Review Article

Overview of preoperative fasting for general anaesthesia

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160 Character summary of article: This article summarizes previous and current international preoperative fasting guidelines and examines the reasons underlying their ongoing development.

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Abstract

The primary goal of fasting prior to general anaesthesia is to reduce the risk of pulmonary aspiration, displacement of gastric contents into the lungs. As gastric volume, alongside patient age, current medications and type of surgery are associated with increased incidence of pulmonary aspiration. The preoperative fasting guidelines have been developed to reduce total fasting duration. Most recommend clear fluids up to two hours prior to surgery and solid food up to six hours prior to surgery. Reducing fasting time aims to minimize the negative metabolic effects of prolonged fasting, such as insulin resistance, catabolism, increased gastric acidity, discomfort, hypotension and dehydration. When combined with the negative effects associated with surgical trauma, many of these, particularly insulin resistance, have been associated with poor postoperative outcomes. Preoperative carbohydrate loading through the use of a glucose beverage has been examined as a method of reducing insulin resistance. There is a large amount of evidence suggesting it is a safe and effective preoperative tool. Patient compliance has been identified as a limitation of preoperative fasting guidelines, associated with a lack of understanding regarding their risk of pulmonary aspiration. Altering guidelines to include a default treatment program, consisting of carbohydrate treatment, minimum hydration requirements and enhancements in preoperative assessments to improve patient understanding, would likely improve patient outcomes.

Introduction

Although there are enormous benefits of general anaesthesia in surgical procedures, the use of general anaesthesia nonetheless poses innate risks to patient safety. To minimise these risks, evidence-based guidelines are implemented into clinical practice. These guidelines consolidate the best up-to-date evidence to provide health practitioners with easily accessible and accurate information. Often, these are region-specific and adapted at multiple levels of health service provision.

Australian anaesthetic guidelines are developed by the Australian and New Zealand College of Anaesthetists (ANZCA), with similar organisations existing for different regions worldwide [1]. While management decisions are ultimately up to the treating team, these standardised guidelines provide a useful reference tool to assist in the decision-making process. The objective of standardised guidelines is to minimise the risk of events, which may lead to iatrogenic morbidity or mortality of patients undergoing general anaesthesia.

One of the most well-known preoperative recommendations outlined in guidelines is on preoperative fasting. In all forms of its existence, the goal of preoperative fasting has been to diminish the risk of perioperative pulmonary aspiration, by reducing gastric volume and acidity [2]. When developing fasting protocols, the risk of pulmonary aspiration must be balanced against other negative metabolic effects associated with fasting.

This review will compare previous and current international preoperative fasting guidelines and integrate information regarding the event of pulmonary aspiration, discuss the development and future advancement of current fasting guidelines.

Historical Perspective on Fasting

Knowledge regarding gastric emptying time has progressed significantly since being first identified in 1833 by Beaumont [3], who observed that it took up to five hours for solid food to be cleared from the stomach and significantly less time for clear fluids. In 1883, Lister [4] suggested that a fast from solid foods was required approximately five to six hours prior to surgery. He also suggested that two hours was adequate time for removal of clear fluids, such as water. Although it is not clear when the transition occurred, it was reported that American anaesthetics textbooks in the 1960s published “nil-by-mouth” (NPO) guidelines [5]. These guidelines advised against the consumption of solid food and clear and non-clear liquid after midnight the night before surgery. In some cases, patients had fasting times of 15 hours or more. NPO technique was commonplace during the decades following, and in a 1995 survey of American anaesthetists, 50% still used the nil-by-mouth fasting guideline indiscriminately [6]. However, the prevalence of NPO was declining and in a 1999 review, the American Society of Anaesthesiologists (ASA) published new guidelines for preoperative fasting [7]. These permitted clear fluids two or more hours, breast milk four or more hours and solid food and non-human milk six or more hours prior to surgery.

Pulmonary Aspiration

Pulmonary aspiration is defined as the displacement of gastric contents into the tracheobronchial tree [8]. Although outcomes can be severe, the risk of pulmonary aspiration may appear falsely low due to its infrequent occurrence.

Since 1970, three large population studies have investigated the incidence of fatal and non-fatal pulmonary aspiration events in patients undergoing general anaesthesia during elective and emergency surgery. These took place at major centres in Sweden, America, and Norway (n=185,358, n=215,488, and n=85,594 patients, respectively) [9-11]. Of the total 486,440 patients, there was an average pulmonary aspiration event rate of 1 in 2,717 surgeries. When examined exclusively, it can be seen that fatal primary aspiration events were less common; however, large variation exists between reported incidences. From two of the studies above (n=185,358 and n=215,488 patients), the average incidence of fatal aspiration event was calculated to be 1 in 57,274 surgeries, but the Royal College of Anaesthetists 4th National Audit Project (NAP4) estimated a much lower incidence in the United Kingdom of 1 in 360,000 [12].

Whilst death is a consequence of the most severe adverse events, non-fatal cases also have detrimental long-term effects on health. For example, Olsson *et al*. reported that 47% of non-fatal cases of perioperative pulmonary aspiration went on to develop severe postoperative lung damage secondary to aspiration pneumonitis [9].

Risk Factors Contributing to Occurrence of Pulmonary Aspiration

There are a number of factors that increase a patient’s risk of suffering a pulmonary aspiration event. Accurate preoperative assessment of these factors is a crucial component of identifying a patient’s level of risk. Guidelines have been published by ANZCA as to the goals, expected outcomes, and methodology of a proper preoperative assessment [1].

Initial assessment segregates patients in accordance with the ASA physical status classification system (Table 1). Physical status is assessed on a scale, ranging from 1 (normal and healthy) to 6 (brain-dead) [13]. Higher grades of preoperative ASA physical status have been shown to be a predictor for increased incidence of pulmonary aspiration [14,15].

Following assessment, further precautions may then be taken with high-risk patients to reduce patient harm and improve surgical outcomes. Robinson and Davidson summarise a list of available strategies for high-risk patients [16].

In the context of anaesthesia, where laryngeal protective reflexes, such as cough and gag reflexes are obtunded, risk factors that alter the integrity of the upper and/or lower oesophageal sphincter are particularly relevant. As increased age is associated with decreased oesophageal sphincter muscle tone [17], elderly patients fall into this risk category. Similarly, certain medications, including opioids, muscarinic receptor antagonists, and both β-adrenoreceptor agonists and antagonists, have been found to decrease sphincter tone [18]. Inadequate depth of anaesthesia also poses a risk, where accidental stimulation of previously attenuated gastrointestinal motor response could contribute to an aspiration event [16].

Risks for pulmonary aspiration are also present at a health service level, for example, it has been found that risk varies based on anaesthetist experience levels. The NAP4 project found that of the 29 aspiration cases reviewed 15 were performed by a trainee [12]. The type of surgery may also play a role, as aspiration occurred three times more often in thoracic surgeries compared to any other region [10]. The position chosen for intubation and extubation also altered the likelihood of aspiration, with a sideways orientation being associated with lower risk [16].

Other identified risk factors directly relate to an increase in the gastric volume of the stomach. Gastric volume is implicated in the occurrence of pulmonary aspiration events, with greater gastric volume associated with a high risk of aspiration [19]. The decreased rate of gastric emptying, for example, in the cases of gastrointestinal obstruction or diabetes mellitus, results in an increase of gastric volume [20]. Conditions, such as these, which decrease gastrointestinal motility, worsen the risk of an aspiration event. Similarly, opioid use also reduces motility and gastric emptying and significantly increases the patient's risk of aspiration [18]. Pregnancy has also been documented to increase gastric volume [21].

Preoperative fasting guidelines have been established and developed over time to reduce perioperative gastric volume. In cases of emergency surgery, where a strict preoperative fasting protocol is not possible, the risk of an aspiration event is significantly increased. Previous studies found that the incidence of such an event increased three to fourfold when comparing emergency surgery to elective procedures [14,22,23].

Metabolic Consequences of Preoperative Fasting and Surgical Trauma

Whilst preoperative fasting is necessary to reduce the incidence of pulmonary aspiration, prolonged lack of solids or fluid has been demonstrated to have a number of negative metabolic effects, which can in fact worsen postoperative patient outcomes. The primary result of any period of fasting is a decrease in the body's physiological response to insulin, insulin resistance [24]. Insulin resistance is a protective metabolic mechanism and is also seen following surgical trauma. The gold-standard method of measuring insulin resistance is the hyperinsulinaemic/euglycaemic glucose clamp technique [25]. To achieve the greatest postoperative outcome, a balance must be sought between fasting enough to reduce perioperative gastric volume and not fasting for longer than necessary, in order to reduce the degree of insulin resistance and other negative metabolic effects.

Prolonged fasting results in a hypometabolic state with generalised catabolism to maintain energy requirements. This is hormonally mediated and adrenaline release results in adrenergic activation, with subsequent lipolysis, free fatty acid release and ketogenesis [26]. The rate of insulin release is also reduced, resulting in a decrease in the endogenous insulin/glucagon ratio, initiating gluconeogenesis in the liver and peripheral tissues in conjunction with the above mentioned insulin resistance [26].

The body's response to surgical trauma is a state of catabolism, similar to a starvation response. In contrast to the starvation response, surgical trauma increases the overall metabolic rate, increasing the required energy of tissues. This is a consequence of the release of stress hormones, including adrenaline, catecholamines, cortisol, and glucagon [26]. These facilitate the breakdown of glycogen, protein and fat. Insulin release is also a major event that occurs following the physiological stress of surgery; however, due to decreased insulin sensitivity, blood glucose concentrations remain constant and, in most cases, increase perioperatively [27].

The resultant degree of insulin resistance is dependent on the type (for example, gastrointestinal or thoracic) and the length of surgery, with positive association between surgery time and degree of insulin resistance [28]. Onset is almost immediately after initial tissue trauma occurs and significant metabolic effects are present for approximately five days postoperatively. Normalisation of the insulin response occurs, on average, after 20 postoperative days [27]. Insulin resistance is associated with prolonged recovery times whereas postoperative normalisation of insulin sensitivity significantly correlates with reduced length of postoperative stay [29].

Enhanced recovery after surgery (ERAS) is a multinational initiative to prevent postoperative complications, including insulin resistance, across a range of systems. ERAS protocols involve modifications to care practices in order to decrease surgical stress response and maintain preoperative organ function across many surgical specialties [30]. ERAS protocols for reducing perioperative insulin resistance during surgery involve preoperative carbohydrate loading, using thoracic epidural anaesthesia and early enteral feeding [31].

Managing the effects of insulin resistance through an insulin infusion may also be an effective strategy for reducing insulin resistance and mortality associated with physiological trauma and stress in a surgical setting. This has been demonstrated in an intensive care setting, where stress-related hyperglycaemic conditions were prevented via insulin infusion. This significantly reduced mortality and complication rates when compared to cases where hyperglycaemia was not treated with infusion [32]. The management of insulin resistance in surgical cases may, therefore, play an important role in reducing mortality during surgical procedures.

Along with the hormonal changes seen, prolonged fasting has a number of other negative effects. Fasting has been shown to lower the pH of the gastric and duodenal contents, with longer periods of fasting associated with higher acidity [40]. Whilst the event of pulmonary aspiration has a decreased incidence in the fasted state, there is still potential for an aspiration event to occur. In this case, increased gastric acidity would cause a greater degree of damage to the lungs in comparison to chemical pneumonitis from stomach contents in a fed state.

The process of fasting is uncomfortable and has many short-term side effects. These can include discomfort, nausea, headaches, dizziness, and hypotension [41]. While none of these conditions are life threatening, they are important to consider when implementing strict fasting guidelines. In the event of excessive fasting, patients suffer these symptoms for no benefit, and may be exposed to potential risks such as insulin resistance, which leads to increased postoperative recovery time, and lowered pH of the gastric contents.

Hydration status is also important to consider in fasting patients. Adequate preoperative hydration is associated with decreased perception of pain, decreased postoperative nausea and improved postoperative recovery [42,43,44]. Dehydration may also increase the risk of postoperative acute kidney injury in some patients [45,46].

Prevention of Insulin Resistance in a Clinical Setting

To investigate whether the addition of glucose pre-, peri-, and/or postoperatively can prevent insulin resistance and large-scale catabolism, applications of glucose solution have been examined. Ljungqvist *et al.* saw that a constant intravenous infusion of 300 g glucose solution between three hours preoperatively and three hours postoperatively reduced the length of hospital stay by an average of 20% (one day) [30]. Using a similar methodology (continuous glucose and insulin infusion of 5 mg/kg/min and 0.8 mU/kg/min, respectively, from three hours prior to surgery), Nygren *et al.* saw similar effects, with a difference in insulin sensitivity of approximately 50% between treatment and control groups [33].

Preoperative oral carbohydrate solution administration has also been examined. Four studies have examined the effect of oral carbohydrate solution on gastric emptying in order to identify if there was an increased risk of pulmonary aspiration risk [34-37]. No significant difference between gastric emptying times of water and carbohydrate solution was found in any of the studies [34-37]. Subsequent studies thus treated carbohydrate solution as a 'clear fluid', enabling it to be safely consumed closer to the time of surgery than a solid meal, without the increased risk of aspiration. In a 2014 systematic review, Bilku *et al.* described seven studies examining the effect of preoperative carbohydrate solution on insulin resistance, six of which reported a significant decrease in insulin resistance and one study reported non-significance [38]. Soop *et al.* also reported a significant effect, with glucose beverage consumed two hours preoperatively decreasing the reduction of insulin sensitivity by 25% compared to the control group [39].

Recent Guidelines

Current guidelines take the risks of prolonged fasting and residual gastric volume into consideration. The current guidelines from the American Society of Anaesthesiologists (ASA), European Society of Anaesthesiology (ESA), and the Australian and New Zealand College of Anaesthetists (ANZCA) are summarised in Table 2 [1,47,48]. It can be seen that the recommendations of all three associations are very similar, with the only variation being with regard to high fat foods.

Most current guidelines have a shorter minimum duration of fasting than previous nil-by-mouth after midnight guidelines. This has been due to evidence supporting the safety of shorter fasting periods (gastric volume studies previously mentioned) and the detrimental metabolic effects of prolonged fasting, including insulin resistance, decreased blood glucose concentration, discomfort, and worsened postoperative recovery. This evidence has a prompted a reduction in fasting to the minimum amount of time that has been shown to provide a safe gastric volume whilst not increasing the risk of pulmonary aspiration.

A point of interest is that Table 2 does not include preoperative oral carbohydrate beverages. Whilst not listed, all three guidelines allow these to be consumed up to two hours prior to surgery. The ASA guideline review discusses their safety, citing studies that have examined gastric emptying times and conclude that they are safe for preoperative consumption, but does not mention any metabolic advantages. European Society of Anaesthesiology guidelines similarly mention gastric emptying and safety, but also cite research concluding an improved metabolic response and increased patient well-being using carbohydrate beverages. However, whilst these are permitted, they are not a requirement and their use is up to the anaesthetist's discretion.

Similarly, there is no required level of fluid consumption outlined in for any of the guidelines. All three organisations "encourage clear fluid consumption up to two hours prior to surgery," yet level of consumption is not measured or controlled. Even though clear fluid consumption is permitted, dehydration may occur if consumption is not monitored, along with the previously discussed negative outcomes that are associated with preoperative dehydration.

Challenges and Advancements

While institutions develop these guidelines to improve patient safety, noncompliance is a detrimental limitation to their effectiveness. Current noncompliance with preoperative fasting guidelines has been reported to range between 1.5 and 3.9% [49-51]. Due to the significant risks associated with noncompliance, improvement in this area is required. One of the reasons for noncompliance has been identified as a lack of patient understanding regarding the risks of anaesthesia, the severity of noncompliance and the fundamental reasons for fasting preoperatively [51,52]. Lim *et al.* saw that only 44.6% of surveyed patients understood the reason for fasting. Those who could identify the correct reason were more likely to perceive it as important [51]. Walker *et al.* produced similar conclusions, with patients who did not understand the reason for fasting being five times more likely to underrate the importance of compliance [52]. This identifies a problematic lack in communication between medical professionals and patients, which can be addressed through education during the preoperative assessment of the patient.

Gastric sonography is one method of assessing a patient's aspiration risk without having to consider other comorbidities or compliance with preoperative fasting protocols [53]. Gastric sonography involves a bedside assessment of a patient's gastric contents, analysing the nature of the contents (solid or clear fluid) and the gastric volume. A systematic review conducted by Van de Putte and Perlas analysed seventeen individual studies that addressed the identification of gastric contents and/or volume [54]. It reported two mathematical models of gastric volume prediction that are currently thought of as accurate and clinically applicable. Gastric sonography is thought to be a useful clinical tool to assess aspiration risks in cases of emergency surgery, patient non-compliance and the presence of multiple significant comorbidities that delay gastric emptying.

Conclusion

Preoperative fasting is a critical protocol put in place to reduce the risk of perioperative pulmonary aspiration. Originally implemented with long fasting periods of up to fifteen hours, protocols have been improved to reduce unnecessary fasting times and he subsequent negative metabolic effects. This review describes both historical and current guidelines and explains the reasons for their development. Understanding the risks associated with anaesthesia and the most up-to-date protocols to reduce aspiration risk is important to medical students interested in anaesthetics and surgical specialties.

Whilst AMA, ESA, and ANZCA literature lists fasting as compulsory, there is limited regulation of minimum consumption levels of clear fluid, disposing patients to dehydration, or compulsory preoperative carbohydrate uptake, which has been associated with decreased postoperative insulin resistance. Future incorporation of these factors into current guidelines may improve patient outcomes.

Increasing patient compliance may also improve outcomes. The preoperative assessment should be altered to increase patient understanding regarding the risk factors involved with anaesthesia, and underlying reason and clinical significance of the preoperative fasting protocols. The results of previous studies suggest that lack of education in this area is responsible for noncompliance.

Finally, gastric sonography is an accurate and reliable bedside test that may improve clinicians' abilities to accurately assess gastric volume and thus a patient's risk of pulmonary aspiration.

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Table 1: American Society of Anaesthesiologists Physical Status classification levels and associated definitions.

ASA Physical Status Classification	**Definition**
1	Normal healthy patient
2	Patient with mild systemic disease
3	Patient with severe systemic disease
4	Patient with severe systemic disease that is a constant threat to life
5	Moribund patient who is not expected to survive without the operation
6	Declared brain-dead patient whose organs are being removed for donor purposes

Table 2: Comparison of international preoperative fasting guidelines for various substances

Association	Clear Liquid	EL	Non-fatty solid food and non-human milk	EL	High fat food or Meat	EL
ASA (2017)	> 2hrs	1++	> 6	1	>8	*
ESA (2011)	> 2hrs	1++	> 6	1+	No differentiation between high-fat and low-fat solids	*
ANZCA (2016)	> 2hrs	*	> 6 (“Light meal only”)	*	No differentiation between high-fat and low-fat solids	*

All values represented as number of hours prior to surgery. Evidence level (EL) measures the strength of the supplied evidence; represented as a grade from 1 to 4. 1=high-quality meta-analyses, systematic reviews of RCT’s or RCT’s with very low risk of bias. 2= well-conducted case-control or cohort study with low risk of bias. 3= non-analytical study. 4= expert opinion. *Level of evidence not provided. “+” represents evidence of greater strength.