

Gastric emptying for liquids of different compositions in children

T. Du^{1,5}, L. Hill¹, L. Ding^{2,3}, A. J. Towbin^{3,4}, M. DeJonckheere^{1,6}, P. Bennett⁴, N. Hagerman^{1,3}, A. M. Varughese^{1,3} and J. N. Pratap^{1,3,*}

¹Departments of Anesthesiology, ²Biostatistics and Epidemiology, Cincinnati Children's Hospital Medical Center, Cincinnati, OH, USA, ³University of Cincinnati College of Medicine, Cincinnati, OH, USA, ⁴Department of Radiology, Cincinnati Children's Hospital Medical Center, Cincinnati, OH, USA, ⁵Department of Anaesthesia, Lady Cilento Children's Hospital, South Brisbane, Queensland, Australia and ⁶Department of Family Medicine, University of Michigan Medical School, Ann Arbor, MI, USA

*Corresponding author. E-mail: jayant.pratap@cchmc.org

Abstract

Background. Pre-operative fasting balances safety against patient discomfort. We compared the gastric emptying profiles of a novel clear, high protein drink against a "traditional" clear and a non-clear fluid.

Methods. We conducted a prospective cross-sectional study with 48 healthy volunteers, eight to 14 yr of age, fasted overnight and without risk factors for abnormal gastrointestinal motility. Subjects were randomized in equal ratio to ingest 296 ml of apple juice, 2% milk or Ensure Clear. The gastric antrum was seen by ultrasound in the right lateral decubitus position at baseline, after ingestion, then every 30 min thereafter until return to baseline or six h. Gastric antral cross-sectional area was measured independently by two anaesthetists, and compared between drinks.

Results. Gastric emptying differed between apple juice, 2% milk and Ensure Clear by analysis of co-variance ($P < 0.0001$), and was faster in males than females ($P < 0.01$). The terminal phase however was similar using interval-censored time to gastric emptying in a survival model ($P = 0.17$) or by comparing proportions with empty stomach vs not empty at 90 min ($P = 1.0$), 120 min ($P = 0.32$), 150 min ($P = 0.11$), 180 min ($P = 0.76$) or 210 min ($P = 1.0$).

Conclusions. Despite early differences, clearance from the stomach of apple juice, 2% milk or Ensure Clear is similar at the terminal phase, which is the period of greatest relevance to preoperative fasting recommendations. The stomach is essentially clear by 3–3.5 h for all three drinks studied. The differentiation between liquids in current guidelines is not supported by this study.

Clinical trial registration. clinicaltrials.gov NCT02938065 clinicaltrials.gov/ct2/show/NCT02938065.

Key words: fasting; paediatrics; ultrasonography

Editor's key points

- Most paediatric fasting guidelines recommend ingestion of optically clear fluids only, during the six h before surgery.
- Guidelines commonly specifically prohibit ingestion of milk during the six h before surgery.
- The authors compared gastric emptying after ingestion of apple juice, 2% (reduced fat) milk and a clear high protein drink.
- The study results do not support the differentiation between liquids in current guidelines.

Preoperative fasting recommendations for elective surgery represent a compromise between maximizing anaesthesia safety and minimizing patient discomfort. The risks of aspiration under anaesthesia are likely low,¹ but potential resultant pulmonary complications may be severe, and are balanced against the patient's thirst, hunger, and hypoglycaemia² while fasting plus resulting metabolic stress.³ The history of preoperative fasting instructions has been riddled with dogma,⁴ but modern guidelines differentiate optically clear from other fluids and solids in terms of the recommended period of abstinence.⁵

In recent years, new drinks (e.g. Ensure Clear) have arrived to the market that are optically clear but with more protein than standard clear fluids. The authors have encountered in their clinical practice children who have drunk these within the few hours before surgery in view of their 'clear' moniker. Moreover, surgical patients are increasingly encouraged to take nutrition late before surgery as part of 'Enhanced Recovery After Surgery' protocols.³ Uncertainty regarding the appropriate place of such drinks within the existing fasting schedule motivated the current study.

Ultrasound scanning of the gastric antrum has been validated as a non-invasive method to assess gastric volume,⁶ including in anaesthesia practice⁷ and even in children.^{8–10} Measurements of gastric emptying have been shown to be highly reproducible on different occasions and when made by different observers.⁶

This study seeks to compare the gastric emptying profile of a novel clear, high protein drink (Ensure Clear) to that of a "traditional" clear fluid (apple juice) and a non-clear fluid (2% milk) in a healthy paediatric population. As a secondary aim, we also examined the satiety profile after ingestion of these beverages.

Methods

With Institutional Review Board approval, we conducted a prospective cross-sectional study with healthy volunteers. The study was registered at clinicaltrials.gov on July 25, 2016 with reference NCT02938065. The study took place at the Imaging Research Center of Cincinnati Children's Hospital Medical Center. Healthy volunteers were sought by posting study advertisements on community message boards within the hospital and through an e-mail to all hospital employees. The participants provided assent as appropriate to their age and were rewarded with a gift voucher. Volunteers were enrolled between July and August 2016.

We enrolled 48 children, eight to 14 yrs of age, fasted overnight and without risk factors for abnormal gastrointestinal motility. Inclusion required that their legal guardians were able to understand the protocol and to provide written informed

consent and that their general health met criteria for ASA physical status classification I or II. Exclusions were: obesity ($BMI > 35 \text{ kg m}^{-2}$); known prior gastrointestinal surgery or disorders; medications except oral contraceptives; known allergy or intolerance to milk, apple juice or Ensure Clear (Abbott Nutrition, Lake Forest, IL, U.S.A.). Recorded patient characteristic data included weight, height, age, gender and race.

Study protocol

48 subjects were randomized in equal ratio (16 per group) to ingest 296 ml (10 fl oz) of either apple juice, 2% cow's milk or Ensure Clear. This volume was chosen for being the stated portion size of Ensure Clear and the volume of the container in which it is sold, and to avoid errors in measuring out or administration. Randomization was performed from a computer-generated list of random numbers. A standardized scanning protocol was carried out beginning before ingestion of the study drink to determine an empty baseline measurement. Scanning continued within five min after ingestion of 296 ml of drink (stored at 4 degrees Celsius until administration). The gastric antrum was visualized in the right lateral decubitus position at baseline, after ingestion, then every 30 min thereafter until return to the pre-ingestion baseline or 6 h (whichever sooner). Qualified sonography technologists, blinded to group assignment, performed all studies and saved images for later analysis. Ultrasound examinations were conducted with curvilinear-array 6C1 (5.5 MHz) and 4C1 (4 MHz) transducers using a Accuson S3000 system (Siemens, Malvern, PA, U.S.A.). The gastric antrum was imaged in a sagittal plane, between the left lobe of the liver and the pancreas, at the level of the aorta, with the subjects in the right lateral decubitus, as previously reported.^{7 11} The gastric antrum visualized in the right lateral position was previously demonstrated to give most accurate measurements of ingested fluid volumes in adults¹³ and in children.⁸ The scanning plane was optimized to assess the cross-sectional area by obtaining a view perpendicular to the long axis of the antrum. Frequent peristaltic contractions are a normal occurrence after ingestion of fluid and are readily recognized during gastric ultrasound assessment as temporary decreases in antral diameter. Sonographers were instructed to obtain a single image for each time point between (and not during) peristaltic contractions to avoid underestimating gastric antral cross-sectional area (CSA).

From the saved images, CSA was measured independently by two investigators, also blinded to group assignment, based on measurement of orthogonal diameters D1 and D2 using MergePACS software (Merge Healthcare, Chicago, IL, U.S.A.). CSA was calculated using the standard formula for surface area of an ellipse, assuming that the antrum has a perfect elliptical shape, $CSA = D1 \times D2 \times \pi / 4$. This method of antral area measurement has high intra- and inter-rater reliability and is equivalent to the previously reported free-tracing method of area measurement using the internal calliper of the ultrasound unit.¹⁴

Hunger was measured using the validated Hunger Satiety Score (HSS), where the child self-reports hunger using a one to five visual analogue ordinal scale with higher scores denoting greater satiety.¹⁵ Polling occurred before each CSA measurement for each child.

Statistical analysis

Patient characteristics are expressed as the median with interquartile range (IQR) or percentage, as appropriate (Table 1). Patient characteristics were compared between groups by the

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