



From the *Journal archives*: Gastric fluid volume and pH in elective patients following unrestricted oral fluid until three hours before surgery

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Editors' Note: Classics Revisited

Key Articles from the *Canadian Journal of Anesthesia Archives*: 1954–2013

As part of the *Journal's* 60th anniversary Diamond Jubilee Celebration, a number of seminal articles from the *Journal* archives are highlighted in the *Journal's* 61st printed volume and online at: www.springer.com/12630. The following article was selected on the basis of its novelty at the time of publication, its scientific merit, and its overall importance to clinical practice: *Maltby JR, Lewis P, Martin A, Sutherland LR*. Gastric fluid volume and pH in elective patients following unrestricted oral fluid until three hours before surgery. *Can J Anaesth* 1991; 38: 425–9. In this article Dr. William M. Splinter presents expert commentary on how this article provided needed information to allow clinicians to make rational decisions regarding preoperative fasting. He also highlights how current fasting decisions are frequently too conservative and not always congruent with what is known about the science of preoperative fasting.

Hilary P. Grocott MD, Editor-in-Chief
Donald R. Miller MD, Former Editor-in-Chief

Article summary

The seminal article by Maltby *et al.* demonstrated the safety of unrestricted clear oral fluid ingestion three hours before surgery. Maltby and his co-investigators studied 199 healthy adults who presented for elective surgery to determine if unrestricted clear oral fluids up to three hours before surgery would have an impact on gastric fluid volume and gastric pH. Among these patients, 105 (study group) ingested 50–1200 mL of oral fluids on the morning of surgery. The remaining 94 subjects (control group) ingested no exogenous fluids on the day of surgery. Gastric fluid volumes did not differ between the subgroups. Also, patients with a particularly brief fasting time (i.e., as little as 1.3 hr) behaved similarly to patients who had been on a prolonged fast. Also, those who ingested large volumes of fluids had gastric volumes and pH values similar to those in other subgroups. The authors concluded that healthy patients could safely ingest unlimited amounts of clear fluids up to three hours before elective anesthesia and surgery.

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Citation: *Maltby JR, Lewis P, Martin A, Sutherland LR*. Gastric fluid volume and pH in elective patients following unrestricted oral fluid until three hours before surgery. *Can J Anaesth* 1991; 38: 425–9.

Purpose: This seminal article established the safety of clear fluid ingestion before elective anesthesia. It also updated readers on the normal physiology associated with clear fluid and solid food ingestion and reviewed safe practices for preoperative ingestion of each.

Principal findings: The article by Maltby *et al.* confirmed the safety of unrestricted clear fluid ingestion up to three hours before elective surgery by healthy adult patients.

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Subsequent research confirmed the safety of this approach, and other studies have established the benefits of a reduced fasting time. Further research demonstrated that the clear fluid fast can be safely decreased to as little as one hour if managed in a prescriptive fashion. Also, the safety of solid food ingestion on the day of surgery has recently been revisited by other investigators.

Conclusions: The landmark paper of Maltby *et al.* established the safety of preoperative clear fluid ingestion before anesthesia, with an improved and less expensive perioperative course for all patients undergoing elective surgery. Subsequent research confirmed their results and expanded on other issues such as reducing the clear fluids fast to one hour and permitting ingestion of low-calorie solid foods several hours before anesthesia, such as an early morning meal in patients scheduled for afternoon surgery.

During the 1980s it was routine for patients to undergo an extended fast prior to elective surgery, a practice that continues directly and indirectly in many institutions, particularly in North America.¹ Many anesthesiologists and surgeons often discreetly (though often not so discreetly) prefer their patients to maintain an extended fast despite the physicians' respective institutions having liberalized their fasting guidelines. As a resident in training during the 1980s, our classic preoperative anesthesia order was "NPO > MN" (i.e., nil *per os* after midnight). Adults and children scheduled for surgery late in the day often had an intravenous infusion started to maintain preoperative hydration. Not only was this practice highly labour-intensive, from the perspective of a child and the family it often increased the negativity of what was already a rather unpleasant event.

Although the precise origin of the classic NPO > MN order is not known, it likely was based on "expert" opinion that was in turn undoubtedly based on the fear of perioperative aspiration pneumonitis (Mendelson's syndrome).² It was believed that primary risk factors for aspiration pneumonitis were an increased gastric residual volume and decreased gastric pH. Hence, these two factors had to be optimized before anesthesia and surgery. Subsequent research identified three important risk factors for pulmonary aspiration: emergency surgery, inadequate levels of anesthesia, and gastrointestinal pathology.³ Prior to the emergence of this information, patients underwent extended fasting periods to minimize their gastric residual volume. It should be noted that in Mendelson's study only the patients who aspirated clear fluids survived. The two deaths that occurred were caused by aspiration of solid material. (Presumably death was due to combined asphyxia and chemical pneumonitis).

In the early days, there was little routine restriction of food or fluid ingestion prior to anesthesia. In some

jurisdictions, most notably Europe and the United Kingdom during the 1980s, patients were routinely allowed small meals/a light breakfast (e.g., tea and toast) early in the morning when scheduled for anesthesia in the afternoon.⁴ It was almost two decades later (in North America) that a small meal such as tea and toast was considered acceptable if ingested six hours or more before elective surgery.⁵ It is not surprising that during the 1980s as anesthesiologists trained in Europe increasingly migrated to North America they questioned their Canadian counterparts about the common practice of perioperative fasting. Maltby was one of the early leaders in questioning it, with his important article ultimately demonstrating that unrestricted clear fluids were safe up to three hours before surgery.⁶

Maltby *et al.*'s results were a major surprise to most North American-trained anesthesiologists. Many of us had been thoroughly 'brain-washed' that NPO > MN was the only safe option. Anything else was highly questionable—if not extremely dangerous. In fact, elective anesthesia/surgery was deferred for any patient who did not comply with that rule. Many surgeons and patients were chastised for non-compliance. Accordingly, some thought that Maltby's research was heretical. On the contrary, Maltby and his co-investigators were not reckless. Rather, their research was based on a vast clinical experience outside North America and, more importantly, on the knowledge of how the stomach routinely manages its contents.⁷

The stomach has many complex functions. Serving as a repository for everything we eat, this efficient organ macerates the food, begins the initial stages of digestion, and then carefully, slowly, and almost methodically releases its contents into the small bowel via the pylorus. It handles solid food and clear fluids quite independently.⁸ Solid food empties following zero-order kinetics. That is, the stomach typically empties at a constant rate according to the number of calories per hour (usually approximately 200 kcal·hr⁻¹).^{9,10} Thus, if the solid-food caloric intake is doubled, the solid food takes twice as long to be digested and emptied into the small bowel. Alternatively, after a low-calorie, simple, solid-food meal (e.g., toast for breakfast), the toast is rapidly emptied from the stomach so there is minimal gastric contents during the afternoon.^{4,6}

There are slight differences in how the gastrointestinal tract handles food comprised of specific content, such as lipids, carbohydrates, and proteins.¹⁰ It is largely a function of the caloric content. As lipids have the highest caloric content per weight, they are emptied more slowly. Also, many of the "gems" provided by our mothers make sense. For example, if one ingests a sweet, high-calorie snack just before a meal there is a sense of food in the stomach (causing a loss of appetite). Finally, individuals who have undergone gastric bypass surgery, such as Whipple's

procedure, typically lack this calorie-regulated stomach emptying and develop a dumping syndrome.

The path for clear fluids is dramatically different. Fluids empty from the stomach rapidly, following first-order kinetics (i.e., a decline described by an exponential curve).¹¹ Some clear fluids, such as normal (0.9%) saline, have short half-lives (i.e., minutes), effectively flushing through the stomach.¹² Simplistically, clear fluids empty somewhat independently of solids, so they do not “wash down” any solids that lie beyond the esophagus. Clear fluids with a high-calorie content, however, do slow down the emptying of solid food because a 200 kcal·hr⁻¹ limit is followed. That is, if 200 kcal of clear fluid ingested during a meal empties from the stomach during any given hour, minimal amounts of the solid food ingested subsequently leave the stomach. Thus, the half-life of gastric contents can vary dramatically according to the caloric properties of the clear fluids. Isoosmotic fluids such as saline and most drinks ingested by marathon runners are readily absorbed, whereas fluids of high-calorie content and those with markedly non-physiologic osmolality empty from the stomach much more slowly to minimize any dumping syndrome and sudden shifts in serum osmolality.

There are two other important issues to consider with regard to first-order kinetics and normal gastric function. Some amount of fluid is always present in the stomach. If a clear fluid has a ten-minute half-life, even after 30 min only 7/8 of it is gone. In addition, oral and gastric secretions are constantly being added to the stomach. We produce saliva at a rate of 0.4–1 mL·kg⁻¹·hr⁻¹ along with the endogenous gastric secretions.¹³ Thus, an 80-kg adult man adds 0.4–1.0 × 2 × 80, or 64–160 mL·hr⁻¹. Accordingly, after an eight-hour “fast,” roughly 500–1250 mL of fluid is added naturally to the stomach. This added volume is constantly diluting and facilitating the washout of what we drink. For example, whereas a patient with a bowel obstruction often accumulates large volumes of these secretions in the stomach (or drains them via a nasogastric tube) during an eight-hour period, a patient fasting for eight hours (i.e., NPO > MN) is steadily emptying 500–1250 mL of fluid from the stomach.

With all these facts in mind, what is the next step in considering fasting “rules”? Following the landmark paper of Maltby *et al.*, subsequent research resulted in decreasing the preoperative fasting period even further. We now deem it safe to allow prescriptive clear fluid ingestion up 1 hr before anesthesia in a variety of age groups, from infants to adults.^{10,14,15} We thus have less physiologically deranged patients awaiting anesthesia. They are no longer dehydrated, irritable, hungry, or thirsty. Indeed, these patients may have an improved insulin response during the perioperative period, as has been suggested by topical research addressing enhanced recovery programs after surgery.^{16,17}

In conclusion, Maltby and his colleagues’ landmark paper established the safety of preoperative clear fluid ingestion. It has led to more optimal and safe anesthesia practices, along with an improved, less expensive perioperative course for all patients undergoing elective surgery. Subsequent research confirmed their results and has expanded to address issues they introduced. Examples include reducing the clear fluids fast to one hour and permitting the ingestion of low-calorie solid foods up to several hours before anesthesia, such as a light meal during the early morning for patients scheduled for afternoon surgery.

Key points

- Routine, prolonged fasting before elective surgery is no longer indicated.
- Clear, aqueous fluids empty from the stomach soon after ingestion.
- Routine fasting guidelines had previously been based on low levels of evidence, with higher levels of evidence having been ignored.
- Healthy patients may safely ingest clear, aqueous fluids up to one hour before elective anesthesia when given in a prescribed fashion (e.g., a 180-mL glass of water).
- Healthy patients may safely ingest small portions of solid foods a few hours before elective anesthesia and surgery.
- Routine preoperative ingestion of foods, including solids and liquids, should be based on evidence-based medicine, not anecdotal experiences or unsubstantiated beliefs.

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Conflicts of interest None declared.

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