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REVIEW ARTICLE

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Enhanced recovery after surgery—Preoperative fasting and glucose loading—A review

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In this review, we explore the rationale and history behind the practice of preoperative fasting in elective surgery including the gradual move toward longer fasting and the more recent change in direction of practice. Gastric emptying physiology and the metabolic effects of prolonged fasting and carbohydrate loading are examined. Most recent guidelines related to these topics are discussed and practical recommendations for implementing these guidelines are suggested.

KEYWORDS
fasting, glucose, preoperative, review

1 | INTRODUCTION

General anesthesia results in suppression of the gag, cough, and swallow reflexes. Since these reflexes normally protect the airway, their suppression carries the risk of regurgitation of stomach contents with resultant pulmonary aspiration, a potentially fatal complication. For this reason, reduction of stomach content at the time of general anesthesia has long been known to be vital to patient safety. Despite the lack of compelling evidence to support this practice, 6-8 h of total preoperative fasting is still considered essential by many surgeons and anesthesiologists and non-adherence to fasting recommendations is a common reason for postponement or cancellation of surgery, leading to excess resource consumption and inconvenience to patients and provider. As a precaution, patients frequently end up fasting for 12 h or more because of delays and changes in operating room schedules as well as the use of a traditional "nil per oral after midnight" paradigm.

It has been clear for some time not only does prolonged fasting deprive patients of nutrition and hydration but that the metabolic response to long fasting leads to intensification of the response occurring after surgical trauma (mainly manifested as increased insulin resistance) and loss of lean body mass.[1] In addition prolonged fasting can lead to an increase in catabolic pathways that might increase the risk of certain postoperative complication.[2,3] In fact, there has not been any evidence indicating that a shorter fast of 2-3 h, which includes oral clear or carbohydrate rich fluids, results in an increased risk of aspiration, regurgitation, or related morbidity compared with the standard policy of "nil by mouth after midnight."

The aim of this review is to examine the rational and dogma behind preoperative fasting, discuss the evidence behind administration of oral carbohydrate rich fluids preoperatively (glucose loading), provide current guidelines on fasting, and give practical recommendations to perioperative providers involved in changing the culture around preoperative fasting (Figure 1).

2 | HISTORY

Interestingly, the original purpose of preoperative fasting was not the concern for aspiration but to minimize the unpleasantness of vomiting.[4] The first reported case of aspiration under anesthesia was in a soldier from Burma in 1862 and in 1883 Sir John Lister was the first to distinguish solid food from clear liquids while publishing simple fasting guidelines. Most textbooks continued this distinction, while others recommended a 2-4-h fast for both. In the 1960s and 70s, however, there was a gradual movement toward longer fasting and absolute fasting from midnight without a distinction between solids and liquids.[5,6] It is unclear why the earlier distinction between the two was not preserved.

The belief that many healthy patients with no risk factors are also at high risk of acid aspiration was based off of the work of Roberts, Shirley, and Raidoo et al who determined that 0.8 mL/kg gastric contents at pH 1.0 injected directly into the trachea of anaesthetized monkeys produced severe pneumonitis.[7] This represented 50 mL in adult humans, but the investigators did not attempt to determine the gastric volume required to produce regurgitation and aspiration of that volume.

- Liberalizing of oral clear fluid Intake and the use of carbohydrate based preoperative beverages prior to elective surgery should be a standard part of any comprehensive perioperative program
- In order to institute change it is important to obtain multidisciplinary consensus with early involvement of surgery, anesthesia and nursing leadership.
- Perioperative protocols should be created taking into account national guidelines as well as local patient and practice patterns
- Protocols should be disseminated to front-line providers to ensure consistent messaging to patients across a spectrum of interactions
- Constant re-engagement and feedback to address any barriers to implementation

FIGURE 1 Practical Recommendations for Surgeons—The following recommendations should be part of any comprehensive perioperative recovery program

Clinical investigation demonstrated that gastric fluid volume exceeded 25 mL with pH < 2.5 in up to 80% of healthy patients who fasted for at least 8 h (from midnight) before elective surgery[8,9] and this cemented the idea of prolonged fasting in the management of these patients.

In the 1980s, these recommendations started being questioned when Miller et al showed that a light breakfast <4 h before surgery made no significant difference to gastric median volume or pH compared with an overnight fast.[10] In the 1980s and early 90s, clinical trials in several countries comparing residual gastric volumes in patients allowed to drink liquids on the day of surgery versus fasting demonstrated that intake of oral liquids until 2 h before general anesthesia was safe.[11] The first editorials on liberalizing fluid intake appeared in the anesthesia literature in the early 1990s,[12,13] but textbooks were slow to change their recommendations. In 1996, the ASA appointed a task force on preoperative fasting to review relevant clinical human research studies published between 1966 and 1996 and their recommendations were published in Anesthesiology in 1999.[14] Unfortunately, adherence to these recommendations is still not universal today, almost 2 decades later. This is easily demonstrated when examining the Internet where online fasting recommendations are often inconsistent with current guidelines, particularly among health care institution websites.[15]

3 | GASTRIC EMPTYING PHYSIOLOGY

Emptying of gastric contents differs significantly for liquids and solids. The half-emptying time of neutral, iso-osmolar inert solution such as 500 mL isotonic saline is 12 min; 90% passes through the pylorus within 1 h and virtually all within 2 h.[16] The rate of emptying for solids depends on the type and quantity of food and the size of the food particles. This can range from 4 h for digestible solids to 12 h for indigestible solids, such as cellulose-containing vegetables.[17] Factors such as smoking, functional dyspepsia, psychological stress, and female hormones may further prolong gastric emptying times for solids.[18–21]

4 | METABOLIC EFFECTS OF PROLONGED FASTING

Animal models of severe stress have shown that 6-24 h fasting in animals results in substantially less capacity to cope with hemorrhage or endotoxemia.[22] These studies indicated that the availability of carbohydrates and the metabolic setting of the fed state were crucial to recovery. The same investigations in humans have demonstrated the importance of insulin resistance in the perioperative period.[23] Elective surgery leads to a transient increase in insulin resistance that serves as a marker for metabolic stress and lasts for about 2-3 weeks depending on the type of surgery.[24,25] After an elective operation, the nature of this insulin resistance is influenced by the choice of surgical technique[26,27]; appropriate control of pain[28]; postoperative muscle inactivity[29]; and duration of preoperative fasting.[30]

During insulin-resistant states, glucose uptake by the cells is decreased and consequently glycogen formation stops, and glycogen stores in the liver and muscles are depleted. Simultaneously with the reduction of glucose uptake, endogenous glucose production is enhanced. The resultant hyperglycemia is associated with elevated risk of complications.[31]

5 | THE ROLE OF PREOPERATIVE GLUCOSE LOADING

The main objective of preoperative carbohydrate loading is to produce the change in metabolism that normally takes place when breakfast is eaten. This elicits an endogenous release of insulin that turns off the overnight fasting state of the metabolism. After intake of a carbohydrate drink, the body metabolism is in a carbohydrate-storing state, as expected. When the trauma of surgery occurs, there are mediators released that shut off glucose uptake in muscle and increase glucose production. These two components together make up the insulin resistance. If the patient is pretreated with carbohydrates, the starting point for these two reactions are much more anabolic and hence the stress results in a less catabolic end setting compared with if the patient already has a starting point toward the catabolic state by being fasted overnight.[32] Preoperatively, this can be effectively achieved either by giving a high-dose glucose infusion (> = 5 mg/kg/min) or by providing a sufficiently concentrated carbohydrate-containing beverage.[33] Several trials have confirmed this[34–36] and a meta-analysis has shown that oral carbohydrate administered 2-4 h before elective surgery reduces postoperative insulin resistance.[37] While both water and carbohydrate-rich preoperative beverages reduce preoperative thirst, the addition of carbohydrate also reduces hunger and anxiety, and improves overall well being.[38] In addition, even patients with preoperative insulin resistance are not adversely affected by glucose loading.[39]

The addition of carbohydrate-rich fluids in the preoperative period has also shown to have significant benefits in the postoperative period. Glucose loading is associated with less perioperative discomfort including general discomfort, malaise, thirst, hunger, and weakness,[40] a reduction in postoperative nausea/vomiting,[41] and preservation of

muscle mass postoperatively.[42] In at least one meta-analysis[43] and one Cochrane review[44] it has been shown to shorten postoperative length of stay by up to 1 Day compared to patients who underwent prolonged fasting.

6 | CURRENT GUIDELINES

In 2015, the ASA Committee on Standards and Practice Parameters requested that the updated guidelines published in 2011 be re-evaluated and the most recent update was published in March 2017.[45] The fasting recommendations included a minimum fasting period of 2 h for clear liquids; 4 h for breast milk; 6 h for non-human milk, infant formula, or light meal (toast and clears); and 8 h or longer for Fried foods, fatty foods, or meat.

The ERAS Society Guidelines from 2013 recommended clear fluids up to 2 h and solids up to 6 h prior to induction of anesthesia. They also recommended the use of preoperative oral carbohydrates routinely, even in diabetic patients where carbohydrate treatment can be given along with the diabetic medication.[46]

The American Society for Enhanced Recovery (ASER) consensus statement 2016 echoes these and recommends unrestricted access to clear fluids for oral intake up to 2 h before the induction of anesthesia to maintain hydration while minimizing the risk of aspiration and that these fluids contain at least 45 g of carbohydrate to improve insulin sensitivity (except in type I diabetics due to their insulin deficiency state).[47]

7 | EXCEPTIONS TO LIBERAL FASTING GUIDELINES

While the above guidelines can be used safely for most patients about to undergo elective anesthesia and surgery, strict preoperative fasting is still recommended for all those having emergency operations. Other situations in which longer fasting periods should still be used include gastrointestinal obstruction of any form, or cancer in the upper gastrointestinal tract.[48] Pregnant women, morbidly obese patients, those with gastroesophageal reflux and diabetes may constitute another group at risk for short-term fasting. In patients were gastric emptying may be delayed (duodenal obstruction, etc) additional specific safety measures should be taken at the induction of anesthesia. In such patients the role of newer point of care techniques such as the use of gastric ultrasound to assess stomach volume[49] is still emerging.

8 | PRACTICAL RECOMMENDATIONS FOR PROMOTING CHANGE

The liberalization of oral clear fluid intake and the use of carbohydrate based preoperative beverages prior to elective surgery should be a standard part of any comprehensive perioperative program. The most important aspect of instituting this change involves obtaining multidisciplinary consensus and aligning messaging to reflect this consensus. We recommend early involvement of surgical, anesthesia, and nursing leadership with a development of a preoperative protocol that take into account national guidelines but also local factors that may influence your perioperative processes. For example, although most guidelines advocate clear fluids up to 2 h prior to induction of anesthesia we determined that a 4 h period was more suitable for us since operations often get completed before the scheduled time (or cancelled) and the additional 2 h provides us flexibility in bringing cases forward. While there are numerous drinks available for preoperative glucose loading with some including proteins and other nutritional supplements that may provide incremental benefits, we advocate for a drink with the appropriate carbohydrate concentration (at least 45 gm) that is inexpensive, easily available, and agreeable in taste. Once a consensus is reached and a protocol is in place, this needs to be disseminated to front line providers so that a consistent message is provided to patients. This should involve inclusion of the protocol in any preoperative instructions given by the surgeon and anesthesia teams, updating any relevant web pages, clear instructions to outpatient and preoperative nursing as well as to anyone who may communicate with patients in the preoperative period. If any barriers to implementation are identified, these must be addressed and often more than one solution is required. We initially chose a carbohydrate drink that was not easily available at local pharmacies and grocery stores and our solution was to hand a packet of the drink to patients with instruction at the time of surgery booking as well as to allow additional clear nutritional drinks that were more readily available in the protocol. Any change to long-standing practice should be measured to assess progress and ideally this should be done in the immediate preoperative period to accurately gauge the change in practice.

Finally any quality improvement process requires constant re-engagement and continued commitment to bring about lasting change and we recommend intermittent multi-disciplinary meetings between frontline providers and leadership of surgery, anesthesia, and nursing to ensure that any barriers are addressed.

DISCLOSURE STATEMENT

The authors have no disclosures with regard to this work.

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REFERENCES

1. Pimenta GP, de Aguilar-Nascimento JE. Prolonged preoperative fasting in elective surgical patients: why should we reduce it? *Nutr Clin Pract*. 2014;29:22–28.
2. Nygren J, Soop M, Thorell A, Efendic S, Nair KS, Ljungqvist O. Preoperative oral carbohydrate administration reduces postoperative insulin resistance. *Clin Nutr*. 1998;17:65–71.

3. Thorell A, Alston-Smith J, Ljungqvist O. The effect of preoperative carbohydrate loading on hormonal changes, hepatic glycogen, and glucoregulatory enzymes during abdominal surgery. *Nutrition*. 1996;12:690–695.
4. Maltby JR. Fasting from midnight—the history behind the dogma. *Best Pract Res Clin Anaesthesiol*. 2006;20:363–378.
5. Lee JA, Atkinson RS. *A Synopsis of Anaesthesia*. 5th ed. Bristol, England, United Kingdom: John Wright & Sons Ltd:64.
6. Cohen DD, Dillon GB. Anesthesia for Outpatient Surgery. *JAMA*. 1966;196:1114–1116. https://doi.org/10.1001/jama.1966.03100260052015
7. Raidoo DM, Rocke DA, Brock-Utne JG, et al. Critical volume for pulmonary acid aspiration: reappraisal in a primate model. *Br J Anaesth*. 1990;65:248–250.
8. Stoelting RK. Responses to atropine, glycopyrrolate, and riopan of gastric fluid pH and volume in adult patients. *Anesthesiology*. 1978;48:367–369.
9. Salmenpera M, Kortilla K, Kalima T. Reduction of the risk of acid pulmonary aspiration in anaesthetized patients after cimetidine premedication. *Acta Anaesthesiol Scand*. 1980;24:25–30.
10. Miller M, Wishart HY, Nimmo WS. Gastric contents at induction of anaesthesia. Is a 4-hour fast necessary? *Br J Anaesth*. 1983;55:1185–1188.
11. Søreide E, Strømskag KE, Steen PA. Statistical aspects in studies of preoperative fluid intake and gastric content. *Acta Anaesthesiol Scand*. 1995;39:738–743.
12. Schreiner MS, Triebwasser A, Keon TP. Ingestion of liquids compared with preoperative fasting in pediatric outpatients. *Anesthesiology*. 1990;72:593–597.
13. Strunin L. How long should patients fast before surgery. Time for new guidelines. *Br J Anaesth*. 1993;70:1–3.
14. American Society of Anaesthesiologists Task Force on Preoperative Fasting. Practice guidelines for preoperative fasting and the use of pharmacologic agents to reduce the risk of pulmonary aspiration: application to healthy patients undergoing elective procedures: a report by the American Society of Anaesthesiologists Task Force on Preoperative Fasting. *Anesthesiology*. 1999;90:896–905.
15. Roughead T, Sewell D, Ryerson CJ, Fisher JH, Flexman AM. Internet-based resources frequently provide inaccurate and out-of-date recommendations on preoperative fasting: a systematic review. *Anesth Analg*. 2016;123:1463–1468.
16. Hunt JN. Some properties of an elementary osmoreceptor mechanism. *J Physiol*. 1956;132:267–288.
17. Hinder RA, Kelly KA. Canine gastric emptying of solids and liquids. *Am J Physiol*. 1977;133:E335–E340.
18. Minami H, McCallum RW. The physiology and pathophysiology of gastric emptying in humans. *Gastroenterology*. 1984;86:1592–1610.
19. Petring OU, Blake DW. Gastric emptying in adults: an overview related to anaesthesia. *Anaesth Intensive Care*. 1993;21:774–781.
20. Scott AM, Kellow JEK, Shuter B, Nolan JM, Hoschl R, Jones MP. Effects of cigarette smoking on solid and liquid intragastric distribution and gastric emptying. *Gastroenterology*. 1993;104:410–416.
21. Hutson WR, Roehrkasse RL, Wald A. Influence of gender and menopause on gastric emptying and motility. *Gastroenterology*. 1989;96:11–17.
22. Ljungqvist O, Nygren J, Hausel J, Thorell A. Preoperative nutrition therapy—novel developments. *Scand J Nutr*. 2000;44:3–7.
23. Thorell A, Guntiak M, Efendic S, Ḧaggmark T, Ljungqvist O. Insulin resistance after abdominal surgery. *Br J Surg*. 1994;81:59–63.
24. Thorell A, Nygren J, Ljungqvist O. Insulin resistance: a marker of surgical stress. *Curr Opin Clin Nutr Metab Care*. 1999;2:69–78.
25. Soop M, Nygren J, Thorell A, Ljungqvist O. Stress-induced insulin resistance: recent developments. *Curr Opin Clin Nutr Metab Care*. 2007;10:181–186.
26. Thorell A, Nygren J, Ess P, et al. The metabolic response to cholecystectomy: insulin resistance after open compared with laparoscopic operation. *Eur J Surg*. 1996;162:187–191.
27. Kanno H, Kiyama T, Fujita I, et al. Laparoscopic surgery improves blood glucose homeostasis and insulin resistance following distal gastrectomy for cancer. *JPEN J Parenter Enteral Nutr*. 2009;33:686–690.
28. Greisen J, Juhl CB, Gr.fte T, Vilstrup H, Jensen TS, Schmitz O. Acute pain induces insulin resistance in humans. *Anesthesiology*. 2001;95:578–584.
29. Biens RS, Ringholm S, Kiilerich K, et al. GLUT4 and glycogen synthase are key players in bed rest-induced insulin resistance. *Diabetes*. 2012;61:1090–1099.
30. Faria MS, de Aguilar-Nascimento JE, Pimenta OS, Alvarenga LC, Jr, Dock-Nascimento DB, Slhessarenko N. Preoperative fasting of 2 hours minimizes insulin resistance and organic response to trauma after videocholecystectomy: a randomized, controlled, clinical trial. *World J Surg*. 2009;33:1158–1164.
31. Blixt C, Ahlstedt C, Ljungqvist O, Isaksson B, Kalman S, Rooyackers O. The effect of perioperative glucose control on postoperative insulin resistance. *Clin Nutr*. 2012;31:676–681. 18.
32. Ljungqvist O. Modulating postoperative insulin resistance by preoperative carbohydrate loading. *Best Pract Res Clin Anaesthesiol*. 2009;23:401–409.
33. Nygren J, Thorell A, Jacobsson H, et al. Preoperative gastric emptying. Effects of anxiety and carbohydrate administration. *Ann Surg*. 1995;222:728–734.
34. Soop M, Nygren J, Myrenfors P, Thorell A, Ljungqvist O. Preoperative oral carbohydrate treatment attenuates immediate postoperative insulin resistance. *Am J Physiol Endocrinol Metab*. 2001;280:E576–E583.
35. Nygren J, Soop M, Thorell A, Efendic S, Nair KS, Ljungqvist O. Preoperative oral carbohydrate administration reduces postoperative insulin resistance. *Clin Nutr*. 1998;17:65–71.
36. Perrone F, da-Silva-Filho AC, Adôrno IF, et al. Effects of preoperative feeding with a whey protein plus carbohydrate drink on the acute phase response and insulin resistance: a randomized trial. *Nutr J*. 2011;10:66.
37. Awad S, Varadhan KK, Ljungqvist O, Lobo DN. A meta-analysis of randomized controlled trials on preoperative oral carbohydrate treatment in elective surgery. *Clin Nutr*. 2013;32:34–44.
38. Hausel J, Nygren J, Lagerkranser M, et al. A carbohydrate-rich drink reduces preoperative discomfort in elective surgery patients. *Anesth Analg*. 2001;93:1344–1350.
39. Can MF, Yagci G, Dag B, et al. Preoperative administration of oral carbohydrate-rich solutions: comparison of glucometabolic responses and tolerability between patients with and without insulin resistance. *Nutrition*. 2009;25:72–77.
40. Yildiz H, Gunal SE, Yilmaz G, Yucel S. Oral carbohydrate supplementation reduces preoperative discomfort in laparoscopic cholecystectomy. *J Invest Surg*. 2013;26:89–95.
41. Hausel J, Nygren J, Thorell A, Lagerkranser M, Ljungqvist O. Randomized clinical trial of the effects of oral preoperative carbohydrates on postoperative nausea and vomiting after laparoscopic cholecystectomy. *Br J Surg*. 2005;92:415–421.
42. Yuill KA, Richardson RA, Davidson HI, Garden OJ, Parks RW. The administration of an oral carbohydrate-containing fluid prior to major elective upper-gastrointestinal surgery preserves skeletal muscle mass postoperatively—a randomised clinical trial. *Clin Nutr*. 2005;24:32–37.
43. Awad S, Varadhan KK, Ljungqvist O, Lobo DN. A meta-analysis of randomized controlled trials on preoperative oral carbohydrate treatment in elective surgery. *Clin Nutr*. 2013;32:34–44.
44. Smith MD, McCall J, Plank L, Herbison GP, Soop M, Nygren J. Preoperative carbohydrate treatment for enhancing recovery after elective surgery. *Cochrane Database Syst Rev*. 2014;14:CD009161.

45. Practice guidelines for preoperative fasting and the use of pharmacologic agents to reduce the risk of pulmonary aspiration: application to healthy patients undergoing elective procedures; an updated report by the american society of anesthesiologists task force on preoperative fasting and the use of pharmacologic agents to reduce the risk of pulmonary aspiration. *Anesthesiology*. 2017;126:376–393.
46. Gustafsson UO, Scott MJ, Schwenk W, et al. Guidelines for perioperative care in elective colonic surgery: enhanced recovery after surgery society recommendations. *World J Surg*. 2013;37: 259–284.
47. Thiele RH, Raghunathan K, Brudney CS, et al. American Society for Enhanced Recovery (ASER) and Perioperative Quality Initiative (POQI) joint consensus statement on perioperative fluid management within an enhanced recovery pathway for colorectal surgery. *Perioper Med (Lond)*. 2016;5:24.
48. Ljungqvist O, Søreide E. Preoperative fasting. *Br J Surg*. 2003;90: 400–406.
49. Perlas A, Chan VW, Lupu CM, Mitsakakis N, Hanbidge A. Ultrasound assessment of gastric content and volume. *Anesthesiology*. 2009;111: 82–89.

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