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Use of wireless motility capsule to determine gastric emptying and small intestinal transit times in critically ill trauma patients☆,☆☆,★

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Abstract

Purpose: The purpose of this study is to use a novel wireless motility capsule to compare gastric emptying and small bowel transit times in critically ill trauma patients and healthy volunteers.

Materials and Methods: We evaluated gastric emptying, small bowel transit time, and total intestinal transit time in 8 critically ill trauma patients. These data were compared with those obtained in 87 healthy volunteers from a separate trial. Data were obtained with a motility capsule that wirelessly transmitted pH, pressure, and temperature to a recorder attached to each subject's abdomen.

Results: The gastric emptying time was significantly longer in critically ill patients (median, 13.9; interquartile range [IQR], 6.6-48.3 hours) than in healthy volunteers (median, 3.0; IQR, 2.5-3.9 hours), $P < .001$. The small bowel transit time in critically ill patients was significantly longer than in healthy volunteers (median, 6.7 hours; IQR, 4.4-8.5 hours vs median, 3.8 hours; IQR, 3.1-4.7 hours), $P = .01$. Furthermore, the capsules passed after 10 (IQR, 8.5-13) days in the critical care group and 1.2 (IQR, 0.9-1.9) days in healthy volunteers ($P < .001$).

Conclusions: Both gastric emptying and small bowel transit were delayed in critically ill trauma patients.

1. Introduction

Delayed gastric emptying is a well-known problem in critically ill patients [1-7] and is associated with feeding disturbances and inadequate nutrition. However, evaluating gastrointestinal function remains challenging in critically ill patients who are mechanically ventilated. Many tests that are

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practical and accurate under standardized, controlled conditions often fail in the critical care setting. For example, the consensus recommendations for gastric emptying scintigraphy that have been published recently [8] are impractical in intubated patients because they recommend low-fat, egg-white meal with imaging at 0, 1, 2, and 4 hours after meal ingestion. Another test, the lactulose hydrogen breath test, relies on prompt bacterial breakdown of lactulose in the colon; however, changes in bacterial flora—which are presumably common in critical care patients—can produce false transit times [9].

The ^{13}C-octanoic acid breath test was reported by Ritz et al [4] as successful when used bedside to measure gastric emptying. However, manometry only assesses the upper gastrointestinal function, mainly esophagus, stomach, and proximal small bowel. Finally, video capsule technology has been used to determine small bowel transit time and pathomorphology in critically ill patients, although inadequate battery lifespan of the capsule (approximately 8-10 hours) could prevent complete examination in some cases [10].

An alternative technique, wireless capsule technology, may be useful for evaluating gastrointestinal motility in critical care patients. There are reports of using wireless capsule technology to measure intestinal temperature, pressure, and pH dating to the 1950s [11-13], but a brief communication in *Nature* in 2000 by Iddan launched the era of video capsule endoscopy in humans [14]. A newly developed motility capsule for assessing gastric emptying in patients with suspected gastroparesis has been available since 2006 [15-20]. It is a wireless capsule that transmits pH, pressure, and temperature (Fig. 1).

We describe the first use of a novel motility capsule to compare gastric emptying and small bowel transit times in critically ill trauma patients with intracranial hemorrhage with times recorded previously in healthy volunteers. Second, we compared critically ill patients and volunteers on whole-gut transit time.

Fig. 1 SmartPill GI Monitoring Capsule; SmartPill, Inc, Buffalo, NY.

2. Materials and methods

This prospective cohort study (NCT01159002) was approved by the Human Studies Committee of the University of Louisville, and authorized representatives of participating patients provided written informed consent.

All hospital intensive care units (ICUs) were screened for patients twice daily by the principal investigator. Patients were enrolled within 36 hours of ICU admission. Eligible patients were intubated, ventilated, and had an Acute Physiology, Age, Chronic Health Evaluation score of greater than 25. All had major trauma and had an intracranial hemorrhage. Patients were excluded if they were younger than 18 years, had open abdominal trauma or inflammatory bowel disease, had a history of complicated (eg, total or partial gastrectomy, colectomy) or unknown abdominal surgery, or presented with clinical evidence of ileus or suspected obstruction. Patients with a pacemaker were also excluded because the capsule we used is not recommended for use in these patients.

We enrolled 8 patients who were sedated with propofol (25-50 $\mu g \cdot kg^{-1} \cdot min^{-1}$) or midazolam and were given intravenous morphine/fentanyl intermittently. Patients were maintained supine, with the head of the bed elevated 30°.

Positioning of the motility capsule (SmartPill GI Monitoring Capsule; SmartPill, Inc, Buffalo, NY) was coupled with the medically necessary feeding tube placement 2 days after patients were admitted to an ICU. The capsule was inserted with a delivery device (AdvanCE, Mentor, Ohio) into the esophagus using a laryngoscope to overcome the narrowing of the hypopharynx caused by the endotracheal tube and then advanced blindly into the stomach. The capsule was deployed into the stomach, and its position was confirmed radiographically. Intestinal feeding was delayed for 12 hours after capsule insertion. Data were transmitted to a recorder attached to the patient over a 5-day period.

MotiliGI software (MotiliGI 1.3.1; SmartPill, Inc) (Fig. 2) was used to calculate gastric emptying. The transition from stomach to small bowel was marked by an abrupt pH rise (>3 pH units) from gastric baseline to a pH greater than 4 as well as a change in pressure patterns before emptying [21-23]. Pressure recordings showed high-amplitude phasic contractions just before the capsule's emptying from the stomach. The pH change marked the end of the gastric pressure analysis window and the beginning of the small bowel pressure analysis window. Small bowel transit time was calculated from the time the capsule entered the duodenum until it reached the cecum characterized by a drop in pH and pressure changes. Pressure patterns are characterized as high-amplitude phasic gastric contractions, mean peak amplitude, and mean contractions per minute. Mean peak amplitude (between 10 and 300 mm Hg) is the sum of amplitudes/number of contractions.

The control group consisted of 87 healthy volunteers with no history of major abdominal surgery. They were studied in a separate, multicenter trial, NCT001282884, which was approved by the local institutional review board. Each subject gave informed consent before enrollment. After an overnight