson
jackson12@otterbein.edu

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Joel Jackson, BSN, RN, CCRN

Department of Nursing, Otterbein University

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DNP Final Scholarly Project Committee:

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Brian Garrett, DNP, CRNA (Project Chair/Advisor)

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Joy Shoemaker, DNP (Project Team Member)

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Amy Bishop, DNP, AGCNS (Project Team Member)

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Abstract

When a patient undergoes anesthesia, there are inherent risks that the providers should protect the patient from. Despite adherence to fasting guidelines established by the American Society of Anesthesiologists (ASA), patients undergoing anesthesia continue to experience intrapulmonary aspiration of gastric contents. There are several factors that delay gastric emptying, including coexisting disease, trauma, pain, and opioid use. Gastric ultrasound assessment of the gastric antrum is a relatively new technology in anesthesia and can be used to assess the gastric antrum and provide information to anesthesia providers regarding the risk of aspiration in the perioperative period. The primary aim of this project was to develop evidence-based practice (EBP) guidelines for using point-of-care ultrasound (POCUS) of the stomach as a preoperative aspiration risk stratification tool. In addition to the primary aim, secondary objectives included developing a comprehensive plan to implement the guidelines as established, a comprehensive plan to monitor and measure the guidelines' effect, and a comprehensive plan to adjust the guidelines if the outcomes are less than desirable. A literature search, review, and synthesis were conducted to establish the background of gastric ultrasound in anesthesia and to determine if the measurements were accurate. Guidelines were developed for theoretical implementation at a level-one trauma center in the midwestern United States. Following the implementation of the guidelines, a retrospective review will be conducted with measurement and analysis of outcomes, and adjustments will be made, if necessary, as described by the comprehensive adjustment plan. By using POCUS preoperatively, the risk of perioperative aspiration is reduced.

Keywords: Anesthesia, gastric emptying, aspiration, ultrasound, antrum

Introduction

Pulmonary aspiration has a long history of negative implications for patients undergoing anesthesia. Mendelson (1946) first described pulmonary aspiration as an asthma-like syndrome after aspiration of gastric contents during obstetric surgery. According to Mendelson (1983), he connected the dots to aspiration after he inhaled gastric fluid after a night of indulgence in alcohol. When Mendelson investigated aspiration pneumonia, the cited perioperative parturient mortality was 70% or higher. Mendelson (1946) further noted that "rapid, smooth induction, universal intubation with an inflatable endotracheal cuff; cricoid pressure to seal off the esophagus during the interval between loss of consciousness and successful intubation; and extubation after the patient is completely responsive" helped to avoid aspiration pneumonitis (p. 24). Given that the severity of aspiration is directly proportional to the acidity and volume of gastric content, researchers suggested prophylactically increasing the pH to > 2.5 and volume to < 1.5 ml/kg (Mendelson, 1946).

Intraoperative pulmonary aspiration is multi-factorial and requires an in-depth history and physical, awareness of risk stratification, techniques to avoid events, and strategies to manage an unexpectedly full stomach (Nason, 2015). The induction of anesthesia with a full stomach may result in the regurgitation of stomach contents into the pulmonary system. According to the ASA (2017), aspiration pneumonia, respiratory compromise, and related morbidities resulting from aspiration may have fatal consequences. Despite the subjective reports of compliance with established fasting guidelines from the ASA, patients continue to suffer from the sequelae associated with pulmonary aspiration of gastric contents in the perioperative period which suggests that patients provide inaccurate history of oral intake or that physiology or iatrogenic factors extend gastric emptying.

Sun et. al (2021) retrospectively reviewed 166,491 anesthetic records to establish the incidence, morbidity, and mortality associated with pulmonary aspiration events. The authors of the study found 20 cases of pulmonary aspiration (1:8,325), 20 cases of regurgitation without aspiration (1:8,325). The morbidity of pulmonary aspiration was 1:16,649 and mortality of 1:55,497. The authors of the study further noted that 76% of the regurgitation events during the induction of anesthesia resulted in aspiration. Compared to elective procedures, emergent procedures presented the highest risk. The authors reviewed anesthetic records using keywords and noted that underreporting of regurgitation and aspiration events was possible as well as aspiration events that go undetected.

Background

A comprehensive investigation into each unique patient produces a risk profile. The ASA (2017) suggests that anesthesia providers complete a thorough preoperative assessment before induction of anesthesia, including ASA physical status, age, sex, type of surgery, and adherence to fasting guidelines. To assist anesthetists in perioperative aspiration risk stratification, the ASA routinely reviews and updates guidelines for fasting recommendations. The most recent guidance given for healthy patients of all ages undergoing elective procedures includes an absolute fasting period of two hours for clear liquids, four hours for human breast milk, six hours for infant formula, nonhuman milk, and a light meal, and eight hours for fried or fatty foods and meat (American Society of Anesthesiologists, 2017). The ASA acknowledges that fasting guidelines cannot be applied ubiquitously, especially in situations where gastric emptying is affected, such as pregnancy, obesity, diabetes, hiatal hernia, gastroesophageal reflux disease (GERD), ileus, bowel obstruction, emergency care, or enteral tube feeding. Certain patients present with

indicators of complex airway management and may require additional strategies to reduce the risk of aspiration.

Traditionally, anesthetists use medications to block gastric acid secretion, increase the pH of gastric contents, promote gastric motility, and prevent nausea and vomiting for patients at risk for pulmonary aspiration (ASA, 2017). The ASA recommends that non-particulate antacids, such as sodium citrate, sodium bicarbonate, or magnesium trisilicate, be administered to increase gastric pH preoperatively to patients at an increased risk for aspiration. The ASA further recommends the use of gastrointestinal prokinetics (i.e., metoclopramide, cisapride), gastric acid secretion blockers (i.e., cimetidine, ranitidine, famotidine), proton pump inhibitors (i.e., omeprazole, lansoprazole, pantoprazole), and antiemetics (i.e., ondansetron) to patients at risk for pulmonary aspiration. Medications are not the only strategy available to reduce the risk of aspiration.

In addition to pharmacological interventions, airway management techniques used for aspiration prevention in patients vary, especially when there is perceived difficulty with intubation. In these technically complex airway cases, anesthesia providers should employ RSI (rapid sequence induction) intubation or modified RSI methods with a low threshold for awake fiberoptic intubation in patients with both aspiration and difficult airway concerns (Apfelbaum et al., 2021). In the process of RSI, pressure is applied to the cricoid cartilage at 10 Newtons (N) of force initially and 30 N upon loss of consciousness. This maneuver, known as Sellick's Maneuver, is theorized to compress the cartilaginous tracheal structures and occlude the posteriorly positioned esophagus, preventing stomach insufflation and contributing to regurgitation (El-Orbany & Connolly, 2010). While there is controversy regarding the efficacy of Sellick's Maneuver, more recent studies suggest that 30 N of force directed at the low left

paratracheal level is more effective than standard CP at preventing air entry into the esophagus and, ultimately stomach (Gautier et al., 2018).

Anesthesia providers may place nasogastric (NG) tubes into the stomach to evacuate the stomach's liquid content when attached to suction. This leaves the stomach empty aside from solid content that is too large for the bore of the NG tube. The purpose of the NG tube is to reduce the risk of gastric aspiration during induction of anesthesia. Anesthesia providers have not agreed on whether the NG tube should be placed before or after the induction sequence. Prior to induction, placing the NG tube might stimulate the gag reflex resulting in the very regurgitation the anesthetist was attempting to avoid. If placed after induction, NG tubes might also be inadvertently placed in the trachea causing pulmonary irritation or pneumothorax if advanced far enough (Motta et al., 2021).

Technological advancement in healthcare provides tools for clinician use, which yields better objective data to aid in diagnosis. The use of ultrasound revolutionized anesthesia allowing the provider to generate images using sound waves returning from organs, tissue, vasculature, nerves, and other structures (Levitov et al., 2014). Ultrasound frequencies are those greater than 20 kHz compared to the range of human hearing – 20 Hz to 20 kHz. Wavelength describes the speed of sound through a medium and is inversely related to the frequency and directly proportional to propagation speed. Propagation speed is variable and dependent on the medium through which the sound travel. Propagation is, in essence, pulsatile sound waves traveling through a medium. The energy delivered through a medium via ultrasound technology is reflected off structures back toward the transducer creating an echo. A piezoelectric element composed of ceramic crystals converts electrical energy to mechanical energy and then back to electrical energy (Levitov et al., 2014). Higher frequencies produce better image resolution of

near structures. Naturally, deeper structures require lower frequencies but are lower resolution, such as the stomach.

With the increasing availability and familiarity of ultrasound, providers find themselves using ultrasound frequently throughout the day. Despite the utility of ultrasound technology, anesthesia has been slower to adopt the tool than emergency and critical care subspecialties that care for the same patient demographics (Ramsingh et al., 2020). While not widely used throughout the field of anesthesia, some anesthesia providers use ultrasound to grade the appearance of gastric antrum qualitatively and can quantitively estimate gastric volume (Ramsingh et al., 2020). Tankul and colleagues (2022) demonstrated that while qualitative gastric ultrasound is accurate and easy to learn, quantifying gastric volume by novices is more complex and may be inaccurate without proper instruction. The Council on Accreditation of Nurse Anesthesia Education Programs began requiring gastric POCUS evaluation as a clinical experience for students starting a nurse anesthesia program after January 1, 2022, reinforcing the skill's utility (Council on Accreditation, 2021, p. 31). While many anesthesia providers in practice are unfamiliar with the advent of ultrasound, a new generation of anesthesia providers armed with the skill of POCUS will contribute to wide-spread adoption of the tool.

Significance to Nurse Anesthesia

Though the incidence of gastric aspiration is low, the complications can be significant. Sun et al. (2021) demonstrated that while the incidence of pulmonary aspiration is low, half of the patients with pulmonary aspiration required ICU admission, and three of the ten experienced aspiration-related perioperative mortality. The authors of the study noted that aspiration risks and incidence were associated with confirmed aspiration events. Within the study, out of the 4,469 who underwent emergent surgical patients who underwent rapid sequence induction (RSI),

twelve developed gastric regurgitation during induction. The data therefore suggests that traditional methods are not performed without risk.

The financial implications of aspiration events are significant as well. The most recent literature suggests that the first ventilated ICU day is the most costly at $10,794, with an average total cost of $47,158 for patients requiring mechanical ventilation during treatment (Dasta et al., 2005). In cases evaluated in the ASA Closed Claims Project, pulmonary aspiration accounted for 5% of the claims, and two-thirds of patients suffered death or permanent severe injury (Warner et al., 2021, p. 288). The authors identified risk factors for aspiration in 107 out of 115 cases with the top. The risk factors identified in the study included: emergency procedure (n=52), gastrointestinal obstruction (n=41), acute intrabdominal process (n=29), morbid obesity (n=25), diabetes (n=18), recent oral intake (n=17), recent opioid administration (n=10), major trauma (n=9), previous gastric bypass or sleeve (n=9), neurologic disease (n=6), pregnancy (n=4), and other non-specific risk factors (n=2). The authors further noted that substandard anesthetic management occurred in 89 of the 115 cases, with the top three issues identified as a lack of a nasogastric tube before aspiration (n=36), poor management of the aspiration event (n=31), and use of a supraglottic airway or mask in a patient at risk for aspiration (n=17). These findings indicate the critical need for risk reduction and employing an array of techniques, tools, and strategies to avoid morbidity, mortality, and excessive financial burden on patients and their families.

Problem Statement

(P) In patients undergoing anesthesia with specific risk-identified comorbidities or conditions, (I) would the development and implementation of EBP guidelines for evaluation of

preoperative gastric status using point-of-care ultrasound (C) versus traditional anesthetic approaches (O) affect the incidence of perioperative aspiration?

Project Objectives

The objectives of the project provide actionable and measurable goals to achieve. According to Moran et al. (2019), higher-level objectives focus on application, analysis, evaluation, creation, and communicate the project's design and guide its direction.

The objectives of the DNP project are:

1. Develop evidence-based practice (EBP) guidelines for the use of point-of-care ultrasound of the stomach as a preoperative aspiration risk stratification tool.
2. Develop a comprehensive plan to implement the guidelines related to the use of ultrasound for gastric antrum assessment.
3. Develop a comprehensive plan on how to monitor the outcomes related to perioperative aspiration.
4. Develop a comprehensive plan to adjust the guidelines if the incidence of perioperative aspiration is not desirable.

Objective one addresses the design of EBP guidelines using research-backed methods to create a deliverable package format to assess aspiration risk, which assists with disseminating findings. The development of policies is a level-six objective (Moran et al., 2019). Objective two demonstrates a level three objective by implementing the guidelines developed in the first objective (Moran et al., 2019). The project aims to establish guidelines that could be theoretically at any healthcare center where anesthesia providers care for patients.

To account for adjustments to the project, the team must have a plan to monitor the implementation and modify aspects of the practice change. The process of monitoring and

measuring (objective three) the effectiveness of the implemented guidelines describes a level five objective, which involves evaluation through monitoring and detection of undesirable or unexpected outcomes (Moran et al., 2019, Table 11.3). Analyzing and understanding data are level four and two objectives, respectively (Moran et al., 2019). Based upon the finding of the outcome analysis, adjustment of the guidelines or abandonment of the clinical practice change may be necessary. Revising the program is accomplished through objective four – a level five objective (Moran et al., 2019, Table 11.3). The success of the project can be measured, in part, by evaluating to completion of the objectives.

Project Framework

The Iowa Model (Appendix D) is an evidence-based practice (EBP) framework developed by nurses at the University of Iowa Hospitals in the 1990s and is a commonly used, multi-step implementation tool for EBP (Buckwalter et al., 2017). The Iowa Model is based on the Diffusion of Innovations theory developed by Everett Rogers in 1962, which theorizes how new ideas and technology spread (Melnyk & Fineout-Overholt, 2018). The Iowa Model has undergone several revisions to meet the EBP demands of an ever-changing healthcare system. The Iowa Model now uses a ten-step, multiphase process to implement EBP measures in healthcare and includes three distinct decision points. Buckwalter et al. (2017) demonstrated that topic priority, critique, pilot, and institute change were the most problematic steps according to participants. The authors then revised the model to its state today. The Iowa Model is an appropriate framework for implementing a point-of-care ultrasound program to stratify risk related to the regurgitation of gastric contents in the perioperative setting and is used in this project with permission from the developers (Appendix A).

Step 1: Identify Triggering Issues

The first step of the Iowa Model requires the user to identify a triggering issue that could be a clinically identified problem, organizational initiative, new evidence, accreditation or regulatory change, or philosophy of care (Cullen et al., 2017). Patients with risk factors identified in the literature review of this project present for surgery having complied with current ASA fasting guidelines that fail to address the true risk of pulmonary aspiration which may precipitate major complications and even death. At the facility where this project implements guidelines, anesthesia providers do not use ultrasound as a preoperative risk assessment tool. There is growing evidence for using ultrasound for qualitative measurement of the gastric antrum preoperatively, and patients expect healthcare providers to integrate technology into their care.

Step 2: State the Question or Purpose

After considering the triggering issue, the clinician must present the clinical problem in a uniform question format. Step two of the Iowa Model is to state the question and purpose of the inquiry (Cullen et al., 2017). Using the defined PICOT question as a framework for an EBP retains focus, guides research, and helps the team determine how to implement and evaluate the EBP initiative (Buckwalter et al., 2017). The purpose of the project is to establish the need for a change in practice, set forth EBP guidelines, and implement the guidelines while monitoring the effect. The guidelines identify populations at risk for perioperative aspiration despite adherence to fasting guidelines and progression through traditional anesthesia delivery methods.

Step 3: Decision Point 1 - Is This a Priority?

The first decision point in the Iowa Model is to decide whether the topic is a priority. Topics with importance are those aligned with organizational priorities, safety, leadership support, adequate resources, data, patient volume, and staff to move forward (Cullen et al., 2017,

p. 22). The list of potential EBP project topics is innumerable; thus, prioritization is necessary to focus on the most pressing issues. According to Buckwalter et al. (2017), patient safety, feasibility, and the existence of leadership support are among the many indications for moving forward with a topic (p. 22). Identifying individuals overseeing the care where the triggering issue arises is a starting point for inquiry.

Step 4: Form a Team

Teamwork is an essential facet of the healthcare system. Involving key stakeholders at the beginning of the EBP process is essential for a program to be successful (Cullen et al., 2017). According to Buckwalter et al. (2017), stakeholders must be convinced that and EBP project is worth the time required to implement and this includes those who might oppose it. Project leaders must consider recruiting informal team members who can provide information, secure equipment, and facilitate implementation. The project team must first obtain buy-in from the Chief Anesthesiologist, Chief CRNA, and other administrative faculty through a presentation of a set of clinical guidelines, an implementation plan, a plan for monitoring implementation and effect, and how to adjust the program based on outcome analysis. Likewise, other healthcare team members (i.e., preoperative nursing staff) must understand the purpose of the clinical practice change and how their respective roles are affected.

Next, buy-in from surgeons is necessary. Surgeons might conclude that the addition of preoperative stomach ultrasound contributes to unnecessary delays preoperatively and cancellation of cases that anesthesia previously would have performed with a statistically low incidence of aspiration. However, patient safety must remain at the forefront of the clinician's mind, and continual measurement of outcomes will demonstrate whether the program is effective at improving outcomes.

Representatives from the billing department can provide information on coding for bedside POCUS assessment. Information about revenue generation from a billable procedure shows that patient safety and financial return on investment are integral to the clinical practice change. Generation of revenue may strengthen the support for the program implementation for administrators who focus on day-to-day budget evaluation and identify the expenditure on ultrasound machines, extra training hour wages, and more tasks for staff as unproductive expenses.

Reimbursement rates for a limited abdominal ultrasound with documentation are available using the Center for Medicare and Medicaid Services Physician Fee Schedule tool. Billing for Current Procedural Terminology (CPT) code 76705 provides reimbursement of $114.76, broken down into $32.38 for professional exam performance and $82.48 for technology and supplies (Centers for Medicare and Medicaid Services, 2022). While reimbursement may vary by payor, a reasonable return on investment is feasible.

Colleagues from the information technology department can assist with the merging of still ultrasound images of the gastric antrum into the electronic medical record (EMR) as well as drop box descriptions and free text areas for further narrative description. Seamless technology integration will allow for smooth implementation and likely reduce staff frustration with the process.

Biomedical engineering can potentially relocate an existing ultrasound machine to the preoperative area and determine which locations are suitable for additional devices. Following this evaluation, the purchasing department can facilitate acquiring an ultrasound machine through the healthcare facility's vendor.

Nurses from informatics and quality assurance/quality improvement (QA/QI) are essential team members to establish baseline perioperative aspiration rates through retrospective chart review, and to monitor the program following implementation. Furthermore, these team members are well-versed in hospital policies and process improvement.

Finally, staff from the risk or legal department can help facilitate the monitoring of outcomes and potentially provide information about past litigation resulting from aspiration at the target facility. Any clinical practice change might negatively impact patients, so these team members must be involved.

Step 5: Assemble, Appraise and Synthesize Body of Evidence

When clinical practice changes happen, there must be a strong evidentiary basis for the change to deliver high quality EBP care. Assembling, appraising, and synthesizing evidence pertinent to the elements of the PICOT question allows clinicians to generate relevant, evidence-based recommendations using a transparent and reproducible process (Cullen et al., 2017). To develop EBP guidelines, a literature search and review must be completed to establish the best available evidence about gastric ultrasound in anesthesia.

Literature Search

PubMed and Otterbein OneSearch were used to collect the most up-to-date literature. PubMed is an online resource maintained by the National Institutes of Health through the National Library of Medicine and contains research, literature, and journals with over 33 million citations (PubMed, 2022). Otterbein OneSearch is operated through the Otterbein University Courtright Memorial Library and searches 299 resources for literature using the EBSCO Discovery Service (Otterbein Courtright Memorial Library, 2022).

Literature abstracts were first searched using PubMed using the operators anesthes* AND ultrasound AND aspiration AND stomach NOT pregnancy NOT obstet* NOT pediatric and were limited to peer-reviewed literature published in English in the preceding five years. The initial search resulted in 36 hits. The literature was then systematically reviewed for pertinence. Of the 36 articles, 17 were selected for inclusion (Appendix B).

Next, literature abstracts were searched using OneSearch and the operators anesthes* AND stomach AND ultrasound AND aspiration NOT pediatric NOT pregnancy NOT obstet* and limited to peer-reviewed literature published in English in the preceding five years. The initial search resulted in 29 hits. Eight results were cross-resulted in PubMed, and four were duplicates not already excluded through the discovery service. Four articles did not pertain to gastric ultrasound; thus, they were excluded. Ultimately, four papers were selected for inclusion (Appendix B).

Literature Review and Synthesis

Grading Scale. The first topic in the literature review addresses the grading scale used to describe the gastric antrum using uniform language. Healthcare providers use ultrasound to assess the quality of gastric content in the antrum and discern between an empty antrum, clear fluid, thick fluid, or solid content (Bouvet et al., 2021). In contrast to the majority of the literature reviewed, the authors used a high-risk volume cut-off of 0.8 mL/kg as opposed to 1.5 ml/kg and defined an antral CSA of >340 mm^2 as high risk with 91% specificity. Using the CSA measurement, gastric volume is estimated using a mathematical equation.

Much of the recent literature alludes to preliminary work to develop the Perlas Guidelines for gastric ultrasound. Perlas et al. (2009) first described bedside POCUS as a reliable tool to determine gastric content by evaluating the gastric antrum and establishing whether the stomach

was empty and whether the gastric content was gas, fluid, or solid. The authors first evaluated the gastric content using two-dimensional ultrasonography in 18 healthy volunteers in five prandial states (fasting, ingestion of 250 mL of water, 500 mL of water, 500 mL of effervescent water, and a solid meal). In the study's second phase, the authors demonstrated a correlation between gastric volume and the CSA of the gastric antrum. The findings of the study serve as the basis for gastric ultrasonography.

Years later, the primary investigator and colleagues published a framework for bedside gastric POCUS for aspiration risk. Given the novelty of gastric POCUS, the authors focused on mechanism-based indication rather than an evidentiary basis (Perlas et al., 2016). The authors presented their recommendations using the I-AIM (Indication, Acquisition, Interpretation, Medical Management) framework.

The indication was pre-anesthetic aspiration risk assessment in questionable fasting status, including:

1. Elective procedures with non-compliance with NPO instructions.
2. Urgent and emergent surgeries.
3. Unknown NPO status (Perlas et al., 2016, Table 1).

Acquisition involved obtaining the necessary ultrasonographic views using a low-frequency curved probe with the patient in the right lateral decubitus (RLD) position. Interpretation of the ultrasound image graded the appearance of the gastric antrum where Grade 0 was an empty stomach with a bull's eye pattern, Grade 1 suggested low gastric volume in the RLD only, and Grade II suggested high gastric volume when the authors saw hypoechoic content in the RLD and supine positions. The authors described the appearance of hyperechoic or heterogeneous content and a distended gastric antrum as thick fluid or solid content separately.

Finally, the authors related the images to the clinical context (history and physical, elective vs. urgent vs. emergent procedure, time since last meal, type and amount of meal, and other aspiration risk factors including diabetes, GERD, stroke, active labor, and neuromuscular disease) with adequate, technically difficult, or inadequate ultrasound imaging. The authors classified the images into three categories:

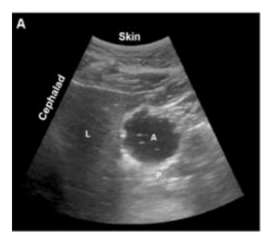
1. Empty stomach or baseline gastric secretions suggesting low aspiration risk,

2. Clear fluid content (>1.5 ml/kg derived from volume (mL) + 27 + 14.6 x right lateral CSA – 1.28 x age) suggesting higher than baseline gastric secretions and a high aspiration risk, and

3. Thick or solid content suggests high aspiration risk.

Medical decision-making involved deciding on anesthetic timing (proceed, delay, cancel), deciding the anesthetic technique (general vs. regional anesthesia), and determining aspiration precautions (need for intubation, rapid sequence induction, nasogastric tube placement).

Another study used the Perlas grading scale as part of their research. Shorbagy et al. (2021) echoed the gastric antrum descriptions established by Perlas et al. (2009). The authors noted that a Grade 0 antrum appeared like a bullseye pattern (Figure 3). In contrast, the researchers described a Grade 1, fluid-filled antrum as a starry night using ultrasound technology (Figure 4a). A Grade II antrum containing solid content appeared to be frosted glass to the researchers, which conferred the most significant aspiration risk (Figure 5).



In the selected literature for the project, 18 studies used the Perlas grading scale to indicate the state of the gastric antrum in addition to formula-

derived gastric volume estimation. One literature review by Xiao et al. (2021) and one editorial by Bouvet et al. (2021) did not independently address gastric ultrasound. One case report was published regarding qualitative assessment alone (Falyar & Kantzavelos, 2018). The available research collected in the literature search bear many similarities which strengthens the evidence for uniform grading.

One study measured the gastric antral CSA alone in 300 patients who fasted for at least six hours before unplanned surgery. They established that body mass index and morphine administration were associated with larger gastric areas (P=0.01, 0.04, respectively) (Dupont et al., 2017, p. 1114). The authors concluded that fasting time was not associated with the gastric area; therefore, fasting time alone should not serve as a ubiquitous measure of safety. "Stomach emptying may be delayed in patients awaiting unplanned surgery due to stress, pain, or opiate analgesia" in addition to medications and disease processes (p. 1112).

Ohashi et al. (2018) evaluated the stomachs of 222 fasted patients scheduled for surgery and demonstrated that 4.1% of patients had gastric residual volumes of >100 mL and 2.7% had volumes that exceeded >1.5 mL/kg, which researchers suggest is the cut-off for safe gastric volume (p. 610). The authors noted that their analysis failed to predict increased gastric residual volume based on risk factors such as BMI, GERD, and ASA status (p. 611). However, the authors acknowledge the relatively low power of this aspect of their work.

Work by Van de Putte et al. (2017) evaluated 538 patients compliant with fasting instructions before surgery (2 hours for clear fluids, 6 hours for a light meal, and 8 hours for fried or fatty food). They completed conclusive ultrasound examinations in 512 patients and found that 32 (6.2%) had a full stomach (Van de Putte et al., 2017, p. 366). Of the 32, 9 (1.7%) had solid content, and 23 (4.5%) had a clear fluid volume of greater than 1.5 ml/kg (p. 366). Only six

of the 32 patients with full stomachs had a risk factor disposing them to delayed gastric emptying (GERD, diabetes, chronic neurological disease, and cannabis use). The authors of the study suggested that despite their findings, anesthesia providers should not scan every patient presenting for surgery with ultrasound, but if any doubt about gastric volume exists, providers should conduct an ultrasound exam. The authors suggest that appropriate scenarios for gastric ultrasound are urgent/emergency surgery, diabetes, renal or liver dysfunction, neurological disorders, an unclear history, or lack of adherence to fasting instructions. Scanning every patient for surgery would, indeed, cause significant delays.

In summary, recent studies validated the grading system developed by Perlas and colleagues (2009). All the researchers agreed that an antrum collapsed – a *bullseye* antrum – conferred a low risk for aspiration. A *starry night* indicated the presence of fluid in the stomach, which warranted further investigation of fasting history and oral intake. Finally, solid content in the stomach gave an appearance of frosted glass and spurred concern for high aspiration risk. Furthermore, the common theme among studies was that 1.5 ml/kg of fluid in the RLD is a reasonable cut-off for full stomach designation. The culmination of these findings suggests that the Perlas grading scale and volume estimation are appropriate for use in a clinical practice change in the project.

Disease-related Delayed Gastric Emptying. There are many contributing factors to gastric volume and clearance. Sabry et al. (2019) evaluated 50 patients who fasted for eight hours, half of which were diabetics with a six-year history of the disease and demonstrated that the patients in the diabetic group had a higher median cross-sectional area (CSA) on ultrasound (13.8 mm^2 compared to 8.8 mm^2), higher gastric residual volume (177 mL versus 83 mL), and higher volume upon aspiration of a nasogastric tube (150 mL versus 75 mL) compared to the

nondiabetic control group. The authors noted a strong correlation between calculated and aspirated volumes.

Similarly, Zhou et al. (2019) showed that nearly half of the diabetic patients studied had full stomachs after following preoperative fasting guidelines. Zhou et al. (2019) evaluated 108 patients, 52 of which had non-insulin-dependent diabetes mellitus and 50 that did not (p. 5). Researchers excluded six patients enrolled in the study due to the inability to visualize the gastric antrum with ultrasound. A total of fifty-seven patients, 18 of which were non-diabetics, were found to have intermediate or full stomachs and were subsequently reassessed with ultrasound every ten minutes until researchers detected an empty stomach. The authors determined that diabetics took 146.5 minutes compared to 124.5 minutes (p=0.014) for nondiabetics following clear liquid ingestion and 426.5 minutes versus 370 minutes (p=0.042) following a light meal (Zhou et al., 2019, p. 5). Overall, diabetic patients had a higher prevalence of full stomach when compared to nondiabetic patients (48.1% vs. 8.00%, P=0.000) after fasting for two hours following clear liquids and six hours following a meal. Finally, the researchers noted a correlation between diabetes-related eye disease and full stomach determination amongst the diabetic patients studied (p=0.026), suggesting that the degree of illness increases the likelihood of delayed gastric emptying.

Contrary to the previous findings, other researchers demonstrated that although 23 out of the 53 patients studied had delayed gastric emptying predisposing factors (DGEF), only one patient had gastric volume putting the patient at a higher risk of aspiration (1.57 ml/kg) as indicated by ultrasound following a 12 hour fast (Castañer et al., 2020, p. 486). The authors defined DGEF as diabetes mellitus, previous abdominal surgery, chronic opioid treatment, GERD, irritable bowel syndrome (IBS), and renal or hepatic disease. Obesity limited gastric

antrum assessment in two of the 53 patients evaluated. Researchers could not visualize one antrum due to gastric anatomy.

The literature suggests that diabetes is not the only predictive medical disease than can cause a patient to have delayed gastric emptying. Gupta and colleagues (2020) evaluated the stomachs of 200 end-stage renal disease (ESRD) patients following a light meal's recommended six-hour fasting period. The authors excluded patients with diabetes, gastrointestinal disease, and allergies to metoclopramide. The authors then randomized patients; half of the patients (Group A) received a placebo intervention, while half received oral metoclopramide, 10 mg. Clinicians scanned patients using ultrasound following six hours of fasting. The authors found that 14% of patients in the placebo group had empty stomachs using the Perlas criteria compared to 71% (P=<0.001) in the intervention group. The authors concluded that current ASA guidelines fail to address all comorbidities and increase the risk for pulmonary aspiration.

Delaying surgery or delivering conservative anesthesia management both pose potential risks to patients. Case reports suggest that patients with significant comorbid disease (ASA III) requiring emergent surgery can undergo less conservative anesthetic management (i.e., monitored anesthesia care) when anesthesia providers use ultrasound to evaluate the stomach in cases with questionable or unknown fasting status (Falyar & Kantzavelos, 2018). While the goal of ultrasound assessment of the gastric antrum is to identity full stomachs, identifying an empty stomach can impact patients, too.

Gastric Emptying in the Critically Ill. Two studies in the literature search evaluated the utility of ultrasound measurement of stomach contents in critically ill ICU patients. The purpose of both studies was to establish stomach status near endotracheal extubation and liberation from mechanical ventilation.

The first study reviewed addresses a population of patients who may require surgical intervention. Nguyen et al. (2021) evaluated 100 ICU patients receiving enteral nutrition who fasted for less than six hours, at least six hours, or had not received enteral nutrition for 48 hours before scanning. Of the patients scanned, 65 had empty stomachs, 10 had liquid content, and 25 had solid content. Most notably, 17 patients who had fasted for greater than six hours or had not received enteral nutrition had thick fluid or solid content in their stomachs (Nguyen et al., 2021). These findings suggest that ICU patients may have full stomachs despite fasting, which may have implications for nurse anesthetists managing the critically ill in the operating room or emergency airway encounters throughout the hospital.

According to the literature, delayed gastric emptying, diabetes, renal disease, and critical illness appear to have the most substantial effect on slowing the clearance of stomach contents. Researchers agree that previous abdominal surgery, GERD, acute and chronic opioid use, and diseases affecting the nervous system play a role in gastric emptying. Thus, the patient populations evaluated in the literature serve as reasonable indicators for preoperative assessment of the gastric antrum with ultrasound. Notably, morbid obesity presents a challenge for clinicians interested in examining the gastric antrum.

Accuracy of Measurements. The accuracy of measurements is an important consideration. Kruisselbrink et al. (2019) randomized 42 fasted participants into three equal groups on two separate occasions 24 hours apart to establish the sensitivity and specificity of gastric ultrasound. The first group remained fasted, the second ingested 250 mL of apple juice, and the third consumed a muffin and cup of coffee with cream. Two patients presented with full stomachs at baseline despite prolonged fasting, which alone produces concern. After three minutes, a blinded anesthesiologist assessed the gastric antrum of all participants. Out of the 80

assessments, the scanner identified 40 full stomach true positives and 39 fasted true negatives. Using a 95% CI, the researchers demonstrated a sensitivity of 1.0 and a specificity of 0.975 with meager rates of false negatives or false positives. The findings of the study suggest that the intervention is sensitive, specific, and useful.

A strikingly similar study by Johnson et al. (2021) investigated the sensitivity and specificity of gastric ultrasound by randomizing 42 participants into three equal groups. Each group either remained fasted, consumed one donut, or ingested 360 mL of water. Following an eight-hour fast, a scanner blinded to the randomization recorded examinations which two additional sonographic experts then scored using the Perlas guidelines. The researchers determined that the sensitivity was between 95 and 100% for liquids but less sensitive for fasted or solid ingestion patients (45-60%, 87.5.-90%, respectively). Specificity was 87.5-90% for liquids, 80-90% for solids, and 90-87.5% for fasted patients. The researchers reported a false negative rate as high as 55% for fasted patients and those who ingested solids and false negative rates as high as 20% in the same cohorts.

Another study compared calculated volume and measured volume. Segura-Grau et al. (2021) compared the estimated gastric volume determined by ultrasound with suctioned volume by endoscopy in 40 patients who fasted from solid content for ten hours and liquid content for four hours. The researchers could not visualize the gastric antrum in two patients with a BMI greater than 40 kg/m^2 and showed no difference between calculated and measured volumes using the most accepted method in the literature ($V3 = 27.0 + 14.6 \times$ right lateral $CSA - 1.28 \times age$). All the patients evaluated had gastric volumes of <1.5 ml/kg after fasting. The findings of the study suggest that measurement of gastric volume with ultrasound is accurate.

The literature review identified a study that assessed the accuracy of ultrasound evaluation in untrained hands. Tankul et al. (2022) studied the gastric ultrasound scanning of two regional anesthesiologists who were not previously trained in the skill. The anesthesiologists completed self-directed training through online materials and hands-on practice for qualitative and quantitative assessment of the gastric antrum. Following education, the anesthesiologists scanned 47 randomized participants who were told to fast for eight hours before presenting to the study site. The researchers randomized study participants into five groups who either: fasted, ingested 100, 200, or 300 mL of apple juice, or ingested solid food. After five minutes, the newly trained blinded anesthesiologists scanned the participants randomly, graded the gastric antrum using the Perlas criteria, and measured the volume when indicated.

Tankul et. al (2022) established a success rate of 96% between the two anesthesiologists in correctly identifying the grade of the gastric antrum and ingested volumes. There was no significant difference in the time required to complete the examinations by the newly trained anesthesiologists (P= >0.05). The results of the study establish that anesthesia providers can quickly and accurately describe aspiration risk using ultrasound.

The totality of available evidence about the accuracy of volume estimation is substantial. There is no more significant evidence than estimating volume with ultrasound and subsequently withdrawing the stomach's contents for volumetric measurement. These findings suggest that adequately trained anesthesia providers can use ultrasound to estimate the volume of stomach content in the preoperative patient. When paired with qualitative assessment, providers can rapidly stratify aspiration risk and modify the anesthetic plan if necessary.

Affecting Clinical Practice. An important consideration in the project is how the proposed clinical practice change has been used previously. Cieslak et al. (2020) completed a

multifaceted project that studied gastric ultrasound preoperatively, surveyed anesthesia providers before and after ultrasound scanning, and recorded changes in anesthetic management that resulted from the ultrasound assessments. The authors analyzed 28 anesthesia providers about the criteria they use to assess aspiration risk in patients receiving general anesthetics. The top three factors for choosing RSI intubation were "a full stomach, pregnancy, and emergency surgery" (Cieslak et al., 2020, p. 110).

Next, a sonographer scanned 100 fasted patients and recorded the exams, which anesthesia providers then viewed before the patient's surgery (Cieslak et al., 2020). The study dictated that patients are not less than 18 years old, pregnant, scheduled for monitored anesthesia care (MAC), or have a BMI > 40 kg/m^2. The study found that 14% of the patients scanned were determined to have solid content in their stomachs, whereas 7% had clear liquids present, with three patients having "substantial (> 100 mL) gastric content despite following fasting guidelines" (p. 107). After anesthesia providers assessed the ultrasound scans, there was a 9% change in the anesthetic plan, 6% of which included changing from standard induction to modified RSI and 3% to RSI with cricoid pressure (Cieslak et al., 2020, p. 110).

The authors then surveyed anesthesia providers about the value of gastric ultrasound. They demonstrated that 75.5% of respondents maintained that routine gastric ultrasound was indicated in certain situations, such as "unclear nothing-by-mouth status, trauma/emergency cases, and pregnant patients" (Cieslak et al., 2020, p. 110). The majority of respondents (92%) did not feel that preoperative gastric ultrasound would delay surgery.

Another study evaluated the stomachs of trauma patients requiring surgery. Shorbagy et al. (2021) evaluated 45 polytrauma patients requiring emergency surgery who were 18 years or older with a GCS >10 and were not pregnant, lacked a basilar skull fracture, severe bleeding, and

a history of upper GI disorders, hiatal hernias, GI cancer, upper GI surgery, or GERD. The patients scanned with ultrasound had various fasting times and ingested content.

Using the Perlas classification criteria, ten patients had empty stomachs, while 35 had full stomachs (Shorbagy et al., 2021). Of the 35 full stomachs, 29 had solid content, and 6 had clear fluid measuring > 1.5 ml/kg (p. 7). Providers placed an NG tube in patients with full stomachs and observed a good correlation between estimated volumes and aspirated gastric content through the tubes (200 mL, 190 mL, respectively; $P = <0.001$). Finally, anesthetic management plans changed in 14 instances, with 12 receiving more conservative management (i.e., RSI) and two more liberal management.

Another study addressed fasting practices of outpatient surgery centers. Kaydu and Gokcek (2019) reported that none of the ophthalmologists they surveyed ($n = 7$) implemented fasting guidelines for patients undergoing cataract surgery. The researchers determined that out of the 60 patients scanned with ultrasound, 65% had solid content in their stomachs, 20% had liquid content, and 15% were empty. In 58.33% of patients, the estimated gastric volume was greater than 0.8 ml/kg, and 33% exceeded 1.5 ml/kg. Gastric antral CSA was greater than 340 mm^2 in 98.5% of patients. The findings of the study are concerning from an anesthetic standpoint.

Finally, a study evaluated risk management using gastric ultrasound in surgical patients. Van de Putte et al. (2018) examined 37 patients scheduled for surgery with ultrasound to determine at-risk stomach states and how the imaging affected risk stratification for aspiration. The patients fasted for varying amounts of time. The researchers demonstrated that 14 patients had empty stomachs while 23 had full stomachs. Of the 23 with full stomachs, 14 had solid

content, and eight had liquid volume measuring > 1.5 ml/kg. These findings require the anesthetist to mitigate risk.

The anesthetic management plan changed in 24 patients studied (Van de Putte et al., 2018). The anesthesia providers determined that three patients could safely receive more liberal anesthetics (i.e., laryngeal mask airway instead of endotracheal tube). In 14 patients, surgical delay and cancellation were avoided because ultrasound assessment suggested low-aspiration risks when current guidelines would lead to postponing surgery. In seven cases, patients were at higher risk for aspiration, resulting in one cancellation, four surgical delays, and two receiving a more conservative anesthetic (i.e., RSI). This study exemplifies the utility of ultrasound as an assessment tool.

The evidence in the section discussing the effect of ultrasound assessment on clinical practice is among the more critical literature in the search and review for this project. Researchers demonstrated that anesthesia providers utilized ultrasound to make clinical decisions in the interest of patient safety. While this project focuses on identifying at-risk patients, an added benefit is confirming that a formerly high-risk patient has an empty stomach which might allow a more liberal anesthetic. Some patients presenting for surgery may not tolerate the effects of general anesthesia. In this population, monitored anesthesia care (MAC) may be permitted if a traditionally high-risk patient is down-graded to low aspiration risk.

Limitations. Many studies cited an inability to visualize the gastric antrum in some of the population, mainly due to obesity (BMI >35 kg/m^2) or prior gastroesophageal disease. One case report that resulted in the literature search discussed the lack of data for the use of gastric ultrasound in patients with previous anatomy-altering gastric surgery, such as Roux-en-Y,

despite an increase in the frequency of bariatric surgery (Pai et al., 2019). Such a limitation must be considered in the development of clinical practice guidelines.

There are other limitations noted in the literature. Dupont et al. (2017) noted that despite evidence of reliability in ultrasound measurement of the gastric antrum, some patients might not tolerate the necessary position changes to properly assess antral CSA, such as in hip fracture patients. The authors also reported the inability to visualize the gastric antrum in 12% (37/300) of the studied population. The project must address potential limitations so that anesthesia providers have a clear direction for the clinical practice change.

Step 6: Decision Point 2 - Is There Sufficient Evidence?

After synthesizing the evidence, the project team must put the evidence into action after weighing the level of evidence, risk versus benefit to patients and decide if the evidence is sufficient to support a change in clinical practice (Cullen et al., 2017). Indications to move forward include repeated themes in several articles, similar conclusions among references, sufficient research to organize the papers by study design, and at least one relevant clinical practice guideline (Cullen et al., 2017).

Although none were large, multicenter trials, nearly all the studies came to similar conclusions. Furthermore, there is strong evidence that ultrasound assessment of the gastric antrum is accurate. Work performed by Ciselak et al. (2020) demonstrated the use of guidelines and measured anesthetic management changes following gastric ultrasound. Early work by Perlas et al. (2009) established clear criteria for assessing aspiration risk in preoperative patients. All the evidence evaluated in the literature search and review validated the criteria established in the hallmark literature by Perlas and colleagues. Therefore, there is sufficient evidence to move forward with a clinical practice change.

Step 7: Design and Pilot the Practice Change

The project's first objective is to develop EBP guidelines for the use of point-of-care ultrasound of the stomach as a preoperative aspiration risk stratification tool. Step 7 of the Iowa Model is to design and pilot the practice change. The project design necessitates a defined setting for the practice change and the methods by which the team will carry out the practice change. The project uses a synthesis of existing literature to implement EBP guidelines and therefore does not constitute research, nor does it evaluate human subjects in the clinical area in an experimental fashion.

Setting

The setting for implementing the proposed clinical practice change is a large, urban level one trauma center in the midwestern United States. The surgical population includes outpatient and inpatient procedures, with patients receiving preoperative instruction to fast under current ASA fasting guidelines. Patients undergo preoperative testing and physical evaluation by an anesthesiologist, CRNA, or both. Furthermore, the target healthcare facility for guideline implementation employs anesthesia providers with a baseline knowledge of ultrasound physics, machine operation, and patient evaluation using the technology.

The ideal facility is one with a high operating tempo with a mixed population of patients ranging from ASA Physical Status I to V. ASA Physical Status is used to describe perioperative risk relative to pre-anesthesia medical comorbidities with further consideration given to the type of surgery and level of deconditioning (American Society of Anesthesiologists, 2020). The American Society of Anesthesiologists defines ASA Physical Status I as a normal, healthy patient. In contrast, ASA Physical Status V refers to moribund patients who are not expected to

survive without surgery. ASA physical status is standardized terminology within the anesthetic practice to communicate risk and guide clinical decision-making.

A sizeable surgical center allows for a varied patient population and benefits centers where patients present with medical and trauma emergencies requiring urgent or emergent surgical procedures. Warner et al. (2021) identified emergency surgical procedures as a critical risk factor for aspiration by evaluating 115 closed claims about the aspiration of gastric contents related to anesthesia (p. 287).

Methods

Anesthesia providers will receive a one-hour block of education on how to utilize ultrasound to assess the gastric antrum qualitatively and quantitatively. During this time, a guideline document will be dispersed to the providers, which includes inclusion criteria, grading criteria for the gastric antrum. In addition, the providers will receive education on using the EMR flowsheet for documentation of the ultrasound exam.

Inclusion criteria for using gastric POCUS preoperatively are derived from the literature search, review, and synthesis. Patients that warrant per-operative gastric assessment preoperatively include:

1. Unknown/uncertain NPO status, including those with acutely or chronically altered mental status (intoxication, dementia, etc.)
2. Type I and II diabetics
3. End-stage renal disease
4. Liver disease
5. Critical illness
6. Neuromuscular disorders

7. Acute pain, opioid use

Following ultrasonographic assessment of the gastric antrum, anesthesia providers must make clinical decisions based on their assessment. Patients with empty stomachs (Grade 0) are at low risk for aspiration, and modification of the anesthetic plan is unnecessary. For patients with fluid in their stomachs (Grade I) in the right lateral decubitus position alone measuring <1.5 ml/kg, there is a low aspiration risk, and modification of the anesthetic plan is unnecessary.

High risk for aspiration is assigned to patients with fluid in their stomachs (Grade I) measuring >1.5 ml/kg, and elective surgery should be delayed or canceled. Likewise, when there is fluid in the stomach in both the supine and right lateral decubitus position or if solid matter is present (Grade II), the patient is at high risk for aspiration, and anesthesia providers should modify the timing of surgery. When delaying surgery is not feasible (emergent surgery, for example), anesthesia providers should maximize risk reduction strategies such as gastric pH modifiers, gastrointestinal prokinetics, preoperative nasogastric tube placement, and RSI intubation.

The EMR department will develop a point-and-click form for the preoperative gastric ultrasound to capture data for analysis. The form will include qualitative grading (Grade 0, Grade I, Grade II), patient position, and cross-sectional area, which auto-calculates the estimated gastric volume using the patient's most recently filed weight. Suppose the anesthesia provider determines the patient is at high risk for aspiration. In that case, they will indicate this by checking "high risk" and dictate risk reduction strategies to be employed in the case of unavoidable emergent surgery. Additional checkboxes will indicate whether they delayed or canceled the case based on the ultrasound assessment. The post-anesthesia evaluation progress note will include "do you suspect perioperative aspiration?" as part of the smart text. Including

this modification will allow for the collection of aspiration data (chest imaging, need for ventilation, death, etc.) when the project team evaluates the QI project per the project timeline.

Step 8: Decision Point 3 - Is Change Appropriate for Adoption in Practice?

The Iowa Model framework suggests alternatives if the project team decides that adopting the clinical change is inappropriate following pilot implementation. Cullen et al. (2017) suggest the following as indications to consider alternatives:

- Pilot data show no or equivocal improvement with the practice change
- Risks identified by balancing measures outweigh the benefits
- Challenges to intervention fidelity and integration persist
- Clinicians are resistant to change in practice
- The population is different from the pilot/evidence, or the population had changed since the pilot
- New barriers to practice changes are identified
- Old practice habits persist.

The fourth objective of this project is to develop a comprehensive plan to adjust the guidelines if the outcomes are less than desirable, which is addressed separately in Step 9 below. If clinicians are receptive to change and evidence suggests that the practice change is better than the current practice, then the change is appropriate for adoption into clinical practice (Cullen et al., 2017).

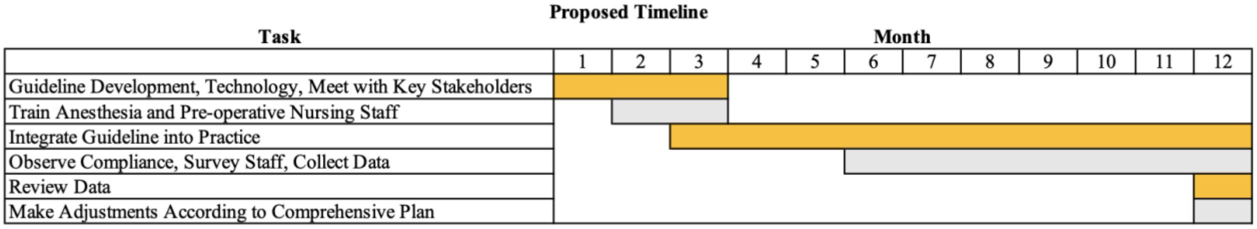
Step 9: Integrate and Sustain Practice Change

Proposed Timeline

The proposed timeline for project implementation spans a total of twelve months. It encompasses all phases of the project, including guideline development, training staff,

integrating the clinical practice change, and monitoring progress, including outcomes. The proposed timeline is summarized in the table below.

Proposed Timeline



In the first month, the project team develops a one-page guideline with relevant data, imaging, and pertinent information about criteria and inclusion for preoperative ultrasound imaging (Appendix C). The team then shares the document with the Chief Anesthesiologist, CRNA, and other key stakeholders who will help facilitate integration into clinical practice. Additionally, representatives from the information technology, biomedical engineering, and billing departments will work to integrate ultrasound technology with the EMR for imaging upload and establish how the hospital will bill for the examinations will be indicated within anesthesia charting.

Biomedical engineering will work with anesthesia providers to determine the best location for an ultrasound designated for a gastric ultrasound examination. The biomedical engineering team will also facilitate purchasing the portable ultrasounds.

During the second month, the project team will train anesthesia providers in gastric ultrasound. During training sessions, the project team will disseminate the guideline document electronically and as a physical printout. The training session also covers guidance for appropriately recording the ultrasound examinations within the EMR.

Preoperative nursing staff and anesthesia technicians receive training using a brief electronic education presentation (i.e., HealthStream). Training these team members on the

necessary equipment for examination and including target patient populations facilitates timely assessment and minimizes delays.

In months three through six, the guidelines are integrated into practice. As with any new process, challenges may arise which may require intervention. Month three marks the beginning of the data set reviewed in the twelfth month. At the end of the sixth month, the project team observes daily processes for compliance with the guidelines. Anesthesia staff will provide feedback to identify opportunities for improvement, challenges experienced, and the perceived benefit of the clinical practice change.

At the end of the final month, the informatics department organizes data for review by stakeholders. Critical data to be examined are the number of ultrasound examinations performed, the number of aspiration events, if any, the number of cases delayed or canceled by anesthesia because of full stomach status on ultrasound examination, and exams not performed when indicated.

Proposed Budget

The total budget for this project is $13,588.20. The two main expenditures for the project are an ultrasound machine and wages for training staff. The cost of materials for printed guideline handouts is estimated to be $50.00. The author donates time to research, guideline development, and education development.

Pricing for an ultrasound machine varies based on the model and probes included. The MSRP for a handheld, portable Butterfly ultrasound is $2,399 (Butterfly Network, 2022)**.** Three Butterfly ultrasounds will be in the preoperative area totaling $7,197. Ideally, the facility would already have several of these portable ultrasounds to be used by staff. It would be reasonable to suggest one ultrasound machine per 8 preoperative holding rooms.

Training of anesthesia staff occurs outside of scheduled hours and takes one hour to complete. The cost to complete the training depends on the number of personnel to be trained but is estimated to be $6,341.20 for ten anesthesiologists and 40 CRNAs using recent Ohio salary data (Salary.com, 2022). These expenses can be offset by the previously established reimbursement rates for ultrasound examinations.

Monitoring Outcomes

The monitoring of outcomes fulfills objective three of the project. According to Cullen et al. (2017), comprehensive evaluation plans consider knowledge, perceptions or attitudes, behaviors or practices, outcomes, and balancing measures. The chief method by which the project team will measure outcomes is through retrospective chart review via charting data compilation by the EMR, QI, and Informatics departments. The outcomes of interest are aspiration incidence, stomachs identified as full, and surgical delays, whether necessary or unnecessary.

The PICOT question driving this project considers perioperative aspiration events as the primary outcome. Should aspiration events increase, several phenomena are possible. First, anesthesia providers may incorrectly identify patients with a low risk for aspiration. Inaccuracy in ultrasound assessment might lead to inappropriate liberal anesthetic management when a more conservative approach is warranted (i.e., RSI). The project team will monitor the accuracy of ultrasound interpretation through random retrospective evaluation of stored ultrasound images. If inaccuracies are detected, the QI program would need to be put on hold until re-education could commence. Another possibility for increased aspiration events is that despite high-risk categorization and maximal risk reduction, patients aspirate due to surgical emergency. Such an

unfortunately unavoidable instance warrants thorough review through traditional root cause analysis.

The next metric project facilitators are interested in is the number of high-risk patients identified. This data will be auto-populated through the action of the anesthesia provider indicating "high risk" in the preoperative ultrasound flowsheet. An increase in the identification of full stomachs is an expected outcome. Such a finding suggests that patients who were otherwise prepared for surgery following compliance with fasting guidelines were at higher risk when anesthesia providers would have otherwise proceeded normally with the anesthetic.

Finally, the project team is interested in quantifying surgical delays. In the context of this project, surgical delays include delaying surgery to allow for gastric clearance, case cancellation, and other surgical delays caused by the QI intervention. Surgical delays allow more time for the stomach to clear its contents, resulting in less regurgitation and pulmonary aspiration risk. The project team will compile and analyze data regarding surgical delays and cancellations.

Information about surgical delays caused by the new preoperative ultrasound assessment intervention is also essential. A few minutes of delay per surgical case culminates into lengthy surgical delays, which may stress an already overbooked surgical day. Feedback from perioperative staff is essential to determine the fluidity of the clinical practice change. There may be a discrepancy between perceived and actual delays, which would warrant further investigation should staff indicate that they believe the program is causing a surgical delay.

Feedback from staff will be pursued in month six of the project implementation through QR codes posted throughout the operative area. The chief anesthesiologist and CRNA will be responsible for generating questions to ensure the clinical practice change is functioning as intended and is achieving organizational goals. Once questionnaire results are received, the chief

anesthesiologist and CRNA will provide a summary of responses to the project team for consideration. A collaborative effort will allow for seamless adjustment of recommendations if modification is required.

Overall, the project team will consider the clinical practice change effective if aspiration incidence decreases, identifies full stomach patients, and the project does not create unwarranted surgical delays. Surgical delay and cancellation are expected outcomes and demonstrate that safer anesthesia is being provided and ultimately benefits patients despite the delay of care.

Adjustment Plan

The fourth objective of this project is to develop a comprehensive plan to adjust the guidelines if the outcomes are less than desirable. The two indicators of the need for guideline modification are aspiration incidence and feedback from anesthesia providers, surgeons, and perioperative staff.

The project team will consider the need for further education for anesthesia providers if monitoring indicates inaccuracies in ultrasound interpretation. The team will involve the Chief of Anesthesia in the case of adjustments to education, as this will require scheduled time to provide education.

After reviewing feedback from the involved staff, adjustments may be necessary. Nursing staff involved in the process will likely give suggestions to improve the workflow. If adjustments to the clinical practice change are required, involving a nursing representative may improve clarity and encourage involvement, ultimately producing a more successful program.

Anesthesia providers might not readily adopt the clinical practice change. Given the relative infrequency of aspiration, anesthesia providers might see the added assessment as a waste of time. Changing someone's behavior, attitude, or perception can be challenging. If there

is a reluctance to change, the project team would be wise to investigate the source of the opposition to establish what could improve the change.

Step 10: Disseminate Results

Following the pilot evaluation of data and measuring outcomes, data is compiled into an infographic and disseminated through email by the Chief Anesthesiologist and CRNA. Results of the project will be internally disseminated and include a summary of evidence, proposed practice change, details about implementation, and evaluation findings (Buckwalter et al., 2017).

External sharing of the evaluation bolsters nursing science and will be accomplished through a poster presentation. External dissemination will occur only after organizational approval. The project results will also be shared with the Otterbein – OhioHealth Nurse Anesthesia Program.

Guideline Recommendation

Recommendation #1

All anesthesia providers should receive education, including hands-on practice, about qualitative gastric antrum assessment and quantitative gastric volume estimation.

Recommendation #2

Patients that warrant preoperative ultrasound assessment of the gastric antrum are those with:

1. Unknown/uncertain NPO status, including those with acutely or chronically altered mental status (intoxication, dementia, etc.)
2. Type I and II diabetics
3. End-stage renal disease
4. Liver disease
5. Critical illness

6. Neuromuscular disorders
7. Acute pain, opioid use

Recommendation #3

Anesthesia providers will document ultrasound imaging and interpretation in the EMR, evaluate the anesthesia plan, and make modifications if indicated. Recommended modifications are:

1. If the urgency of the surgery allows, delay or cancel surgical cases for a patient with a Grade 1 antrum and estimated gastric volume of >1.5 ml/kg in the RLD position or those with a Grade 2 antrum in any position.
2. If the surgery must be performed, consider preoperative premedication, preoperative nasogastric tube suctioning, and RSI intubation.

Conclusion

Ultrasound is a highly sensitive and specific assessment tool anesthesia providers should use to assess aspiration risk in patients with diseases or conditions that delay gastric emptying. Current ASA guidelines do not consider individual risk factors for aspiration yet are applied to all surgical patients thereby creating a patient safety issue. When patients aspirate despite following guidelines and receiving maximal risk reduction, there is a risk of serious complications including death. Should the patient survive the complications, a heavy financial burden awaits them. This project proposed evidence-based guidelines for the routine use of gastric ultrasound to reduce gastric aspiration events in the perioperative period. The proposed guidelines provide direction for anesthesia providers based on their ultrasound assessment of the gastric antrum and suggest management strategies in cases where delaying or cancelling the surgery of a patient with a full stomach cannot be avoided. The patients that anesthesia providers serve deserve safe, equitable care using the best evidence-based strategies.

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Appendix A

Iowa Model Permission

From: **Kimberly Jordan - University of Iowa Hospitals and Clinics** survey-bounce@survey.uiowa.edu
Subject: Permission to Use The Iowa Model Revised: Evidence-Based Practice to Promote Excellence in Health Care
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Appendix B

Literature Review Table

Citation	Purpose	Design/Method	Sample/Setting	Major Variables; definitions	Outcome Measurement	Data Analysis	Findings	Level of Evidence	Quality of Evidence
Bouvet, L., Zieleskiewicz, L., & Hamada, S. R. (2021). Point-of-care gastric ultrasound: An essential tool for an individualised management in anaesthesia and critical care. *Anaesthesia Critical Care & Pain Medicine*, *40*(6), 363–371. https://doi.org/10.1016/j.accpm.2021.100984	Editorial; brief review	Editorial	NA	NA	NA	NA	NA	V	C
Castañer, H., Vendrell Jordà, M., Sala Blanch, X., & Valero, R. (2020). Preoperative bedside ultrasound assessment of gastric volume and evaluation of predisposing factors for delayed gastric emptying: A case–control observational study. *Journal of Clinical Monitoring and Computing*, *35*(3), 483–489. https://doi.org/10.1007/s10877-020-00489-9	Compare gastric antrum on ultrasound of patients with delayed gastric emptying factors to those without after 12 hours fasting	Prospective observational	53 patients; 23 with delayed gastric emptying factors, Excluded age <18 years, ASA IV, pregnant women, BMI > 40 kg/m^2, refusal, history of gastric surgery	Comorbidities Calculated gastric volume	Evaluate differences between patients with comorbidities for delayed gastric emptying Gastric volume in patients undergoing perioperative fasting	T-test;Chi-square	Delayed gastric emptying factors: 14 (66.7%) empty stomach, 7 (33%) non-empty stomach Non-delayed gastric emptying factors: 17 (62.3%) empty stomach, 10 (37%) non-empty stomach	II	B
Cieslak, J., Rice, A., Gadsden, J., & Vacchiano, C. (2020). Does ultrasonographic measurement of gastric content influence airway management decisions? *AANA Journal, 88*(2), 107-113.	Survey of anesthesia providers before and after gastric antrum measurement, ultrasound measurement of gastric antrum	Quasi-experimental	100 fasted patients: 98 elective surgeries, 2 urgent surgeries; mean age 55.4 years Exclusion for refusal, pregnant, less than 18 years of age, prior gastric surgery, or tumor	Ultrasound as a preoperative assessment tool Modification of airway and management plan	Ultrasound determination of gastric content Provider assessment of aspiration risk and airway management plan Provider survey before and after scanning	Descriptive statistics	14% solid gastric content, 7% clear liquid content, 79% no gastric content on ultrasound 9% change in overall airway management technique	II	B
Dupont, G., Gavory, J., Lambert, P., Tsekouras, N., Barbe, N., Presles, E., Bouvet, L., & Molliex, S. (2017). Ultrasonographic gastric volume before unplanned surgery. *Anaesthesia*, *72*(9), 1112–1116. https://doi.org/10.1111/anae.13963	Measure gastric antral cross-sectional area and estimate gastric volume	Quasi-experimental	300 patients before unplanned surgery, fasted at least 6 hours Excluded: active gastric ulcer, upper	Gastric antral cross-sectional area Complications with anesthetic management	Gastric antral cross-sectional area	Univariate logistical regression; adjusted R^2 multivariable regression	88% able to measure gastric antral gross sectional area 35% exceeded empty	II	A

			gastrointestinal bleeding, vagal denervation, scleroderma, pregnant women more than 15 weeks gestation				stomach criteria Fasting time not associated with gastric antral area Body mass index, morphine use associated with increased gastric area		
Falyar, C., & Kantzavelos, L. (2018). Clinical application of point-of-care ultrasound gastric examination in the management of an ASA Class 3E patient: A case report. *AANA Journal, 86*(5), 379-382	NA	Case report	79-year-old ASA IIIE, requiring emergent ureteral stent placement with new AAA in situ	NA	NA	NA	NA	V	C
Gupta, R., Pokhriyal, A., Jindal, P., Sarpal, R., & Goyal, M. (2020). Evaluation of gastric emptying by ultrasonography after recommended fasting period and administration of prokinetic in end-stage renal disease patients. *Anesthesia: Essays and Researches*, *14*(1), 42–48. https://doi.org/10.4103/aer.AER_18_20	Evaluate the efficacy of prokinetic therapy in reducing full stomach classification as indicated by ultrasound in patients with end-stage renal disease	RCT, double-blind, prospective	240 patients; excluded 40 (refusal, history of diabetes or gastrointestinal disease, allergy to Reglan) 100 placebo, 100 intervention	End-stage renal disease Use of prokinetic therapy	Perlas grading scale Quantitative volume estimation Qualitative assessment of gastric antrum Efficacy of prokinetic therapy	T-test; Chi-squared test; Mann-Whitney U-test	14% empty stomach Group A vs. 71% empty stomach Group B (*P*=<0.001, 95% CI)	I	A
Johnson, E., Morbach, J., Blacke, C., & Pecka, S. (2021). Sensitivity and specificity of gastric ultrasonography in determination of gastric contents. *AANA Journal, 89*(1), 9-16.	Establish sensitivity and specificity of gastric ultrasound	RCT	42 patients, 3 equal groups: fasted, liquid ingestion, solid ingestion	Qualitative analysis of gastric antrum	Sensitivity of gastric ultrasound Specificity of gastric ultrasound False positive rates False negative rates	Kruskal-Wallis; Fisher exact; Mann-Whitney;	Sensitivity: 95-100% liquids, 45-75% fasted, 45-60% solids Specificity: 87.5-90% liquids, 80-90% solids, 80-87.5% fasted	I	B
Kaydu, A., & Gokcek, E. (2018). Preoperative assessment of ultrasonographic measurement of antral area for gastric content. *Medical Science Monitor*, *24*, 5542–5548. https://doi.org/10.12659/msm.908520	Evaluate efficacy of bedside ultrasonography in evaluating gastric contents of surgical patients.	Prospective observational	123 patients; 76 male, 44 female 91 >8 hours fasting, 29 <8 hours fasting 3 patients excluded: gas in stomach (2),	Qualitative analysis of gastric antrum Quantitative calculation of gastric volume Relationship between	Perlas grading scale	T-test; Shapiro-Wilk test; Fisher's exact	Antral cross-sectional area higher in group fasted <8 hours (P <0.05) 20.8% of patients fasted >8 hours met full stomach	II	A

			BMI >35 kg/m^2 Single center	age and BMI			criteria (> 340 mm^2), mean cross sectional area 461.64 +/- 135.2 mm^2 No difference between mean antrum cross-sectional area in emergency vs. elective cases Increasing age and BMI linearly increase antral cross-sectional area (r=0.209, P <0.05, r = 0.252, P = 0.05, respectively)		
Kaydu, A., & Gokcek, E. (2019). Sonographic gastric content evaluation in patients undergoing cataract surgery. *Nigerian Journal of Clinical Practice*, *22*(11), 1483–1488. https://doi.org/10.4103/njcp.njcp_329_18	Evaluate stomachs of patients scheduled for cataract surgery	Prospective observational	60 patients scheduled for cataract surgery Excluded patients with upper GI pathologies, hiatal hernias, gastric tumors	Non-fasted patients stomach measurement Use of fasting guidelines	Whether or not patients fasted Grading of antrum Volume estimation	Descriptive statistics; Shapiro-Wilk test, Pearson method	Solid content: 65%, Liquid content: 20%, Empty: 15% None of the ophthalmologists use fasting guidelines	II	B
Kruisselbrink, R., Gharapetian, A., Chaparro, L. E., Ami, N., Richler, D., Chan, V. S., & Perlas, A. (2019). Diagnostic accuracy of point-of-care gastric ultrasound. *Anesthesia & Analgesia*, *128*(1), 89–95. https://doi.org/10.1213/ane.0000000000003372	Establish sensitivity and specificity of gastric ultrasound	RCT	40 patients; 3 equal groups: fasted 8 hours, liquid ingestion, solid ingestion	Fasted vs. Unfasted patients	Qualitative and quantitative measurement of the gastric antrum	Bootstrapping	Sensitivity: 1.0 (95% CI) Specificity: 0.975 (95% CI)	I	B
Nguyen, M., Drihem, A., Berthoud, V., Dransart-Raye, O., Bartamian, L., Gounot, I., Guinot, P.-G., & Bouhemad, B. (2021). Fasting does not guarantee empty stomach in the intensive care unit: A prospective ultrasonographic evaluation (the NUTRIGUS study). *Anaesthesia Critical Care & Pain Medicine*, *40*(6), 100975. https://doi.org/10.1016/j.accpm.2021.100975	Assess the stomachs of ICU patients following fasting and non-fasting periods prior to extubation.	Prospective, observational	112 ICU patients; 12 excluded for poor visualization, abdominal bandages, or postponed extubation	Fasting period Qualitative and quantitative measurement of the stomach Success/failure of extubation	Incidence of full stomach using Perlas criteria Extubation failure and full stomachs	t-test; Fisher's exact test; Spearman correlation method	26% of patients had full stomachs at extubation No difference between empty stomachs and full stomachs in extubation success	II	B
Ohashi, Y., Walker, J. C., Zhang, F., Prindiville, F. E., Hanrahan, J. P., Mendelson, R., & Corcoran, T. (2018). Preoperative gastric residual volumes in fasted patients measured	Use point-of-care gastric ultrasound to establish	Prospective, observational	252 patients; excluded 23 patients for refusal, hemodialysis	Gastric residual volume, quantitative	Perlas mathematical equation for cross-	Chi-squared; ANOVA	110 (49.5% empty stomach, 9 (4.1%) residual	II	A

by bedside ultrasound: A prospective observational study. *Anaesthesia and Intensive Care*, *46*(6), 608–613. https://doi.org/10.1177/0310057x1804600612	gastric residual volume in patients scheduled for surgery.		, gastroesophageal pathology 229 patients scanned, 7 unable to be analyzed	Comorbidities	sectional area Measurement of gastric residual volume Investigate the influence of risk factors for increased gastric residual volume		volume <100 ml, 6 (2.7%) residual volume > 1.5 ml/kg No relationship between at-risk stomach and obesity, DM, GERD, opioid use		
Pai, S.-L., Bojaxhi, E., Logvinov, I. I., Porter, S. B., Feinglass, N. G., Robards, C. B., & Torp, K. D. (2019). Ultrasound assessment of gastric volume after bariatric surgery: A case report. *A&A Practice*, *12*(1), 1–4. https://doi.org/10.1213/xaa.0000000000000824	No data exists for the use of gastric ultrasound in patients with prior gastric operations	Case report	1 patient, status-post Roux-en-Y	NA	NA	NA	NA	V	C
Sabry, R., Hasanin, A., Refaat, S., Abdel Raouf, S., Abdallah, A. S., & Helmy, N. (2019). Evaluation of gastric residual volume in fasting diabetic patients using gastric ultrasound. *Acta Anaesthesiologica Scandinavica*, *63*(5), 615–619. https://doi.org/10.1111/aas.13315	Compare gastric residual volumes and gastric antral cross-sectional area in diabetics and nondiabetics before elective surgery	Prospective observational	50 patients; 25 diabetic, 25 non-diabetic Fasted 8 hours	Gastric antral cross-sectional area Gastric residual volume (calculated) Gastric residual volume (aspirated)	Gastric residual volume in semi-sitting position Gastric residual volume in right lateral positions Qualitative grading for assessment of gastric antrum	Chi-squared test; t-test, Mann-Whitney U test	Gastric antral cross-sectional area 13.8 (9.5-19.5) mm^2 vs. 8.8 (5.5-10.5) mm^2, P <0.001; Gastric residual volume 177 (26-275) mL vs. 83 (50-109) mL, P <0.001; Aspirated volume 150 (85-201) mL vs. 75 (35-87) mL, P <0.001	II	B
Segura-Grau, E., Segura-Grau, A., Araújo, R., Payeras, G., Cabral, J., & Afreixo, V. (2021). Reinforcing the valuable role of gastric ultrasound for volume and content assessment: An observational study. *Brazilian Journal of Anesthesiology (English Edition)*. https://doi.org/10.1016/j.bjane.2021.07.008	Compare estimated gastric volumes with suctioned gastric volumes using upper GI endoscopy	Prospective observational	40 patients; fasted 10 hours of solids and 4 hours of liquids Excluded two for inability to visualize and two for other reasons	Fasting time Calculated volume Suctioned volume	Comparison of calculated volume and aspirated gastric volume	Descriptive statistics; Shapiro-Wilk test; t-test; Pearsons correlation; Quade test	No difference between aspirated volumed and calculated volumes (*p*= 0.0420	II	B
Shorbagy, M. S., Kasem, A. A., Gamal Eldin, A. A., & Mahrose, R. (2021). Routine point-of-care ultrasound (POCUS) assessment of gastric antral content in traumatic emergency surgical patients for prevention of aspiration pneumonitis: An observational clinical trial. *BMC Anesthesiology*, *21*(1).	Determine stomach status with ultrasound, record changes in anesthesia plan, record incidence of aspiration	Prospective observational	45 polytrauma patients Excluded pregnant patients, history of upper GI disorders,	Fasting status Change in anesthetic plan Qualitative and quantitativ	Change in aspiration risk after ultrasound assessment Incidence of perioperat	Student t-test; Chi-squared test, table analysis	Anesthesia technique changes in 31.1% of cases Empty stomach: 10 patients, 35 patients full	II	B

https://doi.org/10.1186/s12871-021-01357-y			hiatal hernia, GI cancer, GCS <10, fractured base of skull, severe bleeding	e measurement of gastric antrum	ive aspiration Correlation between predicted gastric volume and aspirated volume of gastric tube		stomach (29 solid content, 6 clear fluid >1.5 ml/kg) No aspiration events Good correlation between ultrasound estimation and aspirated volume (200, 190 respectively, *p*=<0.001)		
Tankul, R., Halilamien, P., Tangwiwat, S., Dejarkom, S., & Pangthipampai, P. (2022). Qualitative and quantitative gastric ultrasound assessment in highly skilled regional anesthesiologists. *BMC Anesthesiology*, *22*(1), 608–613. https://doi.org/10.1186/s12871-021-01550-z	Evaluate the efficacy of training new anesthesia providers to use ultrasound for fasting status and establish the accuracy of the assessments	Prospective cohort	50 participants; 3 excluded for protocol violation 47 fasted participants randomized to: fasted, 100 ml, 200 ml, 300 ml or solid ingestions Two anesthesiologists newly educated in gastric ultrasound for fasting status	Ease of learning new ultrasound skill Accuracy of qualitative ultrasound scanning Accuracy of quantitative volume estimation	Accuracy of newly trained scanners Ability to quickly learn new skill	ICC	100 ml: 0.706 (95% CI: -0.125 to 0.931); 200 ml 0.660 (95% CI: -0.254 to 0.920); 300 ml: 0.362 (95% CI: -0.498 to 0.807) Overall success of 96%	II	B
Van de Putte, P., Vernieuwe, L., Jerjir, A., Verschueren, L., Tacken, M., & Perlas, A. (2017). When fasted is not empty: A retrospective cohort study of gastric content in fasted surgical patients. *British Journal of Anaesthesia*, *118*(3), 363–371. https://doi.org/10.1093/bja/aew435	Evaluate the stomachs of patients compliant with fasting instructions before surgery	Retrospective cohort	538 patients, compliant with fasting instructions (2h clear liquid, 6h light meal, 8h meal with fried or fatty food)	Perlas grading scale Comorbidities	Qualitative assessment of gastric antrum Quantitative measurement of gastric volume	Descriptive statistics; Shapiro-Wilk test, t-Test; Fisher exact test	Mean fasting time 10.8h for fluids, 13.9h for solids 26 scans inconclusive 32 (6.2%) full stomach, 9 of which had solid content and 243(4.5%) had volume in excess of 1.5 ml/kg	III	A
Van de Putte, P., van Hoonacker, J., & Perlas, A. (2018). Gastric ultrasound to guide anesthetic management in elective surgical patients non-compliant with fasting instructions: A retrospective cohort study. *Minerva Anestesiologica*, *84*(7), 787–795. https://doi.org/10.23736/s0375-9393.17.12305-9	Examine how anesthetic plan changes based on ultrasound imaging of the gastric antrum	Retrospective cohort	37 patients scheduled fuor surgery fasted various times	Qualitative and quantitative measurement of gastric antrum Anesthesia plan	Changes in aspiration risk stratification Incidence of perioperative aspiration	Descriptive statistics; Shapiro-Wilk, McNemar-Bowker's Exact	Empty stomach: 14, Full stomach: 23 (14 solid, 8 fluid > 1.5 ml/kg) Anesthesia plan changed in 64.9% of cases	III	B

							45.9% found to have lower aspiration risk Timing changed in 14 cases, Liberal anesthetic used in 3 cases, 1 cancellation, 4 delayed, 2 RSI		
Xiao, M., Englesakis, M., & Perlas, A. (2021). Gastric content and perioperative pulmonary aspiration in patients with diabetes mellitus: A scoping review. *British Journal of Anaesthesia*, *127*(2), 224–235. https://doi.org/10.1016/j.bja.2021.04.008	Review literature regarding gastric ultrasound use in patients with diabetes	Literature Review	NA	NA	NA	NA	NA	V	B
Zhou, L., Yang, Y., Yang, L., Cao, W., Jing, H., Xu, Y., Jiang, X., Xu, D., Xiao, Q., Jiang, C., & Bo, L. (2019). Point-of-care ultrasound defines gastric content in elective surgical patients with type 2 diabetes mellitus: A prospective cohort study. *BMC Anesthesiology*, *19*(1). https://doi.org/10.1186/s12871-019-0848-x	Evaluate gastric content with ultrasound after ingestion clear liquids or a light meal in diabetic and nondiabetic patients at established fasting times.	Prospective cohort	108 patients; 6 excluded due to inability to visualize gastric antrum 52 diabetic, 50 non-diabetic	The gastric antral cross-sectional area Diabetes-related diseases	Perlas grading scale	Shapiro-Wilk test, Wilcoxon Rank Sum test, Chi-square test	Diabetics have a higher incidence of the full stomach (48.1% vs. 8.00%, *P*=0.000) after fasting following clear liquids and light meal Diabetics take longer to achieve an empty stomach (146.5 vs. 124.5 minutes, *P*=0.014) after clear liquids, (426.5 vs. 370 minutes, *P*=0.042) Diabetes-related eye disease significantly increased risk of full stomach (OR = 4.83, *P*-0.010)	II	A

Appendix C

Guideline Recommendation Document

RECOMMENDATIONS FOR PREOPERATIVE GASTRIC ULTRASOUND

CURRENT PRACTICE

Ultrasound is not currently used as a preoperative aspiration risk stratification tool. Patients are instructed to fast in accordance with ASA guidelines which is confirmed during the preoperative interview. Anesthesia providers develop an anesthetic plan after a history, physical, and assessment are completed. Despite this, patients still, on occasion, regurgitate gastric contents into their lungs.

RECOMMENDATION #1

All anesthesia providers should receive ultrasound education, including hands-on practice, about qualitative gastric antrum assessment with ultrasound and quantitative gastric volume estimation.

RECOMMENDATION #2

The facility will implement the following guidelines related to ultrasound assessment of the gastric antrum.

Patients with risk-identified diseases or conditions, regardless of patient self-report of fasting status, should be scanned preoperatively with ultrasound. These include:

- Unknown/uncertain NPO status, including those with acutely or chronically altered mental status (e.g., intoxication, dementia)
- Type I and Type II Diabetes
- End-stage Renal Disease
- Liver Disease
- Critical Illness
- Neuromuscular Disorders
- Acute Pain
- Opioid Use

RECOMMENDATION #3

Anesthesia providers will document ultrasound imaging and interpretation in the EMR, evaluate the anesthesia plan, and make modifications if indicated. Recommended modifications are:

1. If the urgency of surgery allows, delay or cancel surgical cases for a patient with a Grade I antrum and estimated gastric volume of >1.5 ml/kg in the RLD position, or those with a Grade 2 antrum in any position.
2. If the surgery must be performed, consider:
   - Preoperative administration of gastric pH modifiers, gastrointestinal prokinetics, proton pump inhibitors, antiemetics
   - Preoperative nasogastric tube suctioning
   - RSI intubation

Appendix D

Iowa Model