Preoperative fasting for paediatric anaesthesia

S. PHILLIPS, A. K. DABORN AND D. J. HATCH

As the mortality associated with anaesthesia has fallen to 0.025 per 1000, much interest has now been directed towards reduction in morbidity [67]. An area that has attracted a great deal of recent study is that of preoperative fasting [15]. An accepted prerequisite for all elective surgery, it is greatly disliked by children and may cause delays to surgical operating lists [13]. Preoperative fasting has not always been required. In the late 19th century, Lister advised that preoperative preparation should include taking a cup of tea or beef tea about 2 h before induction of anaesthesia. Fasting became popular after Mendelson reported the link between feeding and aspiration during labour in 1946 [43]. His premise, that fasting allows time for gastric emptying thus reducing the risk of aspiration pneumonitis, seems reasonable. However, recent work has raised doubts about this concept and challenged current preoperative fasting recommendations. Up to 76 % of children have a sufficient volume of acidic gastric contents at induction of anaesthesia to cause chemical pneumonitis, yet the clinical syndrome is rare [16,40]. The risk of developing aspiration pneumonitis must therefore be related to more than the volume and pH of gastric contents. Evidence is accumulating that patients allowed clear fluids until 2 h before surgery have similar gastric contents as those fasted for more than 4 h. While patient comfort is enhanced by reduction of the preoperative fasting period, this concern must be balanced against the important issue of patient safety.

This review examines the incidence and pathogenesis of regurgitation and aspiration pneumonitis in children. It also considers the contribution of fasting to perioperative morbidity and the reduction of risk. New guidelines for fasting paediatric patients before elective surgery are discussed.

Pathophysiology of regurgitation

Regurgitation, or gastro-oesophageal reflux (GOR), occurs when gastric contents flow passively from the stomach into the oesophagus. GOR is prevented normally by the lower oesophageal sphincter (LOS), an anatomically indistinct portion of the lower oesophagus with a high resting tone. LOS pressure increases in parallel with intragastric pressure and reflux is prevented [37]. The human stomach is very distensible and in the adult can accommodate up to 1600 ml of air or 1000 ml of food with little increase in intragastric pressure [50]. In the cat, gastric volumes of 8-41 ml kg⁻¹ are needed to overcome the LOS [55] and similar findings have been reported in humans [69]. Thus the small residual gastric volumes (RGV) found in elective surgical patients do not seem to place them at risk of GOR [25].

Regurgitation after feeding is normal in the first 6 months of life. This results from a relative lack of intra-abdominal oesophagus and resulting abnormal LOS [9, 24]. Most infants with symptomatic GOR improve spontaneously by 18 months of age, but up to 30 % may remain symptomatic until aged 4 yr [29]. The incidence of regurgitation during anaesthesia in children is unknown. In anaesthetized adults, perioperative small volume or “silent” GOR occurs in 0-26 % of adult patients, although the higher values were obtained over 40 yr ago using anaesthetic techniques different from those in use today [4, 8, 17, 26, 74]. Silent regurgitation is probably of no importance during anaesthesia unless the regurgitated material reaches the pharynx when the risk of aspiration increases. When aspiration occurs, gastric contents pass through the larynx and enter the lungs in 50-76 % of patients, although clinical sequelae are uncommon. No adult study has shown a correlation between the development of postoperative pulmonary complications and GOR, and the incidence of GOR has not been shown to be affected by use of a face mask or tracheal anaesthesia [6, 70].

Anaesthesia may contribute to GOR in infants. Intragastric pressure is increased by airway obstruction and ventilation via a face mask may cause inadvertent gastric inflation. Excessive anterior angulation of the larynx during laryngoscopy may facilitate GOR [59]. Hence, in infants, the risk of regurgitation is reduced by tracheal intubation during anaesthesia. Most drugs used for anaesthesia, with the exception of suxamethonium, pancuronium

Key words
Anaesthesia, paediatric. Metabolism, fasting.

(Br. J. Anaesth. 1994; 73: 529-536)
and neostigmine, decrease barrier pressure and may lead to an increased risk of GOR. GOR is, however, more likely to occur in the presence of several identifiable conditions (table 1). Anaesthetists managing children with these conditions should consider manoeuvres to reduce the risk of GOR and subsequent aspiration, such as fasting, 

**Pathogenesis of aspiration pneumonitis**

The mortality associated with paediatric anaesthesia has decreased from three deaths per 10000 in 1964 (26%, as a result of pulmonary aspiration) [20] to less than one in 40000 in 1990 (none because of aspiration) [67], presumably because of improved understanding of risk factors and modern techniques [15]. Perioperative pulmonary aspiration is also rare, occurring in between one and nine per 10000 paediatric anaesthetics, yet it is three times more common in children than in adults [52, 67].

When patients of all ages who inhale gastric contents are followed-up, 47% are found to develop radiographically confirmed aspiration pneumonitis [52]. Risk factors associated with an increased incidence of aspiration are summarized in table 2 [7, 52, 62, 67].

In 1946, Mendelson described two syndromes in parturients. The first (occurring in five of 44016 patients during anaesthesia) was inhalation of solid food leading to complete respiratory obstruction and death (three patients) or massiveatelectasis after coughing up the obstructing material (two patients) [43]. Particulate matter easily blocks small diameter paediatric airways, causes bronchiolitis and potentially chronic respiratory obstruction. The extent of the reaction is determined by particle size and shape rather than volume or pH [65].

The other syndrome (40 in 44016), and that which now bears his name, was aspiration of liquid gastric contents, apparently occurring while the laryngeal reflexes were depressed by general anaesthesia. These patients were critically ill during the acute episode, developing cyanosis, tachycardia and dyspnoea, but not the massive atelectasis and mediastinal shift seen in obstructed patients. All these patients had an afebrile and uncomplicated recovery. Mendelson demonstrated that development of the syndrome in rabbits was dependent on the pH of the aspirated material being acidic. Teabeaut showed that when the pH of aspirated material was greater than 2.4, the pathological changes in the rabbit lung were indistinguishable from those caused by water. The lung injury observed became increasingly severe as pH decreased from 2.4 to 1.5 [65].

Greenfield and co-workers were the first to attempt to quantify the amount of acidic aspirate required to induce the clinical syndrome in dogs. Using hydrochloric acid 0.1 mol litre$^{-1}$, they found that the severity of lung injury increased with volume from 1 to 4 ml kg$^{-1}$ [22]. In 1974, Roberts and Shirley published an editorial which defined the obstetric patient at risk of developing Mendelson's syndrome as having an RGV of at least 25 ml (0.4 ml kg$^{-1}$) with a pH of less than 2.5. The original work, said to be based on experiments in Rhesus monkeys, has never been published [58]. In a large series of rat experiments, the critical volume necessary to cause severe pulmonary damage was shown to be dependent on pH. At a pH value of 1.0, 0.3 ml kg$^{-1}$ was lethal 90% of the time. When the pH was $\geq 1.8$, 1.0-2.0 ml kg$^{-1}$ of aspirate had a mortality of 14% [31]. Further work with juvenile monkeys, reported in 1990, assessed the volume of acid gastric contents needed to produce severe acid aspiration syndrome with a significant mortality (16%) as 0.8 ml kg$^{-1}$ at a pH value of 1 [56].

It does appear that a larger volume of gastric acid is needed to cause pulmonary damage in the monkey than in the rat, even when the aspirated volume is corrected for the relative size of the lung in each species. Such inter-species differences makes extrapolation to humans extremely difficult and potentially inaccurate. The pH and volume of gastric juice necessary to cause pneumonitis in humans has not and cannot be established directly. The definition of Roberts and Shirley has been widely accepted, is the basis for much subsequent work and is of some value when comparing different studies. However, it must be remembered that the clinical aspiration of gastric contents is unlikely ever to be as complete as in an experimental model and that it is also extremely unlikely that the entire RGV ever enters the lungs. Thus this definition is of little value in predicting the risk of aspiration pneumonitis. Although it is

---

**Table 1** Factors increasing the risk of perioperative GOR in infants and children

<table>
<thead>
<tr>
<th>Factor</th>
<th>Risk Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prematurity and dyspnoea</td>
<td>4</td>
</tr>
<tr>
<td>Pre-existing GOR</td>
<td>1</td>
</tr>
<tr>
<td>Increased intragastric pressure/volume</td>
<td>5</td>
</tr>
<tr>
<td>Obesity</td>
<td>8</td>
</tr>
<tr>
<td>Gastrointestinal obstruction and atresia</td>
<td>7</td>
</tr>
<tr>
<td>Prone, lateral, Trendelenburg position</td>
<td>6</td>
</tr>
<tr>
<td>Ascites, large intra-abdominal tumours</td>
<td>1</td>
</tr>
<tr>
<td>Autonomic neuropathy</td>
<td>2</td>
</tr>
<tr>
<td>Emergency surgery</td>
<td>3</td>
</tr>
</tbody>
</table>

---

**Table 2** Risk factors associated with aspiration of gastric contents in infants and children

<table>
<thead>
<tr>
<th>Factor</th>
<th>Risk Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urgent surgery (44%)</td>
<td>4</td>
</tr>
<tr>
<td>Surgery outside normal working hours ($\times 6$)</td>
<td>6</td>
</tr>
<tr>
<td>Factors leading to a full stomach (61%)</td>
<td>1</td>
</tr>
<tr>
<td>Obesity</td>
<td>8</td>
</tr>
<tr>
<td>Raised intracranial pressure</td>
<td>7</td>
</tr>
<tr>
<td>Gastrointestinal disease</td>
<td>5</td>
</tr>
<tr>
<td>Unusual stress or pain</td>
<td>3</td>
</tr>
<tr>
<td>Increased risk of regurgitation (33%)</td>
<td>2</td>
</tr>
<tr>
<td>Impaired bronchial clearing mechanisms</td>
<td>1</td>
</tr>
<tr>
<td>Reduced level of consciousness</td>
<td>1</td>
</tr>
<tr>
<td>Bulbar palsy</td>
<td>2</td>
</tr>
<tr>
<td>Inexperience of anaesthetist (35%)</td>
<td>1</td>
</tr>
<tr>
<td>Airway obstruction (10%)</td>
<td>1</td>
</tr>
</tbody>
</table>
impossible to identify a safe RGV, manoeuvres to minimize RGV or increase pH would seem to be sensible.

In summary, aspiration pneumonitis is rarely associated with paediatric anaesthesia. Inhalation of solid food causes respiratory obstruction and possibly death. Inhalation of liquid gastric contents in excess of 0.4 ml kg\(^{-1}\) with a pH < 2.5 is likely to cause aspiration pneumonitis.

**Does starvation reduce the risk of aspiration in children?**

**GASTRIC PHYSIOLOGY**

Little information specific to paediatric gastric physiology is available and much extrapolation is necessary from adults. The gastric contents depend on continuous gastric secretion (50 ml kg\(^{-1}\) h\(^{-1}\)), swallowed saliva (1 ml kg\(^{-1}\) h\(^{-1}\)), ingested solids and liquids, and the rate of gastric emptying. Gastric secretion can be increased by emotional stimuli and be as high as 500 ml h\(^{-1}\) during the cephalic phase of secretion when associated with hunger [23]. Solids and liquids are handled differently and it is inappropriate to apply the same fasting criteria to both. A meal of discrete solid particles is emptied in a linear pattern with time and 10–30% may remain after 6 h [27].

After ingestion of liquids, gastric emptying in adults approximates to a simple exponential curve, so that the rate of emptying at any time is proportional to the amount still in the stomach. Emptying times are quoted as half-times and for water this is approximately 12 min. This implies that 95% of ingested clear liquid would be cleared from the stomach in 1 h [27].

In term and preterm babies, breast milk leaves the stomach more rapidly than formula. The emptying half-time for breast milk is approximately 25 min, and that for formula milk about twice as long (51 min) [10, 11]. Milk has an irritant effect on the lung, leaving a residue in the alveoli. Feeding mixtures cause a greater degree of pulmonary oedema than human or cow's milk when aspirated because of their high carbohydrate content and hypertonicity [45, 46].

Animal data suggest that the pH of gastric juice after fasting is between 1.5 and 2.4. Recent milk (pH 6.9) or other dairy intake may increase gastric pH (pH 3.8) more than a carbohydrate meal (pH 1.8). However, the severity of reaction produced by particulate matter regardless of pH precludes the use of food to buffer gastric acid [65]. Sugary drinks (pH 4.5) are also more irritant than water [51].

Although increased length of fasting was associated with an increase in gastric acidity in some studies [7, 40], in several others this difference was not observed when the gastric pH of children allowed to drink was compared with those who had fasted [42, 48, 61, 63]. The mean gastric pH of all patients in these studies was less than 2.5.

While the evidence remains inconclusive, fasting certainly does not seem to have any protective action with regard to gastric pH. If anything, fasting may be detrimental, allowing continued undiluted secretion of gastric acid (pH 1). By diluting gastric secretions and stimulating gastric emptying, drinking may impart a beneficial effect.

In summary, clear fluids leave the stomach very rapidly. Milk and solid food are emptied more slowly. Eating and drinking may raise gastric pH by dilution of gastric acid.

**STUDIES OF FASTING REGIMENS**

Although there are institutional variations, most children in the UK are required to abstain from solid food and milk for 6 h and from clear liquids for 4 h before elective surgery. Breast-fed babies are usually allowed milk until 4 h before operation [34]. The fasting interval is frequently extended, especially in children, whose early bedtime may cause them to be fasted for almost 12 h [39, 40, 61].

**Solids**

There appear to be only two studies which have allowed solids within 6 h of anaesthesia. Miller, Wishart and Nimmo compared gastric contents after induction of anaesthesia in 22 women given a light breakfast 2–3 h before induction with 23 women who had fasted for at least 10 h. No difference in volume or pH of the aspirated gastric contents was found. However, many patients in the study group must have fasted for longer than the required 2–3 h as the mean fasting time for this group was 3.8 h. Also, as pointed out by the authors, solid food would not have been detected by their methods [44].

In unpremedicated children aged 1–14 yr, Meakin, Dingwall and Addison compared 55 controls fasted for 4 h with children given either 10 ml kg\(^{-1}\) of orange squash (n = 34) or two biscuits and orange squash (n = 32), 2–4 h before anaesthesia. Food particles were found in the gastric aspirate of 13 of 32 of those who had eaten biscuits 2–4 h earlier and in three others who had biscuits within 6 h of surgery. No particulate matter was found in those who had fasted for more than 6 h [42].

A study in children aged 19–166 months compared gastric aspirates of a fasted control group (n = 33) with those of children given 10 ml kg\(^{-1}\) of cow's milk 4 h before operation (n = 29). Patients were premedicated with oral trimeprazine, morphine i.m. and atropine i.m. before surgery. Although gastric aspirates (mean 6 and 8 ml) were comparable in both groups, RGV was not reported in relation to weight, making comparison of these results with other studies difficult [66].

In another study, gastric aspirates of infants given 5% dextrose 10 ml kg\(^{-1}\), 20% Poly-Joule (a low osmolality glucose polymer) 10 ml kg\(^{-1}\) or cow's milk 10 ml kg\(^{-1}\), 3–4 h before surgery were compared with controls fasted for at least 4 h (mean 353 min). Reducing the fasting time did not increase the risk of aspiration pneumonitis (based on RGV > 0.4 ml kg\(^{-1}\) with pH 2.5) in the glucose and Poly-Joule groups. Twenty-five percent of infants in the milk feed group were considered to be at risk of...
aspiration pneumonitis compared with 7% in all other groups. This was most pronounced in infants less than 3 months of age. The authors concluded that the practice of feeding infants according to their normal feeding pattern does not constitute a greater risk of aspiration pneumonitis if milk is avoided as the last feed [71]. In a subsequent study from the same authors, only three of 62 unpremedicated infants less than 3 months of age had an RGV > 0.4 ml kg\(^{-1}\) when studied 3–4 h after either breast milk or formula milk [72]. It appears that solids and milk can be considered together with regard to preoperative fasting. Both are emptied slowly from the stomach and cause pulmonary obstruction and irritation if inhaled. There is little evidence to suggest that reduction of fasting time for milk or solids should be considered.

In summary, current evidence suggests that all children should abstain from solid food and milk drinks for at least 6 h before anaesthesia.

**Clear fluids**

In recent years, many prospective controlled studies have investigated shorter fasting periods and allowed more liberal volumes of clear fluids, defined as those through which it is possible to read newsprint. Milk or orange juice with pulp, for example, have been excluded in trials reported here. Gastrointestinal disease, pain, trauma and some drugs may delay gastric emptying. These pre-existing factors must be considered in the preoperative assessment. Patients with such factors have also been excluded from all studies described below. Although anxiety was thought to delay gastric emptying, possibly placing preoperative patients at increased risk of GOR, this effect has not been demonstrated in either children or adults [16, 33, 41].

Schreiner, Treibwasser and Keon studied 121 ASA I and II outpatients aged 1–18 yr in a prospectively randomized trial. No solids, milk or juices containing pulp were allowed in each group for 12 h before surgery. Clear fluids were allowed until 8 h before surgery in control children older than 5 yr, 6 h in control children less than 5 yr and until 2 h before surgery in the study group. The last fluid ingested was limited to 225 ml and the average volume consumed during the study period was 8.2 ± 6.5 ml kg\(^{-1}\). Most children (control 87%, study 85%) received pethidine–diazepam–atropine premedication orally. The groups were similar with respect to RGV, pH and the proportions of patients with a gastric volume > 0.4 ml kg\(^{-1}\) and pH < 2.5. Parents reported that the fasting instructions were easier to comply with, children were less irritable and the perioperative experience was tolerated better in the study group. There were no problems with regurgitation, coughing, laryngeal spasm or vomiting during induction. The authors also reported no serious problems and no episodes of aspiration in more than 2000 day-case patients allowed unlimited clear fluids until 2 h before operation [61].

Splinter and Schaeffer studied 148 healthy, unpremedicated children aged 2–12 yr. Allowing unrestricted clear fluids until 2 h before induction of anaesthesia did not alter gastric volume or pH compared with controls fasted for 3 h [63]. In 152 adolescents, similar results were found when patients allowed to drink until 3 h before anaesthesia were compared with those fasted overnight (mean 12.7 h). Patients allowed to drink reported less thirst than fasted controls [64].

Nicolson, Dorsey and Schreirer studied 100 cardiac surgical patients, ASA II–IV, aged 0–8 yr. Exclusion criteria similar to those of Schreiner, Treibwasser and Keon [65] and Splinter and Schaeffer [63] were used. Patients were premedicated with oral atropine only if less than 6 months of age, atropine–pentobarbitone if between 6 months and 1 yr and atropine–pentobarbitone and pethidine if more than 1 yr of age. No child was allowed solid food after 20:00 on the evening before surgery. The control group were permitted unlimited clear fluids until 4 h before induction if less than 6 months of age, until 6 h before induction if 6 months to 5 yr of age and until 8 h before in children older than 5 yr of age. Children in the study group were allowed unlimited clear fluids until 2 h before induction of anaesthesia and were required to drink 2–3 h before induction. Again, RGV and pH were similar in both groups as were the proportions of patients with RGV > 0.4 ml kg\(^{-1}\) and pH < 2.5. Patients allowed to drink were also rated to be less thirsty, less hungry and more comfortable by parents. While this study did not examine potential haemodynamic or metabolic effects of reduced preoperative fast, the authors suggested theoretical advantages of inducing anaesthesia in a euvoaemic patient, eliminating the need for intraoperative glucose containing fluids and avoiding the need for preoperative i.v. fluids in a polycythaemic patient [48].

Meakin, Dingwall and Addison [42] studied the gastric contents of 224 children in six groups: an unpremedicated control group (n = 55) fasted for at least 4 h, a group given orange squash and biscuits (n = 32), a group given 10 ml kg\(^{-1}\) of squash, 2–4 h before operation (n = 34) and three premedicated, fasting groups. Their findings with respect to solids and premedication groups have already been discussed. The control group fasted for a mean of 7.1 h (range 4.1–16.7 h) and were compared with children fasted for a mean of 3 h (2.1–3.8 h). While the pH of gastric aspirates was similar in the two groups, mean RGV in the control group was 0.25 ml kg\(^{-1}\) while that of the study group was 0.39 ml kg\(^{-1}\). This placed 44% of the study patients at risk of aspiration pneumonia using the criteria of Roberts and Shirley [58], compared with 22% of controls. This appears to be the only study which has found increased gastric volumes 2–3 h after intake of clear fluids. It should be noted, however, that the mean RGV in the study group was still less than 0.4 ml kg\(^{-1}\) [42].

In summary, gastric contents of children allowed free clear fluids until 2 h before the scheduled time of anaesthesia appear to be similar to those of children who have endured a long fast. A significant proportion still have an RGV greater than 0.4 ml kg\(^{-1}\) with a pH less than 2.5, but the number in this group is not reduced by prolonged fasting. As much attention should be placed on avoiding regurgitation.
and aspiration by identifying patients at risk and faultless airway management, as on fasting to reduce RGV.

EMERGENCY SURGERY

In a large series of over 185 000 anaesthetics covering all age groups, aspiration was six times more likely to occur at night, with 44% of aspirations occurring in emergency cases. This represents a five-fold increase in the risk of aspiration during emergency surgery compared with an elective procedure [53].

Fasting has been shown to reduce the gastric volume of children presenting for emergency surgery, but does not affect pH. Fifty percent of children had an RGV of more than 0.4 ml kg⁻¹ with a pH < 2.5. Children older than 10 yr of age and with superficial injuries had the lowest risk [62].

Bricker, McLuckie and Nightingale studied gastric aspirates in 110 children aged 1–14 yr undergoing surgery for trauma. Increased fasting times and increased food–injury interval correlated with a reduced RGV. However, 49% had an aspirate of > 0.4 ml kg⁻¹ after 8 h of fasting, as did 31% injured 3 h or more after eating. Further reduction in gastric volume did not occur after 10 h of fasting. Thus this relationship is not reliable enough to predict a safe fasting period after trauma. The short duration of a preoperative fast is not a contraindication to anaesthesia in the presence of a clear surgical indication for early operation. All children presenting for emergency anaesthesia must be assumed to have a full stomach, regardless of the fasting interval, and treated accordingly [7].

In summary, children requiring emergency surgery should avoid all food and drink for at least 6 h before operation if possible. Anaesthetic management should proceed as if the child has a full stomach. Non-urgent cases should be delayed overnight.

Effects of premedication on gastric contents

Opioids are said to delay gastric emptying [68]. However, in a study designed to test the effects of different premedicants on gastric contents, morphine 0.18 mg kg⁻¹ and pentobarbital 2.2 mg kg⁻¹ were given to children by i.m. injection 1 h before anaesthesia. All children were fasted for at least 5 h. RGV and pH were found to be similar to those of unpremedicated controls [60].

The effects of opioids on gastric contents when given as premedication to children allowed clear fluids until 2 h before surgery have not been specifically studied. In studies of unpremedicated children designed to examine the effect of allowing free fluids on gastric contents (rather than the effects of premedication), RGV and gastric pH were similar to those of fasted controls. Premedication comprised pethidine 1.5 mg kg⁻¹, diazepam 0.15 mg kg⁻¹ and atropine 0.02 mg kg⁻¹ [61] or atropine, pethidine and pentobarbital 4 mg kg⁻¹ [48].

In a study of gastric aspirates after trauma in children, RGV and pH were similar in those children who received morphine or pethidine i.m. for analgesia compared with those who did not [7].

Anticholinergics are said to delay gastric emptying and reduce gastric acid secretion. However, in the study of Salem and colleagues on the effects of premedication on gastric contents in children, glycopyrronium 7–10 μg kg⁻¹ reduced gastric volume and increased pH while atropine and hyoscine had no significant effect [60].

Meakin, Dingwall and Addison showed that gastric volume was reduced after temazepam premedication. RGV was increased by premedication with temazepam syrup, but not by temazepam capsules. It was suggested that this may be caused by the alcohol, sorbitol and glycerol elixir in which the syrup is formulated [42].

In summary, it appears that in spite of the potential for opioids and anticholinergics to delay gastric emptying when used as premedication before elective surgery or as analgesia after trauma, the gastric contents of children are unaffected. Allowing children to drink clear fluids until 2 h before surgery does not require a change in premedication practice.

Advantages of a shorter fast

PATIENT COMFORT AND COMPLIANCE

Reducing patient discomfort is the prime reason for changing traditional fasting guidelines. The origin of current fasting guidelines is unclear, but they have become that aspect of anaesthesia most well known and most disliked by children and their parents.

In a survey of the most unpleasant aspects of preoperative preparation in adults, not being allowed to drink was second only to the stress of waiting to be collected for theatre [13]. The advantages to the patients and parents of less thirst and less hunger, [48, 64] leading to greater compliance with fasting regimens, reduced irritability and a better overall preoperative experience [61], have also been reported.

Patient compliance is a potential problem in children, regardless of preoperative instructions. Only 50% of patients comply with doctors' prescription medication and it is not unreasonable to assume a significant non-compliance with preoperative preparation [36]. It is impossible to assess if a liberalizing of fluid restriction leads to non-compliance with respect to solids. Failure to recognize that milk behaves as a solid rather than as a liquid is a potential source of concern which may be overcome by education of parents and nursing staff. The problem has not been reported to date, despite a large number of patients now having observed a reduced fluid fast [61].

AVOIDANCE OF HYPOGLYCAEMIA

Of all the potential disadvantages of prolonged preoperative fast, the most potentially dangerous is that of unrecognized hypoglycaemia during anaesthesia. The reported incidence of this problem varies from 0 to 30% depending on study design, age of patients and definition of hypoglycaemia used. The current consensus of paediatricians and paediatric
textbooks defines hypoglycaemia as a blood glucose concentration less than 2.0 mmol litre$^{-1}$ in term neonates and less than 1.1 mmol litre$^{-1}$ in premature and small-for-gestational-age babies [14]. This is significantly lower than that used in earlier work and confounds comparisons of studies.

In 1972, Watson (hypoglycaemia < 2.2 mmol litre$^{-1}$) reported hypoglycaemia at induction of anaesthesia in 10% of children less than 15 yr of age [73]. In 1973, Bevan and Burn found 29% of children less than 10 yr of age with a blood glucose concentration of less than 3.5 mmol litre$^{-1}$ in induction of anaesthesia [5]. Although neither study was designed to investigate the incidence of preoperative hypoglycaemia following traditional fasting guidelines, they stimulated concern. In 1974, Thomas compared blood glucose concentration at induction of anaesthesia in 33 children who fasted from 06:00 for an afternoon operation with 29 who received 10 ml kg$^{-1}$ of milk 4 h before operation: 28% (n = 5) of the fasted children were found to have blood glucose concentrations less than 2.2 mmol litre$^{-1}$. All these children were less than 47 months of age and 15.5 kg in weight, but none had any signs or symptoms of hypoglycaemia [66]. In 1982, Allison and co-workers reported an incidence of 23% in children less than 4 yr (hypoglycaemia < 3.3 mmol litre$^{-1}$) with 3% less than 2.2 mmol litre$^{-1}$, in this age group [1]. In 1984, Payne and Ireland examined children 4 h after a 5%, glucose drink and still found 12% of children with blood glucose concentration less than 3 mmol litre$^{-1}$. Again, age less than 1 yr or weight below the third percentile increased the risk of hypoglycaemia [54].

Several further reports [2, 21, 32, 49] failed to confirm these findings, although all patients studied had been scheduled for morning surgery. This led to the suggestion that the diurnal variation in metabolism may be responsible for the hypoglycaemia observed by Thomas [66]. This was studied by Redfern, Addison and Meakin [57] in 1986, who found that despite a longer fasting interval, patients on the morning operating list had higher blood glucose concentrations than those on afternoon lists. However, no patient (all aged 1–5 yr), regardless of fasting or operating time, was hypo-glucemic.

The issue of patient weight and age was taken further by van der Walt and Carter in 1986, who studied 123 children aged 5 days to 12 months. They compared arterialized capillary blood glucose concentrations collected immediately before induction of anaesthesia in patients who fasted for a mean of 333 min with those given either milk or glucose drinks 3 or 4 h before surgery. There was no correlation between fasting time, plasma glucose concentration, age or weight [71].

The effect of premedication on blood glucose concentration has not been examined specifically. Temazepam syrup contains 50% glycerol w/v, 45% sorbitol w/v and 9% ethanol w/v and has 36.4 kcal/5 ml. Trimeprazine contains 56.8% sucrose w/v and has 11.36 kcal/5 ml. However, as those reporting hypoglycaemia used calorie-containing premedications [66, 73] and those not reporting hypoglycaemia did not, any direct effect of premedication is unlikely [21, 32, 49, 71].

The majority of patients studied to date have been healthy, well-nourished children presenting for routine surgery. It appears that the incidence of unrecognized hypoglycaemia caused by preoperative fasting in healthy children is very small. It is possible that premature, small-for-gestational-age babies, growth retarded, malnourished or severely compromised children have a higher incidence of hypoglycaemia after a period of starvation. Preoperative preparation for these patients requires individual consideration. Milk drinks, maltose and metoclopramide, i.v. glucose solutions and free, clear glucose drinks have been recommended to avoid hypoglycaemia [19, 54, 66, 73]. Consideration should also be given to the recent evidence of increased neurological damage after hypoxic insults occurring in the presence of hyperglycaemia [18, 35, 38, 46], suggesting that i.v. glucose solutions are a poor choice in routine cases where the added stress of surgery also increases blood glucose concentration [15].

**DEHYDRATION**

Dehydration may occur to a small extent even after a 4-h fast and may increase with a longer fast. However, this leads primarily to discomfort and irritability and does not have haemodynamic consequences in a healthy child. Only in the compromised child is the degree of dehydration caused by fasting potentially significant, so it may be argued that such children should have preoperative i.v. therapy. Dehydration is thus more of a cause for concern when considering patient comfort and compliance. This may be exacerbated by dry mouth caused by anticholinergic premedication which remains popular for paediatric anaesthesia.

The practice of cancelling patients who have fasted for long periods because of concern for dehydration or hypoglycaemia cannot be supported. Similarly, waking children during the night to administer a final drink before the fasting period would seem unreasonable. Children can be given a drink at a more suitable time, for example 06:00 or on waking, and surgery scheduled for a suitable time later that morning.

In summary, allowing free, clear, oral fluids to children until 2 h before induction of anaesthesia improves patient comfort and may increase compliance. It may reduce the risk of hypoglycaemia and the degree of dehydration potentially associated with prolonged fasting.

Some institutions may feel that because of the difficulty in predicting the exact time of surgery on a busy operating list, it is wise to have a routine policy of allowing clear fluids until 3 or 4 h before surgery, but not to postpone those who admit to drinking until 2 h before operation. This may prevent disruption to operating lists if patients are found to be inadequately starved. If patients do drink clear fluids after the nil by mouth order should have been imposed, delay to surgery need be only 2 h.
Preoperative fasting for paediatric anaesthesia

Summary

Preoperative fasting was introduced to reduce the risk and severity of aspiration pneumonitis. Adequate time (6 h) must still be allowed before operation for solid foods to be emptied from the stomach. However, the overwhelming weight of evidence supports the practice of reducing the duration of the preoperative fluid fast for elective paediatric surgical patients [3, 15]. In children allowed free, clear fluids until 2 h before the scheduled time of anaesthesia, gastric contents and thus the risk of aspiration pneumonitis appears to be similar to those children who have endured a longer fast. Potential benefits of reduced thirst, better perioperative experience, improved compliance and reduced hypoglycaemia may be seen. Patients at risk of GOR and aspiration pneumonitis, including those presenting for emergency surgery, must receive special consideration. As aspiration pneumonitis is so rare, careful reporting of complications potentially related to a reduced fasting period is necessary.

References


51. Olson M. The benign effects on rabbits' lungs of the aspiration of water compared with 5% glucose or milk. *Pediatrics* 1970; 46: 538-547.


64. Splinter WM, Schaeffer JD. Ingestion of clear fluids is safe for adolescents up to 3 hours before anaesthesia. *British Journal of Anaesthesia* 1991; 66: 48-52.


