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TECHNICAL NOTE

WILEY

Bedside percutaneous ultrasound gastrostomy tube placement by critical care physicians

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Abstract

Critically ill patients often require gastrostomy tubes. Percutaneous endoscopic gastrostomy has become the most common method of placement but is not widely performed by critical care physicians, in part due to their lack of familiarity and training in upper gastrointestinal endoscopy. Percutaneous ultrasound gastrostomy (PUG) is a novel procedure for gastrostomy tube placement that utilizes ultrasound-based methods already familiar to critical care physicians. This technical note describes bedside PUG in the first five intensive care unit patients. All patients received timely gastrostomy placement, without complication, and were able to quickly achieve goal enteral nutrition.

KEYWORDS

bedside, critical care, gastrostomy, interventional sonography, percutaneous procedure, ultrasound

1 | INTRODUCTION

Critically ill patients often require prolonged enteral nutrition during their acute illnesses and recovery periods, which can be accomplished using nasogastric or gastrostomy tubes.[1] When the requirement for enteral nutrition is expected to exceed 30 days, a gastrostomy tube is typically chosen.[2] It has been estimated that 50% of all gastrostomy tubes in the United States are placed during critical illness.[3] Gastrostomy tubes can be placed endoscopically, surgically, or under imaging guidance, and percutaneous endoscopic gastrostomy (PEG), usually performed by gastroenterologists and surgeons, has become the most common method.[4]

Although PEG placement by interventional pulmonologists has been described as safe and feasible,[5] it has not been widely adopted by critical care physicians, or intensivists, possibly due to their lack of familiarity with and certification in performing upper gastrointestinal endoscopy. When intensivists become proficient in the safe placement of gastrostomy tubes, there may be associated improvements in achieving goal nutrition, costs, length of stay, duration of mechanical ventilation, and patient safety. Percutaneous ultrasound gastrostomy (PUG) is a novel procedure for gastrostomy tube placement designed for physicians, such as intensivists, who are already familiar with ultrasound-guided invasive procedures. Although this procedure has been shown to be feasible in cadavers and has been performed by interventional radiologists in a small study of noncritically ill patients,[4,6] it has not been performed by intensivists on critically ill patients. This technical note is the first description of intensivists performing bedside PUG in the intensive care unit (ICU).

2 | METHODS AND MATERIALS

Three intensivists, all of whom are board certified in internal medicine and adult critical care medicine and two of whom are board certified in adult pulmonary medicine, underwent a 3-h cadaver-based training session on PUG. The session was instructed by a university-based training team, consisting of physicians and nurses, as part of a process toward building a PUG continuing medical education course (www.pugcourse.com). Prior credentialing and proficiency in at least one ultrasound-based procedure, such as ultrasound-guided central line placement was required. The session was "hands-on" and allowed each learner to perform the PUG procedure at least three times.

The PUG procedure has been described elsewhere and was performed using the FDA cleared Point of Care Ultrasound Magnet Aligned Gastrostomy (PUMA-G) System (CoapTech, Baltimore, Maryland).[4] The PUMA-G System includes an external magnet, an internal magnetic balloon catheter and memory shaped pigtail shaped guidewire. Ultrasound was performed with a Philips Sparq ultrasound scanner, equipped with 2 to 6 MHz convex and 4 to 12 MHz linear transducers (Philips, Bothell, Washington). Figure 1 (infographic) and Figure 2 (live case) demonstrate the key steps of the procedure. For each procedure, one sterilely gowned intensivist performed the gastrostomy, and a second intensivist assisted at the head of the bed. Medication administration and vital sign monitoring were performed by a registered nurse, and a respiratory therapist was present to monitor the ventilator and airway. A skin-to-gastric wall distance of 4.5 cm or less, based on sonographic measurement, was a required criterion to perform the procedure, as this is the gastrostomy depth limit approved by the Food and Drug Administration for the PUMA-G System.

PUG starts with the head-of-bed intensivist passing an orogastric tube with a balloon containing a magnetic bar at its distal end through the mouth and into the stomach. The stomach is insufflated with medical air through a nasogastric or orogastric tube. A strong, sterilely sheathed, external magnet is placed onto the prepped external abdominal surface to bring the magnetic tip of the gastric tube balloon (GTB) and the anterior wall of the stomach into contact with the anterior abdominal wall. Once coaptation between the external and internal magnets has been achieved, the external magnet is moved to maneuver the gastric balloon to the desired location in the stomach. The GTB balloon is then filled with colored water by a second operator at the head of the bed while the primary operator uses ultrasound to visualize the fluid-filled balloon using a transabdominal approach (Figure 3) As with all ultrasound interpretation, real-time footage, shown in Supporting Information Video S1, better delineates organs and image artifacts.

Once a safe gastrostomy tract is visualized on real-time ultrasound, 1% lidocaine without epinephrine is used to locally anesthetize the skin and soft tissue of the anterior abdominal wall tract. The fluid-filled balloon is then cannulated with an 18-gauge hollow needle, using real-time sonographic visualization of the entire needle path from skin surface to gastric lumen, assuring no intervening organs or vessels are in the needle path. Colored water is aspirated to confirm needle tip location within the balloon inside the stomach, and a pigtail guidewire is advanced into the balloon via the needle. As the pigtail exits the needle, it re-coils in the balloon. This occurs because the pigtail guidewire is made of nitinol, which regains its initial shape. The guidewire and GTB become mechanically coupled, which aids in pulling the guidewire through the upper GI tract and out of the mouth. With one hand on the guidewire exiting the abdominal wall, and the other hand on the GTB exiting the mouth, the operator slowly withdraws the coupled GTB and guidewire from the mouth until the guidewire exits the mouth. Gastrostomy guidewires are a standard 260 cm in length, which provides sufficient length so that the wire can simultaneously be exiting the mouth at one end and the gastrostomy tract at the other. The guidewire exiting the mouth is then cut, in a marked region of the wire that is resistant to fraying, to remove the coiled end that is associated with the GTB. At this point, there is a guidewire in place entering the percutaneous gastrostomy tract, coursing up the esophagus, and exiting the mouth. Then, the Sachs-Vine technique is performed, where a "push" gastrostomy tube is advanced over the cut end of the guidewire exiting the mouth so that it can be advanced into the stomach and through the gastric and abdominal walls. Like gastrostomy guidewires, push gastrostomy tubes are of sufficient length so that they can simultaneously be exiting the mouth at one end and exiting the gastrostomy tract at the other. Push gastrostomy tubes are tapered at the proximal end, which enables autodilation of the gastrostomy tract as the tube is advanced. The wire is then removed from the lumen of the gastrostomy tube, leaving only the gastrostomy tube in correct position.

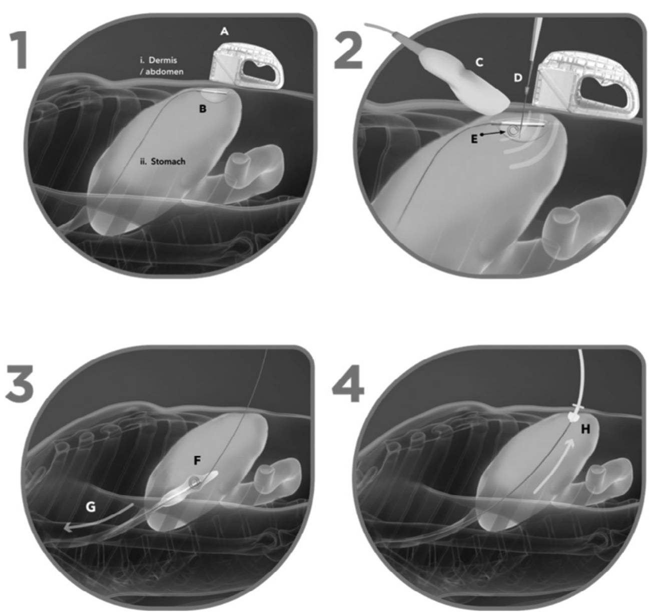

FIGURE 1 A-H, Diagrams demonstrating key steps in the percutaneous ultrasound gastrostomy procedure. Panel 1: External magnet (A) attracts the fluid-filled gastric tube balloon (GTB) within the stomach to the anterior stomach wall. Panel 2: The ultrasound probe (C) is used to identify the GTB and guide the insertion of an 18-gauge needle to puncture the GTB. The memory-shape pigtail guidewire (E) is fed through the needle into GTB. Panel 3: The external magnet is removed, The GTB is deflated and "snares" the pigtail guidewire. The deflated GTB and guidewire in tandem are pulled up through the esophagus (arrow) and out of mouth. Panel 4: Once the pigtail portion of the guidewire exiting mouth has been cut off, a "push"-style feeding tube is passed over cut end of safely-established through-and-through wire (arrow). Push tapered tube autodilates tract and internal bumper holds stomach against the abdominal wall (H)

3 | RESULTS

Characteristics of the five patients are included in Table 1. All patients were mechanically ventilated and sedated during PUG placement. No

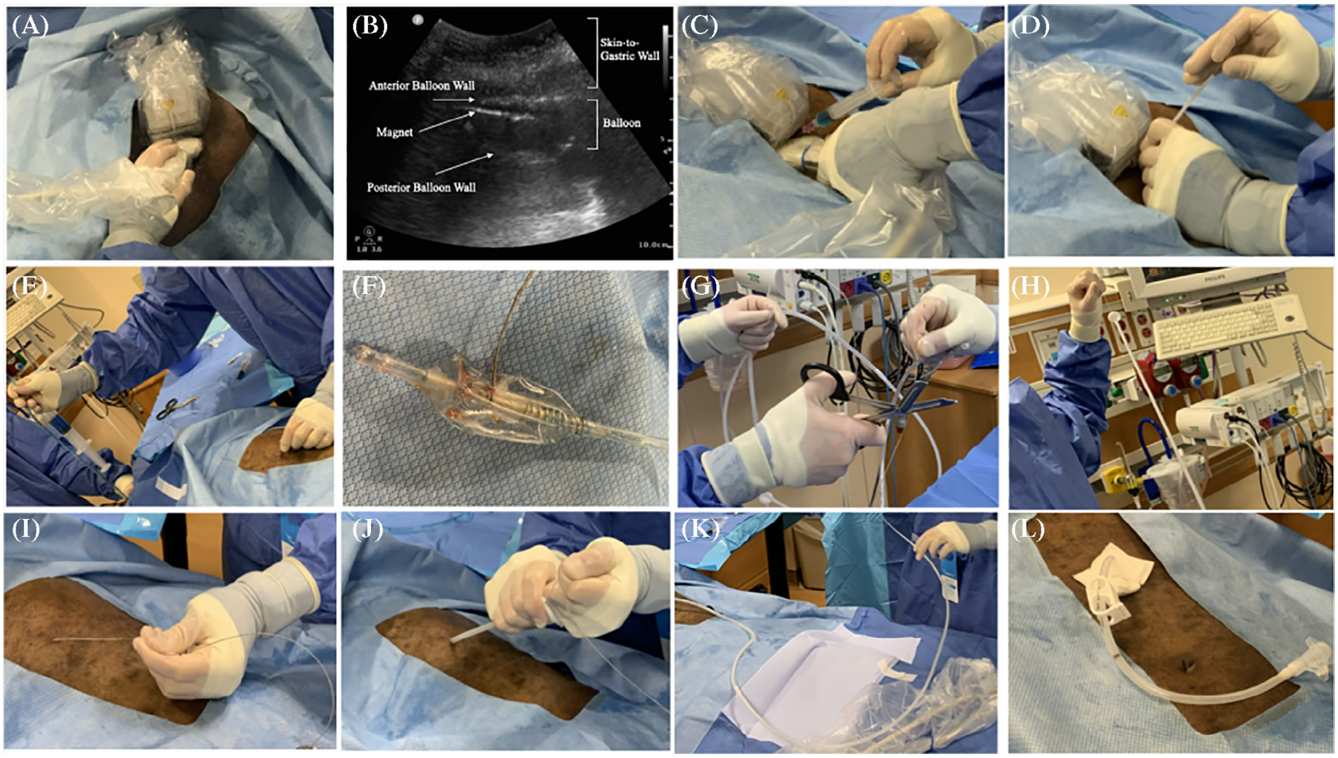

FIGURE 2 A-L, Live case demonstrating key steps in the percutaneous ultrasound gastrostomy procedure. A, After placement of the gastric tube balloon (GTB), insufflation of the stomach, and coaptation of the external and internal magnets, ultrasound probe is used to image region deep to external magnet. B, Sonogram shows the fluid-filled balloon in stomach. C, Colored water (in blue) is aspirated from the GTB within gastric lumen under ultrasound guidance. D, Pigtail guidewire is threaded into the GTB through the 18-gauge needle. E, Guidewire is advanced into gastric lumen while GTB is withdrawn from mouth. F, Mechanically coupled GTB and guidewire, as seen after GTB is withdrawn from mouth. G, Pigtail cut off of guidewire exiting mouth. H, Push gastrostomy tube, with bumper seen at one end, advanced over cut end of wire. I, Tapered end of push gastrostomy tube exits abdominal wall. J, Push gastrostomy tube pulled out of abdominal wall, which dilates gastrostomy tract. K, Push gastrostomy tube withdrawn until resistance felt, indicating bumper is against gastric wall. L, Once guidewire is removed from tube exiting abdominal wall, and gastrostomy tube cut to appropriate length, functioning gastrostomy tube is clamped, capped, and dressed

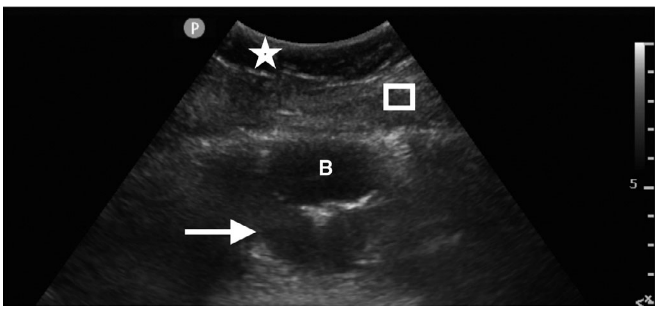

FIGURE 3 Sonogram shows the gastric tube balloon (B) in place in the stomach at a depth of 3-cm from the skin. Star, subcutaneous tissues; square, rectus abdominis muscle; arrow, balloon mirror artifact

complications were identified in the periprocedural or postprocedural periods. The tract depth targeted ranged from 2.5 to 4 cm in patients #2 and #4, respectively. Goal tube feeds were immediately achieved in all patients without any evidence of intolerance or mechanical complications at a minimum of 5 days of follow up. The shortest time goal nutrition was held was 9 hours in patient #5.

4 | DISCUSSION

This is the first report of PUG being performed by intensivists in the ICU. In these critically ill patients, the procedure was feasible and safe. In all cases, the procedure was performed by the intensivist of record for the patient on the day the decision was made to do the procedure, rather than waiting several days for a consultant to perform a gastrostomy procedure. Nutrition was minimally interrupted, as no cases were delayed or canceled, and the decision to resume feeding remained with the primary team. As the ICU team developed further comfort with PUG, there was a trend in shortening times of periprocedural nutrition. This new model could lead to increased goal nutrition, reduced ICU length of stay, reduced hospital length of stay, and minimize the need for transporting critically ill patients outside of the ICU, with likely associated improvements in healthcare savings and patient safety. The amount of training required to prepare the intensivists to perform this procedure was minimal, and the time required to perform the procedure was also reasonable. This learner curve is likely related to PUG's similarity to other ultrasound-based procedures in the ICU.

TABLE 1 Patient and procedure characteristics

Characteristic	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5
Age (years)	64	59	62	34	58
Gender	M	F	F	M	M
BMI (kg/m^2)	31	23.2	17.5	26.7	36.9
Skin-to-gastric wall tract depth (cm)	3.0	2.5	2.7	4.0	3.5
Reason for ICU admission	Acute hypoxemic respiratory failure due to aspiration	Acute on chronic hypercapnic, hypoxemic respiratory failure due to supraglottic stenosis	Septic shock due to urinary tract infection	Acute hypoxemic respiratory failure due to pneumonia	Subdural hematoma
Indications for gastrostomy	Dysphagia after stroke and tracheostomy	Dysphagia after neck radiation and tracheostomy	Severe malnutrition with inability to take adequate oral nutrition	Dysphagia due to encephalopathy and tracheostomy	Dysphagia due to subdural hematoma and encephalopathy
Airway	ET tube	Tracheostomy	ET tube	Tracheostomy	Tracheostomy
Sedatives	Propofol infusion, fentanyl infusion	Propofol infusion, fentanyl infusion	Propofol infusion, fentanyl infusion	Propofol infusion, fentanyl infusion	Propofol infusion, fentanyl infusion
Neuromuscular blockade	None	Cisatracurium infusion	None	Rocuronium bolus	Rocuronium bolus
Vasopressors	None	norepinephrine 0.06 mcg/kg/min	vasopressin, norepinephrine 0.1 mcg/kg/min	norepinephrine 0.04 mcg/kg/min	None
Procedure time (min)	33	25	15	70	30
Formula	Nepro carb steady	Promote	Poor PO intake refused NGT	Osmolite 1.5	Nepro carb steady
Feeding stopped prior procedure (h)	10	4	N/A	12	3
Feeding restarted postprocedure (h)	24	31	22	14	6
Total time feeding held periprocedure	34	35	22	26	9
Time to achieve goal nutrition	Immediate	Immediate	Immediate	Immediate	Immediate

The five patients fell into a range of Centers for Disease Control body mass index (BMI) categories (one "underweight," one "normal," one "overweight," and two "obese"). In this sample, we found that even the obese patients had a skin-to-gastric wall distance of 4.5 cm or less and that PUG was feasible in these patients. Although this did not occur in this short series, there are clearly patients with skin-to-gastric wall distances that would preclude PUG. This series suggests it is appropriate to make decisions about patient candidacy based on objective measurements, such as skin-to-gastric wall distance measured on real-time ultrasound, rather than arbitrary BMI cutoffs or qualitative judgments regarding body habitus.

A lack of certification with performing upper gastrointestinal endoscopy may be one reason why intensivists do not widely perform PEG. An advantage of PUG is that it uses a familiar ultrasound-guided Seldinger technique that intensivists already use for many other routine procedures, such as ultrasound-guided vascular catheter placement. Immediate complications in any gastrostomy procedure include injury to surrounding tissues such as small and large bowel, blood vessels, liver, and spleen. Ultrasound also allows real-time visualization of the entire needle tract, from skin to gastric lumen, which may help avoid inadvertent injury of intra-abdominal organs and vessels, a known complication of PEG and fluoroscopically-guided gastrostomy.[7,8]

Although these are only the first five cases of PUG placement by intensivists and more experience and studies are needed, the cases suggest that this procedure is feasible, safe, and beneficial to our patients and healthcare systems.

CONFLICT OF INTEREST

The authors declare no potential conflict of interests.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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