Preoperative fasting in children: review of existing guidelines and recent developments

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Abstract

The current guidelines for preoperative fasting recommend intervals of 6, 4, and 2 h (6–4–2) of fasting for solids, breast milk, and clear fluids, respectively. The objective is to minimize the risk of pulmonary aspiration of gastric contents, but also to prevent unnecessarily long fasting intervals. Pulmonary aspiration is rare and associated with nearly no mortality in paediatric anaesthesia. The incidence may have decreased during the last decades, judging from several audits published recently. However, several reports of very long fasting intervals have also been published, in spite of the implementation of the 6–4–2 fasting regimens. In this review, we examine the physiological basis for various fasting recommendations, the temporal relationship between fluid intake and residual gastric content, and the pathophysiological effects of preoperative fasting, and review recent publications of various attempts to reduce the incidence of prolonged fasting in children. The pros and cons of the current guidelines will be addressed, and possible strategies for a future revision will be suggested.

Keywords: anaesthesia; aspiration pneumonia; children; gastric emptying; preoperative period

Preanaesthetic or preoperative fasting is a universally applied principle in elective cases to minimize the risk of pulmonary aspiration of gastric content posed by the combination of regurgitation and loss of protective airway reflexes by anaesthetic agents. In the early days of anaesthesia, a light breakfast was often recommended before anaesthesia, but several reports of pulmonary aspiration associated with anaesthesia, including the classic report of a series of 66 obstetric cases by Mendelson,1 resulted in the implementation of various nil by mouth (NBM)-from-midnight recommendations, increasingly enforced from around 1970.2 Subsequently, guidelines published and adopted by the North American and European anaesthesiology organizations—the ASA in 1998/2011, the European Society of Anaesthesiology (ESA) in 2011, and the Scandinavian Society of Anaesthesiology and Intensive Care (SSAI) in 2003—have cemented the principle that solids (including semi-solid food and milk-containing products) should be avoided 6 h and clear fluids 2 h before anaesthesia induction, respectively (6–4–2 regimen).3–5 Infants are usually allowed ingestion of breast milk up to 4 h before anaesthesia.
Editor’s key points

- Pulmonary aspiration associated with anaesthesia is rare. Many children are fasted excessively in spite of the current guidelines.
- This review provides a summary of the physiological, epidemiological, and practical aspects of ensuring safe anaesthesia with regard to fasting in children.
- A suggestion for a revision of the guidelines for preoperative fasting in children is provided.

Guidelines on perioperative fluid management and fasting have recently been reviewed by Lambert and Carey, who found that only two recommendations could be graded as level A: firstly, that preoperative fasting should be minimized, and secondly, that clear fluids may be ingested until 2 h before the administration of anaesthesia.

Recent research has contributed with new insights concerning preoperative fasting in children: firstly, that children are often fasted for unnecessarily long intervals in spite of the implementation of current guidelines; secondly, that prolonged fasting could have detrimental metabolic and behavioural effects in small children; thirdly, that the rationale for 6–4–2 h limits in current guidelines may be questioned; and fourthly, that reducing fasting intervals within or even beyond the 2 h limit may be safe and result in a reduced risk of negative metabolic effects of fasting.

In this review, we will analyse the risk of pulmonary aspiration in paediatric anaesthesia; examine the physiological basis for various fasting recommendations, the temporal relationship between fluid intake and residual gastric content, and the pathophysiological effects of preoperative fasting; and review recent publications of various attempts to reduce the incidence of prolonged fasting in children. The pros and cons of the current guidelines will be addressed, and possible strategies for a future revision will be suggested.

Pulmonary aspiration of gastric contents in paediatric anaesthetic practice

In the last decades, there have been a number of reports in the anaesthetic literature looking at the issue of pulmonary aspiration in both adult and paediatric practice. A recent report of pulmonary aspiration in paediatric practice is a multicentre study of specialist paediatric centres that took place in the United Kingdom. This study revealed a very low incidence of aspiration of 2 and 2.2 per 10 000 cases for both elective and emergency cases, respectively. The study was conducted in the United Kingdom where the 6–4–2 h rule is widespread for fasting. Although the recent multicentre study reports a very low incidence, there are other studies in children that report higher incidences of 9–10 cases per 10 000 cases. The most recent of these, the Anaesthesia Practice in Children Observational Trial (APRICOT) study, was a prospective, multicentre, pan-European study of the incidence of severe critical events in paediatric anaesthesia. In the APRICOT study, the aspiration event led to treatment with suctioning (54%), bronchodilators (30%), intubation/prolonged intubation (9.3%), antibiotics (4.7%), and continuous positive airway pressure (CPAP) (2.3%). The outcome was uneventful in 54% of cases, but led to prolonged intubation (12%), hypoxaemia (30%), or pneumonia (3%) in the remaining cases. Interestingly, not a single admission to intensive care as a result of the aspiration event was registered, in spite of several children needing prolonged intubation or CPAP. If this is not attributable to under-reporting, none of the aspiration events appear to be associated with long-term morbidity or mortality.

In an earlier single-centre study, Warner and colleagues reported a low incidence in elective patients of 2 per 10 000, but a 10-fold higher incidence in emergency cases. This was corroborated neither by the APRICOT study nor by the UK report.

The aforementioned studies all suggest that pulmonary aspiration during anaesthesia is a low-risk event in children, but this view should be balanced with two other reports. The review from the Australian Incident Monitoring Study in 1999 report on 133 cases of pulmonary aspiration in adults and children. Approximately 20% of the cases were children, and there were five deaths in the group as a whole. The National Audit Project 4, from the Royal College of Anaesthetists and the Difficult Airway Society in the United Kingdom entitled ‘Major Complications of Airway Management in the UK’, found that pulmonary aspiration was the commonest cause of death during anaesthesia in adults and accounted for 50% of anaesthesia-related deaths overall in the study period. Therefore, although aspiration of gastric contents is an uncommon event, it can have devastating consequences. Importantly, no single paediatric case of perioperative aspiration-related death and no long-term sequelae from perioperative fluid aspiration have been published so far, although there may have been under-reporting in the literature because of medicolegal restrictions.

Fasting times and the risk of pulmonary aspiration

Although having a large meal just before anaesthesia is probably a very bad idea, there is no solid evidence in the form of randomized controlled trials linking the length of preoperative fasting with the risk of aspiration of gastric contents during anaesthesia.

In a recent multicentre trial with more than 139 000 procedural sedations or anaesthetics in children, the incidence of aspiration was reported to be similar whether the children were fasted or not. Other factors, such as patient- and anaesthetic-related issues, are more likely to be responsible for an aspiration event in the elective situation. Fasting times have, over the last 50 yr or so, come down, particularly relating to clear fluid intake, and this time period has seen the incidence of aspiration events decrease in parallel. The latter development is likely attributable to several factors, such as changes in practice and improvement in the standard of care, but at the very least does not support longer clear fluid fasting intervals than 2 h for elective cases, and may be taken into account when we discuss even shorter fasting times.

The recent studies show that the main risk period for an aspiration event is during induction, but may also occur during maintenance of anaesthesia or during emergence. The patient factors associated with aspiration of gastric contents include a full stomach, bowel obstruction, abdominal pain, diabetes, or associated trauma with reduced gastric emptying. Anaesthetic risk factors from the studies include drug-related issues (e.g. opioids), patient positioning, the choice of airway management, and often ‘light’ or inadequate anaesthesia.

Recurrent themes from all the recent reports include emergency patients, inadequate anaesthesia, obesity,
gastrointestinal pathology, and other factors increasing the likelihood of regurgitation. The combination of patient risk factors with added anaesthetic factors, such as the inappropriate choice of a laryngeal mask and inadequate anaesthesia, is frequently reported. To summarize, pulmonary aspiration is rare in paediatric anaesthetic practice. The anaesthetist needs to be aware of the relevant risk factors outlined earlier and plan the anaesthesia accordingly. In some cases, perhaps a prolonged NBM interval can be reasonable as for emergency surgery. However, for the vast majority of elective paediatric anaesthetics, aspiration is exceedingly rare, whilst very long fasting intervals are not. It is this majority that the present review is henceforth concerned with.

**Physiology of gastric emptying**

Gastric emptying may be studied with various methods, including scintigraphy, aspiration of gastric contents via a nasogastric (NG) tube, pharmaco-kinetic studies of water-soluble substances (e.g. paracetamol) reabsorbed in the proximal intestines, magnetic resonance imaging (MRI), and ultrasound imaging (US). It is beyond the scope of the present review to perform a detailed analysis of the merits and problems of each of the aforementioned methods for determining gastric contents and the rate of gastric emptying. Briefly, the radionuclide method is regarded as the gold standard, in relation to which NG aspiration is the least reliable, whilst MRI and US are increasingly reproducible and less invasive, although there may still be a measure of investigator variability with the latter technique.

Using a standard pharmaco-kinetic terminology, gastric emptying of solids may be described as zero-order elimination, whilst fluids follow first-order kinetics. Thus, solid food will pass from the gastric ventricle to the duodenum at a constant rate, whilst clear fluids are eliminated exponen-tially. This has important consequences: first, a very large meal will inevitably take a long time to be completely eliminated from the stomach—possibly more than 8 h if the food was irresistible and the appetite was stronger than the perception of satiety. Thus, regardless of the regimen implemented, for certain groups of patients (i.e. nocturnally active, hungry teenagers), it may be prudent to ascertain not only at what time the last meal was ingested, but also the amount devoured. On the contrary, most normal children will seldom drink excessively unless they are thirsty. Thus, as long as they are allowed free access to clear fluids in the preoperative period, it is likely that their last drink before surgery will have passed through the gastric ventricle within less than 1 h. For example, with a gastric elimination half-life \( t_{1/2} \) of 10 min, even a 200 ml drink of water or lemonade will be reduced to 25 ml within 30 min of ingestion. With a more conservative \( t_{1/2} \) of 15 min, the residual approaches 50 ml after the same half-hour interval, and less than 25 ml within 1 h. These calculations are corroborated by a study using serial MRI of gastric content volume (GCVw) after ingestion of a sugared fluid, in which the authors report GCVw similar to baseline (overnight fasting) 1 h after ingestion of a limited amount of fluid (3 ml kg\(^{-1}\)). However, a larger amount of fluid (7 ml kg\(^{-1}\)) was not completely eliminated after the 1 h interval. This suggests that repeated (even hourly) small amounts instead of a large single volume of clear fluid could safely be offered to the child waiting for surgery.

The ASA and ESA guidelines regard milk as a solid, as the proteins contained in milk coagulate in the acidic environment of the ventricle. The evidence for this recommendation is weak and may be an unnecessarily conservative view. Although there will be some production of coagulated milk proteins, the greater part of a non-human-milk-based volume may be regarded as clear fluid with a rapid elimination rate, whilst the semi-solid agglutinate is likely to, unless huge quantities are ingested, also be eliminated from the gastric ventricle relatively rapidly, as the absolute volume of solid is small. A recently published model-based meta-analysis of gastric emptying studies indicated only marginally longer mean gastric residence times for infant formula than for breast milk. Indeed, the SSAI guideline recommends that infant formula (which may be based on cow’s milk) may be ingested up to 4 h before anaesthesia. Furthermore, some centres even allow a light meal containing solids, such as bread, up to 4 h in contra-diction to current guidelines. A physiological support for this breach is that, whereas a very large meal may remain in the stomach for a long time, a light meal is likely to be eliminated well within a 4 h interval. A recent MRI study supports the latter hypothesis. In addition, Stümpelmann and colleagues recently used ultrasound measurements of the gastric antral area to show that the mean gastric emptying time was lower than 4 h after a normal breakfast in healthy preschool children.

Whilst the understanding of the physiology of gastric emptying may justify a reduction of several of the current fasting limits, it must be stressed that a disease may alter the normal physiology significantly. For example, gastric motility may be reduced by intestinal obstruction, opioid administration, or the stress of trauma. Furthermore, disorders of the oesophagus, such as achalasia, are highly likely to cause accumulation of fluid and solids in the oesophagus. Thus, understanding the pathophysiology of gastric function is paramount in avoiding the risk of truly dangerous regurgitation and aspiration during anaesthesia. Keeping children with these disorders NBM from midnight is prudent.

**Association between fasting intervals and residual gastric contents**

The rationale for preoperative fasting is to ensure that the patient arrives in the operating theatre with an empty stomach. Thus, current guidelines have used knowledge about the physiology of gastric emptying outlined earlier to estimate safe fasting intervals for liquids and solids within reasonable limits. However, recent research has demonstrated that even a 2 h fasting interval for fluids does not guarantee an empty stomach. On the contrary, there seems to be a considerable inter-individual variation. Schmidt and colleagues showed that, whilst most children had only small amounts of residual gastric content, some children had up to 90 ml of gastric fluid after either 1 or 2 h of fasting. In fact, in the latter and other studies, there was no obvious correlation between fasting interval and intragastric volume. Furthermore, in an MRI study of gastric contents after a light meal ingested 4 or 6 h, there was no difference in intragastric volume. Clinicians may draw two very different conclusions from these findings. Either we should go back to a NBM-from-midnight regimen to allow time for children with slow gastric kinetics (or inherently larger intragastric volume) to empty their stomachs, or we should open up for shorter fasting intervals, as the 2 h limit does not cover all individuals anyway.
Prolonged preoperative fasting: pathophysiology and occurrence

Small children have a higher metabolic rate and reduced glycogen stores compared with adults. In 1974, Thomas found a 28% incidence of hypoglycaemia in toddlers that were starving for at least 6 h, as opposed to those who had a milk drink 4 h before surgery. Furthermore, prolonged fasting is associated with ketoacidosis, especially in children less than 36 months old. It is, therefore, worrying that several authors have reported disconcertingly high incidences of fasting for more than 6 or even as much as 12–21 h in various settings. Interestingly, also prolonged postoperative fasting in small children may influence the need for analgesic, and the incidence of nausea and vomiting.

New strategies to reduce the incidence of prolonged fasting

Recently, several publications have attempted to address the problem of prolonged fasting under the current guidelines. Dennhardt and colleagues implemented a multi-professional programme to reduce real fasting times to intervals close to the 6–4–2 guidelines. They reported a decrease in mean fasting time from 8.5 to 6 h, and a reduction of ‘deviation from the guideline >2 h’ from 70% to 8%. A different approach was studied by Andersson and colleagues, who found that omission of the 2 h fasting limit for clear fluids was not associated with an increased incidence of pulmonary aspiration in a retrospective audit of 10 000 elective paediatric anaesthetics. The latter study was based on an audit of a fasting regimen that has been successfully implemented by a paediatric anaesthesia unit of a large university hospital for more than 15 yr. Another paediatric centre has reported the implementation of a similar rule, with limited amounts of clear fluid offered hourly to children until they were called to theatre.

A recent publication could be seen as an efficient compromise between the two aforementioned strategies. Using a structured quality-improvement programme, Newton and colleagues could document an increase of children fasting less than 4 h from 19% to 72% after the introduction of a standard operating procedure checking on the fasting status on admission and allowing clear fluids up to 1 h before anaesthesia. Furthermore, nurses were encouraged to call to theatre to ask for permission to offer a drink to children that were fasting for more than 4 h.

Thus, reducing the mean duration of fasting can be achieved either by a comprehensive multi-professional education programme to optimize logistics and coach children to drink as close to the 2 h limit as possible, or by omitting or significantly shortening the 2 h interval otherwise required, to bypass the logistic challenges involved in the former strategy.

Reasons for considering a change of current guidelines for preoperative fasting in children

The current guidelines are well established and seem reasonable. Are there any good reasons for changing them? Which are the main reasons for status quo?

Pro

The main reason for considering an update of the current guidelines is the observation that many children are starved for much longer than they need to. Several studies have reported many children fasting for up to 12 or 15 h in spite of the implementation of the 6–4–2 guideline. This may result in side-effects, such as hypoglycaemia, metabolic acidosis, dehydration, cardiovascular instability, discomfort, hunger, thirst, and grumpiness, especially in toddlers and infants. Secondly, our understanding of the physiology of gastric emptying from both old and new studies leads us to conclude that the stomach processes a light meal, even if it includes solids, to negligible amounts within 4 h, and a drink of clear fluids in considerably less time in most children. Thirdly, although it seems like a good idea, there is no sound evidence that fasting actually protects from pulmonary aspiration. With the understanding of human nature and the human factor, it is likely that some children will turn up for anaesthesia after having eaten less than 4 h before surgery, even though officially being prohibited by their healthcare practitioner. Still, the incidence of pulmonary aspiration as a result of gastric regurgitation at induction is strikingly low. Factors, such as inadequate anaesthesia, inappropriate use of supraglottic airways, poor preoperative evaluation, and lack of subspecialist training in paediatric anaesthesia, are thus likely to be more important to address if we are to ensure safe anaesthesia for children.

Con

The current guidelines have a good track record. In a recent audit of almost 120 000 anaesthetics in the United Kingdom, the reported incidence of pulmonary aspiration was 0.02%, similar to two other studies from the last decades. Interestingly, two large retrospective studies from the period before the modern 6–4–2 guidelines were implemented actually reported slightly higher rates of 0.06–0.1%, although it would be meaningless to compare the incidences with statistical methods. Secondly, as mentioned earlier, several studies of gastric emptying have shown that, although most children eliminate both solids and clear fluids well within the 6–4–2 limits, individual subjects seem to have a much slower rate of gastric emptying. Thirdly, the few studies that indicate that more liberal fasting regimens are not associated with a higher incidence of pulmonary aspiration are not conclusive, as they were not powered to show non-inferiority. Finally, a recent single-centre study has demonstrated that it is possible to reduce the number of children that fast for more than 2 h longer than the limits of the 6–4–2 regimen, by means of a multidisciplinary information campaign. So, why change a ‘winning’ concept?

The authors of this review would argue that the reasons for a change, at least in small children, in whom the adverse effects of prolonged fasting may be more significant, outweigh the arguments against. The incidence of pulmonary aspiration is low even with the very liberal 6–4–0 regimen, and there is no physiological or epidemiological evidence that it would increase with a transition from the current guidelines. There is no guarantee that every child has an empty stomach at anaesthesia induction, whichever fasting regimen is used. Multiple studies have demonstrated that many children starve for surprisingly long intervals before surgery with the current
regimens. The logistics of ensuring that this does not happen by informing every child when to stop drinking at the right time are inherently difficult, as every anaesthetist that has been in charge of a busy anaesthesia floor knows. Therefore, we suggest that two small but significant changes to the 6–4–2 regimen are implemented by several paediatric hospitals, whilst auditing the transition to corroborate both safety and efficacy. As a first step, clear fluids could be permitted until 1 h before anaesthesia, vastly simplifying logistics and the task of timely information to parents and children of when to stop drinking. This will have the beneficial effects of avoiding discomfort, thirst, dehydration, and perhaps hypoglycaemia. Importantly, the number of children suffering from excessive fasting will be reduced. Whether a 4 h limit for a ‘light breakfast’ in combination with a more liberal fasting regimen for clear fluids is safe and could further reduce the detrimental effects of fasting needs further investigations. These should be started as soon as possible.

Conclusion and suggestions for future studies

It is now almost 20 yr since the first ASA guidelines on preoperative fasting were published. These and other guidelines were a great step forward from the NMB—from-midnight rule that was then common practice. However, data are accumulating that many children are still starved for unnecessarily long intervals before operation, with resulting predictable metabolic consequences, such as dehydration, ketoacidosis, and hypoglycaemia. To address these problems, a few centres have reduced or mitigated the requirements for clear fluid fasting. The authors of this review conclude that, based on the current evidence, other paediatric hospitals could consider doing the same. Ideally, this should be done within the framework of a large multicentre audit carefully monitoring both the benefits and the safety of a more liberal fasting regimen.

Further research is also needed to elucidate the consequences of fasting in the neonatal population, both regarding the volume of gastric contents at induction and the possible detrimental effects of prolonged fasting. Furthermore, there is lack of knowledge of the variability of the rate of gastric emptying in emergency surgery and in patients with various gastrointestinal mobility disorders, and the role for new modalities, such as gastric ultrasound, to identify cases that do or do not need to be fasted more rigorously than healthy elective patients.

Authors’ contributions

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Design and critical revision: E.S., R.S.
Drafting part of the manuscript and critical revision: R.W.
Design and final critical revision: M.W.

Declaration of interest

The authors declare no conflicts of interest.

References


2. Maltby JR. Fasting from midnight—the history behind the dogma. Best Pract Res Clin Anaesthesiol 2006; 20: 363–78


12. Kluger MT, Short TG. Aspiration during anaesthesia: a review of 133 cases from the Australian Anaesthetic Incident Monitoring Study (AIMS). Anaesthesia 1999; 54: 19–26


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