

Perioperative fasting in adults and children: guidelines from the European Society of Anaesthesiology

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This guideline aims to provide an overview of the present knowledge on aspects of perioperative fasting with assessment of the quality of the evidence. A systematic search was conducted in electronic databases to identify trials published between 1950 and late 2009 concerned with preoperative fasting, early resumption of oral intake and the effects of oral carbohydrate mixtures on gastric emptying and postoperative recovery. One study on preoperative fasting which had not been included in previous reviews and a further 13 studies published since the most recent review were identified. The searches also identified 20 potentially relevant studies of oral carbohydrates and 53 on early resumption of oral intake. Publications were classified in terms of their evidence level, scientific validity and clinical relevance. The Scottish Intercollegiate Guidelines Network scoring system for assessing level of evidence and grade of recommendations was used. The key recommendations are that adults and children should be encouraged to drink clear fluids up to 2 h before elective surgery (including caesarean section) and all but one member of the guidelines group consider that tea or coffee with milk added (up to about one fifth of the total volume) are still clear fluids. Solid food should be prohibited for 6 h before elective

surgery in adults and children, although patients should not have their operation cancelled or delayed just because they are chewing gum, sucking a boiled sweet or smoking immediately prior to induction of anaesthesia. These recommendations also apply to patients with obesity, gastro-oesophageal reflux and diabetes and pregnant women not in labour. There is insufficient evidence to recommend the routine use of antacids, metoclopramide or H₂-receptor antagonists before elective surgery in non-obstetric patients, but an H₂-receptor antagonist should be given before elective caesarean section, with an intravenous H₂-receptor antagonist given prior to emergency caesarean section, supplemented with 30 ml of 0.3 mol l⁻¹ sodium citrate if general anaesthesia is planned. Infants should be fed before elective surgery. Breast milk is safe up to 4 h and other milks up to 6 h. Thereafter, clear fluids should be given as in adults. The guidelines also consider the safety and possible benefits of preoperative carbohydrates and offer advice on the postoperative resumption of oral intake.

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Why were these guidelines produced?

Widespread consultation suggested that guidelines on perioperative fasting would be useful to European Society of Anaesthesiology (ESA) members.

Our guideline aims to provide an overview of the present knowledge on perioperative fasting with assessment of the quality of the evidence in order to allow anaesthesiologists all over Europe to integrate this knowledge in their daily care of patients.

What is similar to previous guidelines?

The ESA guidelines endorse a 2-h fasting interval for clear fluids and a 6-h interval for solids.

What is different from previous guidelines?

The ESA guidelines:

- are recent and include several studies published since previous guidelines;
- increase the emphasis on encouraging patients not to avoid fluids for any longer than is necessary;
- offer practical, pragmatic advice on chewing gum, smoking and drinks containing milk;
- consider the safety and possible benefits of preoperative carbohydrates;
- offer advice on the postoperative resumption of oral intake.

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1. Summary of recommendations

	Evidence	Recommendation
Fasting in adults and children		
Adults and children should be encouraged to drink clear fluids (including water, pulp-free juice and tea or coffee without milk) up to 2 h before elective surgery (including caesarean section)	1++	A
<i>All but one member of the guidelines group consider that tea or coffee with milk added (up to about one fifth of the total volume) are still clear fluids</i>		☑
Solid food should be prohibited for 6 h before elective surgery in adults and children	1+	A
Patients with obesity, gastro-oesophageal reflux and diabetes and pregnant women not in labour can safely follow all of the above guidelines	2–	D
<i>However, these factors may alter their overall anaesthetic management</i>		
Patients should not have their operation cancelled or delayed just because they are chewing gum, sucking a boiled sweet or smoking immediately prior to induction of anaesthesia	1–	B
<i>The above is based solely on effects on gastric emptying and nicotine intake (including smoking, nicotine gum and patches) should be discouraged before elective surgery</i>		☑
Fasting in infants		
Infants should be fed before elective surgery. Breast milk is safe up to 4 h and other milks up to 6 h. Thereafter, clear fluids should be given as in adults	1++	A
Prokinetic and other pharmacological interventions		
There is insufficient evidence of clinical benefit to recommend the routine use of antacids, metoclopramide or H₂-receptor antagonists before elective surgery in non-obstetric patients	1++	A
An H₂-receptor antagonist should be given the night before, and on the morning of, elective caesarean section	1++	A
<i>The guidelines group recognises that most of the evidence relates to surrogate measures, such as changes in gastric volume and pH, rather than a clear impact on mortality</i>		
An intravenous H₂-receptor antagonist should be given prior to emergency caesarean section; this should be supplemented with 30 ml of 0.3 mol l⁻¹ sodium citrate if general anaesthesia is planned	1++	A
<i>The guidelines group recognises that most of the evidence relates to surrogate measures, such as changes in gastric volume and pH, rather than a clear impact on mortality</i>		
Oral carbohydrates		
It is safe for patients (including diabetics) to drink carbohydrate-rich drinks up to 2 h before elective surgery	1++	A
<i>The evidence for safety is derived from studies of products specifically developed for perioperative use (predominantly maltodextrins); not all carbohydrates are necessarily safe</i>		
Drinking carbohydrate-rich fluids before elective surgery improves subjective well being, reduces thirst and hunger and reduces postoperative insulin resistance	1++	A
<i>To date, there is little clear evidence to show reductions in length of postoperative stay and mortality</i>		
Fasting in obstetric patients		
Women should be allowed clear fluids (as defined above) as they desire in labour	1++	A
Solid food should be discouraged during active labour	1+	A
<i>The guidelines group recognise that it may be impractical to stop all women from eating during labour, especially low-risk women. Consideration should be given to easily digestible, low-residue foods</i>		
Postoperative resumption of fluids		
Adults and children should be allowed to resume drinking as soon as they wish after elective surgery. However, fluid intake should not be insisted upon before allowing discharge from a day or ambulatory surgery facility	1++	A

☑ recommended best practice based on the clinical experience of the guidelines development group.

2. Purpose and development of the guideline

The European Society of Anaesthesiology (ESA) is committed to the production of high-quality, evidence-based clinical guidelines. After the formation of the Guidelines Committee in 2008, a prioritisation exercise suggested that guidelines on perioperative fasting would be useful to ESA members and a task force was established in June 2009 to produce this guideline. The chairpersons of the relevant subcommittees (Evidence-based Practice and Quality Improvement, Ambulatory Anaesthesia, Obstetric Anaesthesia, Paediatric Anaesthesia and Anaesthesia for the Elderly) of the ESA Scientific Committee were asked to nominate an ESA member

with expertise in their field to join the task force. Further experts were co-opted onto the task force as required. Several European national anaesthesiology societies have already produced recommendations for aspects of perioperative fasting. Our guideline aims to provide an overview of the present knowledge on the subject with assessment of the quality of the evidence in order to allow anaesthesiologists all over Europe to integrate – wherever possible – this knowledge in their daily care of patients.

Evidence to support the recommendations was obtained as follows. A systematic search was conducted by

members of Cochrane Anaesthesia Review Group of the electronic databases *Ovid*, *MEDLINE* and *Embase* to identify trials published between 1950 and late 2009 concerned with preoperative fasting, early resumption of oral intake and the effects of oral carbohydrate mixtures on gastric emptying and postoperative recovery. A total of 3714 abstracts from *MEDLINE* and 3660 from *Embase* were identified from the search. After elimination of duplicates, irrelevant studies, non-clinical trials and studies with a non-clinical outcome, one study on preoperative fasting which had not been included in previous reviews¹⁻⁴ and a further 13 studies published since the most recent review⁴ were identified. The searches also identified 20 potentially relevant studies of oral carbohydrates and 53 on early resumption of oral intake.

These publications were classified in terms of their evidence level, scientific validity and clinical relevance. We used the Scottish Intercollegiate Guidelines Network (SIGN) scoring system for assessing level of evidence and grade of recommendations (Fig. 1).⁵ Highest priority was given to meta-analyses of randomised, controlled clinical trials. In reaching consensus, particular emphasis was placed on the level of evidence, ethical aspects, patient preferences, clinical relevance, risk/benefit ratios and degree of applicability. For example, a pragmatic solution to an acceptable amount of milk in tea or coffee was agreed based on the unpublished experience accumulated by several members of the group over many years.

These guidelines have undergone the following review process. The final draft was reviewed by members of the relevant Subcommittees of the ESA's Scientific Committee who were not involved in the initial preparation of the guideline. It was posted on the on ESA website for 4 weeks and all ESA members, individual and national, were contacted by electronic mail to invite them to comment on the draft. It was also sent to the International Association for Ambulatory Surgery (IAAS) for information and comment. All those who commented are listed in the 'Acknowledgements' section below. Comments were collated by the chair of the guideline task force and the guideline amended as appropriate. The final manuscript was approved by the Guidelines Committee and Board of the ESA before submission for publication in the *European Journal of Anaesthesiology*.

These guidelines are produced as a service to ESA members and other anaesthesiologists and healthcare staff in Europe. The ESA recognises that practice and opinion varies in different European countries. Despite the availability of the same scientific information, the way in which healthcare services are organised may result in different practices in the various European countries. Thus, it is not always possible to produce guidelines which will be both appropriate and relevant for every

European nation. Although national societies and individuals are free to use the guidelines, modified as necessary for local and national practice contexts, they are under no obligation to do so. Further, the potential legal implications may be a point of concern.⁶ It cannot be emphasised enough that guidelines may not be appropriate for all clinical situations. The decision whether or not to follow a recommendation from a guideline must be made by the responsible physician on an individual basis, taking into account the specific conditions of the patient and the available resources. Therefore, deviations from guidelines for specific reasons should remain possible and can certainly not be interpreted as a base for negligence claims. However, we hope that these guidelines will both assist anaesthesiologists throughout Europe to bring research evidence to bear on their clinical practice and also provide support to colleagues and healthcare funders in making changes and improvements necessary to enhance patient care.

Differences from existing guidelines

Although there is little new evidence relating to fasting for fluids and solids, the current guidelines review more recent literature than any of the existing guidelines. In addition, the American Society of Anesthesiology (ASA) guidelines on the subject⁷ were published in 1999 and contain little on preoperative carbohydrate, whereas the UK Royal College of Nursing guidelines⁴ deal with the safety aspect of preoperative carbohydrate, but not possible benefits. In these current guidelines, we have also tried to address practical problems such as chewing gum.

3. Fasting

3.1. Fluids

Recommendation

Adults and children should be encouraged to drink clear fluids (including water, pulp-free juice and tea or coffee without milk) up to 2 h before elective surgery (including caesarean section) (evidence level 1++, recommendation grade A).

All but one member of the guidelines group consider that tea or coffee with milk added (up to about one fifth of the total volume) are still clear fluids.

Rationale

Since the landmark work of Maltby *et al.*⁸ in 1986, a large body of evidence has been accumulated to show that the oral intake of clear fluids up to 2 h before an elective operation is safe.^{3,9,10} Many countries have, therefore, changed their fasting guidelines, allowing most patients take clear fluids (water, clear juices and coffee or tea without milk) up to 2 h before elective surgery.¹¹

In addition to the liberalising of fasting guidelines, the emphasis is now changing, with the realisation that

Fig. 1

Key to evidence statements and grades of recommendations	
1 ⁺⁺	High-quality meta-analyses, systematic reviews of RCTs, or RCTs with a very low risk of bias
1 ⁺	Well conducted meta-analyses, systematic reviews, or RCTs with a low risk of bias
1 ⁻	Meta-analyses, systematic reviews, or RCTs with a high risk of bias
2 ⁺⁺	High-quality systematic reviews of case-control or cohort studies
2 ⁺	Well conducted case-control or cohort studies with a low risk of confounding or bias and a moderate probability that the relationship is causal
2 ⁻	Case-control or cohort studies with a high risk of confounding or bias and a significant risk that the relationship is not causal
3	Non-analytic studies, e.g. case reports, case series
4	Expert opinion
Grades of recommendation	
<i>Note: the grade of recommendation relates to the strength of the evidence on which the recommendation is based. It does not reflect the clinical importance of the recommendation.</i>	
A	At least one meta-analysis, systematic review, or RCT rated as 1 ⁺⁺ and directly applicable to the target population; or a body of evidence consisting principally of studies rated as 1 ⁺ directly applicable to the target population, and demonstrating overall consistency of results
B	A body of evidence including studies rated as 2 ⁺⁺ , directly applicable to the target population, and demonstrating overall consistency of results; or extrapolated evidence from studies rated as 1 ⁺⁺ or 1 ⁺
C	A body of evidence including studies rated as 2 ⁺ , directly applicable to the target population, and demonstrating overall consistency of results; or extrapolated evidence from studies rated as 2 ⁺⁺
D	Evidence level 3 or 4; or extrapolated evidence from studies rated as 2 ⁺
Good practice points	
<input checked="" type="checkbox"/>	Recommended best practice based on the clinical experience of the guideline development group

Scottish Intercollegiate Guidelines Network (SIGN) grading system. RCT, randomised controlled trial.⁵

prolonged fasting is an inappropriate way to prepare for the stress of surgery. Abstaining from fluids for a prolonged period prior to surgery is detrimental for patients, especially the elderly and small children. Rather than ensuring a minimal fasting interval has been achieved, it is important to encourage patients to keep

drinking up until 2h before surgery in order to reduce their discomfort and improve their well being.

3.1.1. Milk in tea or coffee

Milk in large quantities curdles in the stomach and acts like a solid, but smaller quantities are handled like other

liquids and are safe. There is anecdotal evidence (including from some members of this group) that when milk is allowed to be added to tea or coffee consumed before elective surgery, regurgitation and aspiration are no more likely to occur, but no randomised studies have looked specifically at the safety of this practice. Some studies of preoperative tea and coffee¹²⁻¹⁴ did allow milk to be added if desired (R. Maltby, personal communication), but this is not recorded in the published text and the number of such patients was small. Unpublished work has shown that adding small quantities of milk (from a 12 ml single-portion pot) to a model stomach caused no restriction in emptying, but that adding three or more measures caused clumping (R. Maltby, personal communication). However, the model comprised a glass vessel with a fixed burette tap as an outlet and, therefore, did not mimic either a sphincter which can relax or the effects of churning from muscle contractions.

The lack of evidence from human studies and the uncertainty in defining and controlling a safe amount of milk, means that most guidelines only advocate black tea or coffee. Although this may appear a safe approach, some patients would rather have nothing at all if they are denied milk in their morning cup of tea or coffee. With one exception, the guidelines group considered that tea or coffee with a modest amount of milk added (up to about one fifth of the total volume) should still be considered as clear fluids and, therefore, safe up to 2 h before the induction of anaesthesia. Drinks made predominantly from milk, however, should be treated as solids.

3.2. Solid food Recommendation

Solid food should be prohibited for 6 h before elective surgery in adults and children (evidence level 1+, recommendation grade A).

Rationale

No recent studies have attempted to define a minimal safe period for preoperative fasting for solid food. One previous study found no increase in gastric volume after a light breakfast of tea and buttered toast consumed 2–4 h before elective surgery,¹⁵ but the presence of residual solids in the stomach at induction of anaesthesia could not be ruled out by the methodology used. It remains common practice to avoid solid food for at least 6 h before elective surgery. Most patients will accept this if they are permitted to drink until closer to their surgery. There is no clear benefit to reducing the fasting time for solids below 6 h.

3.3. Chewing gum, sweets and smoking Recommendation

Patients should not have their operation cancelled or delayed just because they are chewing gum, sucking a

boiled sweet or smoking immediately prior to induction of anaesthesia

The above is based solely on effects on gastric emptying and nicotine intake (including smoking, nicotine gum and patches) should be discouraged before elective surgery.

Rationale

There is ongoing debate on how to deal with patients chewing gum in the immediate preoperative period and what constitutes a safe fasting interval. There are only three (partly) randomised controlled studies concerning the intake of chewing gum during the perioperative fasting period.

In one comparison of 77 patients,¹⁶ 16 did not chew any kind of gum, 15 patients were allowed to chew gum until transfer to the operating room and 46 were allowed to chew gum as long as they wished, even until the time of anaesthesia induction. The last group was not allocated by means of randomisation. Both gastric fluid volume as well as pH did not differ significantly among the three groups.

Another study compared 46 children between 5 and 17 years old who were allowed to chew either sugar-free or sugared gum up to 30 min before transfer to the operating room. Both the sugar-free and sugared gum chewers had significantly higher gastric fluid volume and pH than the control group who did not chew any gum.¹⁷

Sørøide *et al.*¹⁸ compared 106 female patients scheduled for elective gynaecologic surgery. They were either smokers or non-smokers and were allowed to chew nicotine-containing chewing gum or nothing (smokers) or sugar-free gum or nothing (non-smokers), respectively. Up to one chewing gum per hour was given until transportation to the operating room. The non-smoking chewers as well as the smokers (chewing or not) had significantly higher gastric fluid volume than the non-smokers who did not chew gum. As far as gastric pH values are concerned, the levels were higher in both non-smoking groups than in both smoking groups. No case of aspiration or other complication during anaesthesia induction was reported. Although the differences in pH and gastric volumes were statistically significant, the authors did not believe the difference (30 versus 20 ml) was clinically significant (E. Sørøide, personal communication).

3.4. Patients with delayed gastric emptying Recommendation

Patients with obesity, gastro-oesophageal reflux and diabetes and pregnant women not in labour can safely follow all of the above guidelines (evidence level 2–, recommendation grade D).

These factors may, however, alter their overall anaesthetic management.

Rationale

A great number of factors can potentially delay gastric emptying. These include obesity, gastro-oesophageal reflux and diabetes. Studies of preoperative fasting have not evaluated these groups of patients adequately enough to provide definitive evidence. However, the evidence which does exist suggests that limitation of gastric emptying is, at most, mild and that these patients can follow the same guidelines as healthy adults. This advice also applies to pregnant women who are not in labour. Opioid analgesia can also delay gastric emptying, but again there is insufficient evidence to make any recommendation. However, patients who have recently taken sufficient opioids to have a significant effect on gastric emptying are unlikely to be undergoing elective surgery often.

4. Medications

Recommendation

There is insufficient evidence of clinical benefit to recommend the routine use of antacids, metoclopramide or H₂-receptor antagonists before elective surgery in non-obstetric patients (evidence level 1++, recommendation grade A).

Rationale

4.1. Prokinetic medications

In contrast to the prevalence of the perioperative use of prokinetics, there is limited evidence to support the prophylactic use of these agents to reduce the risk of perioperative aspiration of gastric contents.

There are single studies that investigate the effect of prokinetics on gastric pH and gastric fluid volume during anaesthesia induction. Iqbal *et al.*¹⁹ compared 75 women undergoing caesarean section under general anaesthesia. Twenty-five women were administered both an H₂-antagonist (ranitidine) with a prokinetic drug (metoclopramide), whereas 25 women served as a placebo control group (another 25 patients received only ranitidine). The combination of the two drugs was significantly more effective in increasing the pH and reducing the gastric fluid volume than placebo.¹⁹

Hong²⁰ investigated the effect of ranitidine and metoclopramide versus placebo. Forty patients scheduled for laparoscopic gynaecological surgery were administered either 50 mg ranitidine with 10 mg metoclopramide intravenously ($n = 20$) or the same volume of isotonic saline in the control group. Gastric fluid volume was significantly higher in the placebo group, as was the gastric pH in the treatment group.²⁰

Bala *et al.*²¹ compared the combination of ranitidine–erythromycin with ranitidine–metoclopramide. Forty ASA I or II patients were given either erythromycin 250 mg and ranitidine 150 mg or ranitidine 150 mg and

metoclopramide 10 mg orally 60–90 min before induction of anaesthesia. There was no significant difference in either gastric pH or fluid volume.²¹

So far, valid studies that investigate the effect of preoperatively administered metoclopramide alone on gastric pH and gastric fluid volume are lacking, although metoclopramide significantly improves gastric emptying in cardiac surgery patients 18 h postoperatively compared with placebo.²²

So far, there is insufficient evidence that preoperatively administered metoclopramide alone improves clinical outcome, reduces gastric fluid volume or increases gastric pH.

4.2. Histamine H₂-antagonists and proton pump inhibitors

The mechanisms of action of H₂-antagonists and proton pump inhibitors (PPIs) differ. The former block H₂-receptors on the stomach's parietal cells, thereby inhibiting the stimulatory effects of histamine on gastric acid secretion; the latter block the enzyme system of hydrogen/potassium ATPase (H⁺/K⁺ ATPase), the 'proton pump' of the gastric parietal cell, such that the stimulatory actions of histamine, gastrin and acetylcholine are inhibited. Both have been applied with the aim of decreasing the risk of deleterious effects resulting from a potential acid aspiration syndrome.

A recent meta-analysis²³ comparing these medications to therapeutic targets suggests that pre-medication with ranitidine is more effective than PPIs in reducing the volume of gastric secretions (by an average of 0.22 ml kg⁻¹, 95% confidence interval 0.04–0.41) and increasing gastric pH (by an average of 0.85 pH units, 95% confidence interval 1.14–0.28). These conclusions could be drawn based on nine randomised controlled trials, of which seven were suitable for meta-analysis. In these trials a total of 223 patients received ranitidine, which was the sole H₂-blocker used in the included trials, and 222 patients received different PPIs (omeprazole, lansoprazole, pantoprazole and rabeprazole). Overall, the size of the trials is rather small. Further, heterogeneity could also be detected with respect to preoperative fasting time, route of administration, repeat administration and the specific PPIs used. It is interesting to note that patients in the trials received ranitidine at doses equivalent to, or less than, the daily recommended dose for the maintenance of peptic ulcer disease, whereas patients received PPIs at doses higher than those recommended for this purpose.

It is not clear how long the potential protective effect on gastric volume or pH lasts. It is also unclear whether these observed effects can be extrapolated to patient populations with a higher risk of aspiration, as all the included trials appeared to be in patients at very low risk of aspiration and the observed parameters were used

as a surrogate for the 'true outcome', that is, mortality or adult respiratory distress syndrome following gastric aspiration, which could not be evaluated.

5. Preoperative carbohydrates: gastric emptying and potential benefits

Recommendation

It is safe for patients (including diabetics) to drink carbohydrate-rich drinks up to 2 h before elective surgery (evidence level 1++, recommendation grade A).

The evidence for safety is derived from studies of products specifically developed for perioperative use (predominantly maltodextrins); not all carbohydrates are necessarily safe.

Rationale

Studies in animal models of severe stress, such as haemorrhage and endotoxaemia, showed that several key systems involved in the stress responses were markedly impaired even if the animal had been fasted for a brief period before the onset of a given stress. These key systems included fluid homeostasis, stress hormone release, aspects of metabolism, muscle function and gut integrity.²⁴ If these models were fasted for as long as 24 h, there was also a difference in survival. This indicates that the metabolic change caused by a recent meal (as opposed to fasting) and the loss of glycogen occurring even after a brief fast is sufficient to alter the stress response.

Allowing patients to drink clear fluids up to 2 h prior to surgery is not likely to produce any major change in metabolism, as these drinks usually do not contain sufficient energy. The best known method for changing metabolism from the overnight fasted state to that of a fed state is the use of carbohydrates. The key change required to be achieved is a prompt insulin response, preferably to an extent similar to that observed after intake of a meal.

In the first instance, intravenous glucose has been proposed and used for this purpose. The insulin response to glucose infusions is determined by the rate of delivery of glucose in a dose-dependent manner. Infusion of glucose (and insulin) has been shown to induce an insulin response to levels of about $60 \mu\text{U ml}^{-1}$,²⁵ reduce postoperative insulin resistance²⁶ and retain substrate oxidation. This is important because postoperative insulin resistance and hyperglycaemia are associated with an impaired outcome after surgery.²⁷ Preoperative oral carbohydrate loading in humans also reduces postoperative insulin resistance. Dietary interventions, therefore, represent a promising and attractive therapeutic strategy to optimise postprandial glycaemia. Thus far, interventions with respect to the preoperative addition of carbohydrates have focused on safety, metabolic effects, personal perioperative well being and postoperative length of stay.

5.1. Carbohydrates versus clear liquids or intravenous infusion

Taniguchi *et al.*²⁸ investigated the safety and effectiveness of oral rehydration as compared with intravenous rehydration prior to general anaesthesia. Fifty patients were randomised to either 1000 ml of oral rehydration solution or 1000 ml of an intravenous electrolyte solution. Volume of gastric contents, as measured directly after induction, was significantly lower in the oral rehydration group.

Kaska *et al.*²⁹ performed a randomised controlled trial comparing preoperative fasting with preoperative preparation with either oral or intravenous intake of carbohydrates, minerals and water.²⁹ Oral intake shortly before surgery did not increase gastric residual volume and was not associated with any risk.

In the study by Nygren *et al.*,³⁰ gastric emptying of a carbohydrate-rich drink was investigated before elective surgery and in a control situation. Patients served as their own control pre and postoperatively. Despite the increased anxiety experienced by patients before surgery, gastric emptying did not differ between the experimental and control situations.

Jarvela *et al.*³¹ investigated the effect of a preoperative oral carbohydrate drink versus overnight fasting on perioperative insulin requirements in 101 non-diabetic patients undergoing elective coronary artery bypass grafting. According to their findings, it is safe to allow cardiac surgery patients to drink clear fluids up to 2 h before induction of anaesthesia, because gastric emptying of the drink was almost total and no aspiration occurred.

Breuer *et al.*³² studied the effects of preoperative oral carbohydrate administration on gastric fluid volume. Before surgery, 188 ASA physical status III–IV patients undergoing elective cardiac surgery were randomised to receive a clear 12.5% carbohydrate drink, flavoured water (placebo), or to fast overnight (control). Carbohydrates and placebo were treated in double-blind format and patients received 800 ml of the corresponding beverage in the evening and 400 ml 2 h before surgery. Ingested liquids did not cause increased gastric fluid volume or other adverse events.

In these five randomised studies, there was no evidence of an increased gastric volume after ingesting carbohydrates. Care should be taken in extrapolating this evidence beyond those specific carbohydrates which have been studied; not all oral carbohydrates will necessarily behave similarly.

5.2. Diabetic patients versus healthy individuals

Investigators have been reluctant to give diabetic patients oral carbohydrates because of the unknown effects on preoperative glycaemia and gastric emptying. Gustafsson *et al.*³³ investigated the effect of preoperative

oral carbohydrate loading in type 2 diabetic patients. Twenty-five patients with type 2 diabetes and 10 healthy controls were studied. A carbohydrate-rich drink (400 ml, 12.5%) was given with paracetamol 1.5 g for determination of gastric emptying. Patients with type 2 diabetes showed no signs of delayed gastric emptying, suggesting that a carbohydrate-rich drink may be safely administered 180 min before anaesthesia without risk of hyperglycaemia or aspiration preoperatively.

On the basis of this limited evidence, diabetes (of either type) should not be seen as a contraindication to preoperative oral carbohydrates.

5.3. New formulas for preoperative drinks

Beverages containing either amino acids (glutamine) or peptides (soy peptides) have been studied with regard to their safety.^{34,35} Glutamine (15 g) with carbohydrate in 300–400 ml of water seems to be safe to give 3 h preoperatively in healthy volunteers based on stomach emptying time. A drink containing soy peptide given to patients admitted for elective bowel resections has been shown to be safe. There was no difference in gastric emptying time between the carbohydrate group (12.5 g per 100 ml carbohydrate drink) and carbohydrate/peptide group (12.5 g per 100 ml carbohydrate and 3.5 g per 100 ml of hydrolysed soy protein).³⁵ More research is necessary to determine the effects of clear liquids with amino acid or hydrolysed protein in metabolic response and insulin sensitivity after surgery.

5.4. Carbohydrates, metabolic response and postoperative discomfort Recommendation

Drinking carbohydrate-rich fluids before elective surgery improves subjective well being, reduces thirst and hunger and reduces postoperative insulin resistance (evidence level 1++, recommendation grade A).

Rationale

In postoperative patients in need of intensive care, studies have shown that, when glucose is controlled by intensive insulin therapy, mortality and morbidity can be reduced.²⁷ In addition, data suggest that postoperative discomfort can be reduced when patients are given a carbohydrate-rich beverage preoperatively.

In a placebo-controlled randomised trial of 252 patients undergoing elective gastrointestinal surgery, it was shown that the intake of carbohydrate-rich clear fluid until 2 h before the operation led to less thirst, restlessness, weakness and concentration problems as compared to placebo.³⁶ Two small placebo-controlled double-blind studies in 15³⁷ and 14³⁸ patients, respectively, undergoing hip surgery, showed that the intake of a carbohydrate-rich clear fluid until 2 h before the operation reduced insulin resistance on days 1 and 3.^{37,38} Another

study of 14 patients displayed less reduced insulin sensitivity after colorectal surgery following preoperative oral carbohydrate administration as compared with patients who were operated on after an overnight fast.³⁹ A recently published study in patients undergoing open colorectal surgery also showed reduced postoperative insulin resistance after preoperative oral carbohydrates, as well as reduced thirst and hunger.⁴⁰ However, a preoperative oral carbohydrate drink did not reduce postoperative insulin resistance or postoperative nausea and vomiting in an investigation of 101 non-diabetic patients undergoing elective coronary artery bypass grafting.³¹

In a randomised study in 65 patients undergoing major abdominal surgery, carbohydrates contributed to the maintenance of muscle mass.⁴¹ In two randomised trials in 86⁴² and 172 patients⁴³ undergoing laparoscopic cholecystectomy, there was either no effect⁴² or only a reduction in postoperative nausea and vomiting.⁴³ Faria *et al.*⁴⁴ showed improved glucose metabolism and organic response in 21 female patients participating in a randomised controlled trial and undergoing laparoscopic cholecystectomy.

Helminen *et al.*⁴⁵ studied 210 patients, undergoing gastrointestinal surgery, randomly assigned to fasting, intravenous or oral carbohydrates. Intravenous glucose infusion did not decrease the sense of thirst and hunger as effectively as in the oral intake group, but it did alleviate the feelings of weakness and tiredness.

Taniguchi *et al.*²⁸ investigated 50 patients randomised to either 1000 ml of oral rehydration solution or 1000 ml of an intravenous electrolyte solution. Patients' satisfaction favoured oral rehydration as they experienced less feelings of hunger, less occurrence of dry mouth and less restriction of movement. Similar subjective benefits were observed in a recent small study of gynaecological patients.⁴⁶

Kaska *et al.*²⁹ performed a randomised controlled trial comparing preoperative fasting with preoperative preparation with either oral or intravenous intake of carbohydrates, minerals and water. Consumption of the mix of water, minerals and carbohydrates offered some protection against surgical trauma in terms of metabolic status, cardiac function and psychosomatic status.

Breuer *et al.*³² studied the effects of preoperative oral carbohydrate administration on postoperative insulin resistance, preoperative discomfort and variables of organ dysfunction in 188 ASA physical status III–IV patients undergoing elective cardiac surgery, including those with non-insulin-dependent type-2 diabetes mellitus. Carbohydrates and placebo were administered in double-blind format and patients received 800 ml of the corresponding beverage in the evening and 400 ml 2 h before surgery. Blood glucose levels and insulin requirements did not differ between the groups. Patients receiving

carbohydrate and placebo were less thirsty compared with controls. The carbohydrate group, however, required less intraoperative inotropic support after initiation of cardiopulmonary bypass weaning ($P < 0.05$).³²

One study of 36 patients undergoing colorectal surgery has demonstrated a reduction in median length of stay associated with oral carbohydrate therapy.⁴⁷ A retrospective analysis of three small prospective randomised trials (one matched-control study), primarily investigating postoperative insulin resistance,²⁴ showed that although the studies were too small to show a significant reduction in length of stay individually, the combined effect was a significant reduction of about 20%.²⁴ This was confirmed in the randomised trial of Yuill *et al.*⁴¹ in 2005 in 72 patients undergoing elective abdominal surgery. However, the recently published randomised trial of Mathur *et al.*⁴⁸ in 142 patients undergoing colorectal surgery or liver resection did not confirm these results.

6. Perioperative fasting in children and infants

Recommendations

Children should be encouraged to drink clear fluids (including water, pulp-free juice and tea or coffee without milk) up to 2 h before elective surgery (evidence level 1++, recommendation grade A).

All but one member of the guidelines group consider that tea or coffee with milk added (up to about one fifth of the total volume) are still clear fluids.

Infants should be fed before elective surgery. Breast milk is safe up to 4 h and other milks up to 6 h. Thereafter, clear fluids should be given as in adults (evidence level 1++, recommendation grade A).

Rationale

The recommendations are based on reviews and guidelines published in the late 1990s and more recently.^{2–4,7,11,49–52} Fasting is aimed at decreasing the risk of pulmonary aspiration, but the incidence of this complication is very low in recent series and, although the risk of aspiration appears to be slightly greater in children than in adults,⁵³ the difference is less than that previously reported. All recent surveys indicate the relatively good outcome of this event in the paediatric population compared with previous series.

There is a lot of evidence that clear fluids can be given up to 2 h prior to surgery in neonates, infants and children. In neonates and infants, gastric emptying of clear fluids follows first-order kinetics as in older children and adults.⁵⁴ Allowing clear fluids prior to surgery improves comfort of the child and the parents, decreases thirst and decreases the risk of preoperative dehydration in young infants.⁵⁵ The volume of fluids permitted in the

preoperative period does not appear to impact on the intragastric volume or pH of children.² This also applies to overweight and obese children.⁵⁶

6.1. Breast milk and infant formula

Fasting time for breast milk and infant formula is slightly more controversial. It was demonstrated more than 25 years ago that the gastric emptying of 110–200 ml of human milk was $82 \pm 11\%$ after 2 h in neonates and infants of less than 1 year of age, $84 \pm 21\%$ after whey-hydrolysed formula, $74 \pm 19\%$ after whey-predominant formula, $61 \pm 17\%$ after casein-predominant formula and $45 \pm 19\%$ after cow's milk.⁵⁷ Thus, human milk and whey-predominant formula emptied faster than casein-predominant formula and cow's milk. Two other studies performed before anaesthesia also demonstrated that breast milk empties from the stomach faster than most formulas in infants and both require more than 2 h to ensure complete gastric emptying.^{54,58} According to these data, the American guidelines recommended 4 h fasting time for breast milk and 6 h for infant formula and non-human milk.⁷ These recommendations were also endorsed by the Royal College of Nursing that considered there was insufficient evidence to change contemporary best practice (i.e. breast milk up to 4 h and formula and cows' milk up to 6 h).⁴ Scandinavian guidelines recommended 4 h fasting for breast milk but also for formula milk in infants of less than 6 months of age.³ Thus, it is recommended to finish breast feeding 4 h before anaesthesia and to stop infant formula 4–6 h prior to anaesthesia depending on the age and on local considerations. Both cow's milk and powdered milk are considered as solid food.

6.2. Solid food

Recommendations for fasting of solid food in children do not differ from those proposed for healthy adults. There is no evidence against these recommendations.

6.3. Trauma

Data on fasting in injured children are minimal. One study suggested that the volume of gastric contents may depend on the nature of the trauma, but gastric content was not related to the length of fasting.⁵⁹ Gastric volume was better linked to the interval between the last meal and the trauma. Thus, the injured child should be considered as a patient with a full stomach. However, an increasing number of minor surgical procedures are done under sedation in the emergency department. The available literature does not provide sufficient evidence to conclude that pre-procedure fasting results in a decreased incidence of adverse outcomes in children undergoing either moderate or deep sedation.^{60,61}

6.4. Postoperative fluids

Oral fluid intake is usually allowed within the first 3 postoperative hours in most paediatric patients. Early

oral fluid intake was previously required in most institutions before discharging the patient from hospital. This view was challenged, as it has been reported that withholding oral fluids postoperatively from children undergoing day surgery reduces the incidence of vomiting.^{62,63} However, the most recent study did not find that postoperative fasting reduces the incidence of vomiting after general anaesthesia in children when compared with a liberal regimen.⁶⁴ Thus, it seems reasonable to let children eat and drink according to their own desires, but not to insist on oral intake before discharge.

7. Fasting in obstetric patients

Recommendations

Women in labour should be allowed clear fluids (as defined above) as they desire. (evidence level 1++, recommendation grade A).

Solid food should be discouraged during active labour (evidence level 1+, recommendation grade A).

Pregnant women, including obese individuals, can consume clear liquids until up to 2 h prior to surgery (under regional or general anaesthesia) (evidence level 2-, recommendation grade D).

An H₂-receptor antagonist should be given the night before, and on the morning of, elective caesarean section (evidence level 1++, recommendation grade A).

An intravenous H₂-receptor antagonist should be given prior to emergency caesarean section; this should be supplemented with 30 ml of 0.3 mol l⁻¹ sodium citrate if general anaesthesia is planned (evidence level 1++, recommendation grade A).

The guidelines group recognises that most of the evidence relates to surrogate measures, such as changes in gastric volume and pH, rather than a clear impact on mortality.

Rationale

7.1. Oral intake during labour

Surgery during labour is usually unplanned, and when it occurs the degree of emergency can range from minimal to surgery that is life saving for either mother or baby. Against this background, logic dictates that all mothers should be starved during labour. However, it is often argued that allowing mothers to eat and drink during labour will prevent ketosis and dehydration and, thereby, improve obstetric outcome. There is currently wide variation in practice with respect to eating during labour in Europe. However, it has now been shown that although eating a light diet during labour will prevent ketosis, it will also increase gastric volume,⁶⁵ whereas when isotonic 'sport drinks' are consumed during labour,⁶⁶ ketosis can be eliminated without an increase in intragastric volume.

A recent randomised controlled study evaluated the effect of food intake during labour on obstetric outcome.

Low-risk nulliparous women in labour ($n = 2443$) were randomised to either an 'eating' or a 'water only' group. The results were analysed by intention to treat. No significant difference was found in the normal vaginal delivery rate; the instrumental vaginal delivery rate; the caesarean section rate; the duration of labour; or the incidence of vomiting.⁶⁷

Maternal death from aspiration of regurgitated gastric content is now extremely rare, and its decline probably owes more to the widespread use of regional anaesthesia for operative obstetrics than to fasting policies. In view of the predominant use of regional techniques on most delivery units, rigid fasting policies are arguably no longer appropriate during labour and mothers should, therefore, be allowed to alleviate thirst during labour by consuming ice chips and clear fluids (isotonic sports drinks, fruit juices, tea and coffee, etc).

As eating confers no benefit to obstetric outcome, women should be discouraged from eating solid food during labour. However, in view of the almost negligible incidence of deaths from aspiration, low-risk women could consume low-residue foods (such as biscuits, toast or cereals) during labour. In addition, when deciding whether or not women should eat during labour, the use of parenteral opioids should also be considered because of their profound delay on the rate of gastric emptying. Units who perform a significant volume of their emergency obstetric surgery under general anaesthesia should probably not allow women in labour to eat.

In high-risk pregnancies, it remains appropriate to not eat during labour and to achieve hydration by limited volumes of oral clear fluids or by the intravenous route.

7.2. Preparation for caesarean section

7.2.1. Preoperative fasting in elective obstetric surgery

Evidence suggests that pregnant women, including obese individuals, can consume clear liquids until up to 2 h prior to surgery (under regional or general anaesthesia)^{68,69} (evidence level 1+, recommendation A).

7.2.2. Recommended drug regimens in detail

7.2.2.1. Elective obstetric surgery All mothers should be actively encouraged to have regional anaesthesia for an elective caesarean section.

An H₂-receptor antagonist (e.g. 150 mg ranitidine) or a PPI (e.g. omeprazole 40 mg) should be given at bedtime and again 60–90 min before the induction of anaesthesia. The administration of oral metoclopramide 10 mg at the same time as the H₂-receptor antagonist or PPI should also be considered.

7.2.2.2. Emergency obstetric surgery under regional anaesthesia Intravenous H₂-antagonist (e.g. ranitidine 50 mg) at time of decision for surgery. In high-risk women

the use of oral H₂-antagonists (ranitidine 150 mg), at regular intervals during labour, should be considered.

7.2.2.3. Emergency obstetric surgery under general anaesthesia Intravenous H₂-antagonist and oral antacid (e.g. 30 ml sodium citrate 0.3 mol l⁻¹) prior to induction of anaesthesia.

7.3. Eating and drinking after caesarean section

The beneficial effects of early postoperative feeding have been clearly demonstrated in colorectal surgery. Traditionally, eating and drinking after caesarean section was not encouraged, food and fluid were usually withheld for the first 12–24 h after surgery, after which fluids were slowly introduced, with food being allowed once bowel sounds had been heard or flatus was passed. A *Cochrane review* published in 2002 (the review included six articles published between 1993 and 2001) concluded that there was no evidence to justify restricting oral fluids or food following uncomplicated caesarean section.⁷⁰

More recent studies have indicated that clear fluids, commenced between 30 min and 2 h after caesarean section, are well tolerated and result in women requiring less intravenous fluids, earlier ambulation and earlier breast-feeding. Earlier solid intake appears to cause more nausea which tends to be self-limiting.^{71–73} Current evidence, therefore, suggests that early oral hydration following caesarean section is well tolerated and should perhaps be encouraged. Solid foods should be introduced more cautiously.

7.4. Effects of pregnancy on gastric function

Gastro-oesophageal reflux, resulting in heartburn, is a common complication of late pregnancy. Pregnancy compromises the integrity of the lower oesophageal sphincter as a result of an alteration in the anatomical relationship of the oesophagus to the diaphragm and stomach, an increase in intragastric pressure and the relaxing effect of progesterone on smooth muscle. A pregnant woman at term, requiring anaesthesia, should, therefore, be regarded as having an incompetent lower oesophageal sphincter. These physiological changes are less 48 h after delivery.⁷⁴

Gastric acid secretion is essentially unchanged during pregnancy.⁷⁵ Pregnancy does not significantly alter the rate of gastric emptying.⁷⁶ Gastric emptying is normal in early labour, but becomes delayed as labour advances.⁷⁷ Parenteral opioids significantly delay gastric emptying during labour, as do bolus doses of epidural and intrathecal opioids.^{78–80} Continuous epidural infusion of low-dose local anaesthetic with fentanyl does not appear to delay gastric emptying until the total dose of fentanyl exceeds 100 µg.⁶⁸

Gastric emptying is not delayed in either obese or non-obese parturients at term who ingest 300 ml water after

an overnight fast.^{69,81} Lewis and Crawford⁸² noted that in patients undergoing elective caesarean section, a meal of both tea (volume unknown) and toast 2–4 h pre-operatively resulted in an increased gastric volume and a decreased gastric pH when compared with a control group of patients. Particulate material was aspirated from the stomachs of two of the 11 patients who consumed both tea and toast. Consumption of tea without toast resulted in an increase in gastric volume, but it did not alter gastric pH.

7.5. Pharmacological prophylaxis against acid pulmonary aspiration in obstetrics

The risk of failed intubation is three to 11 times greater in pregnant patients than in non-pregnant patients.⁸³ Airway oedema, breast enlargement, obesity and the high rate of emergency surgery, all contribute to the risk of failed intubation in pregnant women. Aspiration pneumonia is often associated with difficult or failed intubation during the induction of general anaesthesia. Pregnant women undergoing caesarean section or other surgical procedures (both elective and emergency) should, therefore, receive antacid prophylaxis.

7.5.1. H₂-receptor antagonists

H₂-receptor antagonists block histamine receptors on the oxyntic cell and, thus, decrease gastric acid production. This results in a slight reduction in gastric volume in the fasting patient. When given intravenously, an H₂-receptor antagonist begins to take effect in as little as 30 min, but 60–90 min are required for maximal effect. After oral administration, gastric pH is greater than 2.5 in approximately 60% of patients at 60 min and in 90% at 90 min.

Most studies have evaluated the administration of 50–100 mg of ranitidine administered intravenously or intramuscularly or 150 mg administered orally.^{84–86} These studies have noted that the administration of ranitidine results in a gastric pH greater than 2.5 within 1 h. Therapeutic concentrations of ranitidine are sustained for approximately 8 h.

7.5.2. Proton pump inhibitors

Omeprazole (20–40 mg orally) and lansoprazole (15–30 mg orally) inhibit the hydrogen ion pump on the gastric surface of the oxyntic cell.^{87,88} For elective surgery, the efficacy of prophylaxis when using a PPI is similar to that achieved with an H₂-receptor antagonist. For emergency caesarean section, studies have shown that H₂-receptor antagonists and PPIs, administered intravenously, are equally effective adjuncts to 0.3 mol l⁻¹ sodium citrate for reducing gastric acidity and volume.

A recent meta-analysis on the effect of PPIs and H₂-antagonists (studies included both obstetric and non-obstetric patients) concluded that H₂-antagonists were more efficacious than PPIs for both reducing gastric volume and increasing gastric pH.²³

As antacids such as 0.3 mol l^{-1} sodium citrate can cause nausea and even vomiting, they need not be administered prior to elective surgery under regional anaesthesia if the parturient has already received an H_2 -antagonist or a PPI. However, in the event of emergency obstetric surgery under general anaesthesia, an antacid should be administered shortly before induction of general anaesthesia (e.g. within 20 min) with an H_2 -antagonist, as time constraints may mean that the efficacy of H_2 -antagonists cannot be guaranteed at the time of induction.

Metoclopramide 10 mg can further decrease gastric volume when used in conjunction with an H_2 -antagonist prior to elective caesarean section⁸⁹ and its use should be considered prior to both elective and emergency caesarean section.

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References

- 1 Brady M, Kinn S, Stuart P. Preoperative fasting for adults to prevent perioperative complications. *Cochrane Database Syst Rev* 2003;CD004423.
- 2 Brady M, Kinn S, Ness V, et al. Preoperative fasting for preventing perioperative complications in children [review]. *Cochrane Database Systematic Rev* 2009;CD005285.
- 3 Søreide E, Eriksson LI, Hirlekar G, et al. Preoperative fasting guidelines: an update [review]. *Acta Anaesthesiol Scand* 2005; **49**:1041–1047.
- 4 Royal College of Nursing. Perioperative fasting in adults and children: an RCN guideline for the multidisciplinary team. London: Royal College of Nursing; 2005.
- 5 Scottish Intercollegiate Guidelines Network, Elliott House, 8-10 Hillside Crescent, Edinburgh EH7 5EA. 2010. www.sign.ac.uk.
- 6 Schwartz PJ, Breithardt G, Howard AJ, et al. Task force report: the legal implications of medical guidelines – a task force of the European Society of Cardiology. *Eur Heart J* 1999; **20**:1152–1157.
- 7 American Society of Anesthesiologists 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. *Anesthesiology* 1999; **90**: 896–905.
- 8 Maltby JR, Sutherland AD, Sale JP, Shaffer EA. Preoperative oral fluids: is a five-hour fast justified prior to elective surgery? *Anesth Analg* 1986; **65**:1112–1116.
- 9 Phillips S, Hutchinson S, Davidson T. Preoperative drinking does not affect gastric contents. *Br J Anaesth* 1993; **70**:6–9.
- 10 Søreide E, Stromskag KE, Steen PA. Statistical aspects in studies of preoperative fluid intake and gastric content. *Acta Anaesthesiol Scand* 1995; **39**:738–743.
- 11 Eriksson LI, Sandin R. Fasting guidelines in different countries. *Acta Anaesthesiol Scand* 1996; **40** (8 Pt 2):971–974.
- 12 Scarr M, Maltby JR, Jani K, Sutherland LR. Volume and acidity of residual gastric fluid after oral fluid ingestion before elective ambulatory surgery. *CMAJ* 1989; **141**:1151–1154.
- 13 Hutchinson A, Maltby JR, Reid CRG. Gastric fluid volume and pH in elective inpatients. Part I: Coffee or orange juice versus overnight fast. *Can J Anaesth* 1988; **35**:12–15.
- 14 Maltby JR, Reid CRG, Hutchinson A. Gastric fluid volume and pH in elective inpatients. Part II: Coffee or orange juice with ranitidine. *Can J Anaesth* 1988; **35**:16–19.
- 15 Miller M, Wishart HY, Nimmo WS. Gastric contents at induction of anaesthesia. Is a 4-h fast necessary? *Br J Anaesth* 1983; **55**:1185–1188.
- 16 Dubin SA, Jense HG, McCranie JM, Zubar V. Sugarless gum chewing before surgery does not increase gastric fluid volume or acidity. *Can J Anaesth* 1994; **41**:603–606.
- 17 Schoenfelder RC, Ponnamma CM, Freyle D, et al. Residual gastric fluid volume and chewing gum before surgery. *Anesth Analg* 2006; **102**:415–417.
- 18 Søreide E, Holst-Larsen H, Veel T, Steen PA. The effects of chewing gum on gastric content prior to induction of general anesthesia. *Anesth Analg* 1995; **80**:985–989.
- 19 Iqbal MS, Ashfaq M, Akram M. Gastric fluid volume and pH: a comparison of effects of ranitidine alone with combination of ranitidine and metoclopramide in patients undergoing elective caesarean section. *Ann King Edward Med Coll* 2000; **6**:189–191.
- 20 Hong JY. Effects of metoclopramide and ranitidine on preoperative gastric contents in day-case surgery. *Yonsei Med J* 2006; **47**:315–318.
- 21 Bala I, Prasad K, Bhukal I, et al. Effect of preoperative oral erythromycin, erythromycin-ranitidine, and ranitidine-metoclopramide on gastric fluid pH and volume. *J Clin Anesth* 2008; **20**:30–34.
- 22 Sustic A, Zelic M, Protic A, et al. Metoclopramide improves gastric but not gallbladder emptying in cardiac surgery patients with early intragastric enteral feeding: randomized controlled trial. *Croat Med J* 2005; **46**:239–244.

- 23 Clark K, Lam LT, Gibson S, Currow D. The effect of ranitidine versus proton pump inhibitors on gastric secretions: a meta-analysis of randomised control trials [review]. *Anaesthesia* 2009; **64**:652–657.
- 24 Ljungqvist O, Nygren J, Thorell A. Insulin resistance and elective surgery [review]. *Surgery* 2000; **128**:757–760.
- 25 Wolfe RR, Allsop JR, Burke JF. Glucose metabolism in man: responses to intravenous glucose infusion. *Metabolism* 1979; **28**:210–220.
- 26 Ljungqvist O, Thorell A, Gutniak M, et al. Glucose infusion instead of preoperative fasting reduces postoperative insulin resistance [review]. *J Am Coll Surg* 1994; **178**:329–336.
- 27 Van den Berghe GH. Role of intravenous insulin therapy in critically ill patients [review]. *Endocr Pract* 2004; **2**:17–20.
- 28 Taniguchi H, Sasaki T, Fujita H, et al. Preoperative fluid and electrolyte management with oral rehydration therapy. *J Anesth* 2009; **23**:222–229.
- 29 Kaska M, Grosmanova T, Havel E, et al. The impact and safety of preoperative oral or intravenous carbohydrate administration versus fasting in colorectal surgery: a randomized controlled trial. *Wien Klin Wochenschr* 2010; **122**:23–30.
- 30 Nygren J, Thorell A, Jacobsson H, et al. Preoperative gastric emptying. Effects of anxiety and oral carbohydrate administration. *Ann Surg* 1995; **222**:728–734.
- 31 Jarvela K, Maaranen P, Sisto T. Preoperative oral carbohydrate treatment before coronary artery bypass surgery. *Acta Anaesthesiol Scand* 2008; **52**:793–797.
- 32 Breuer JP, von Dossow V, von Heymann C, et al. Preoperative oral carbohydrate administration to ASA III-IV patients undergoing elective cardiac surgery. *Anesth Analg* 2006; **103**:1099–1108.
- 33 Gustafsson UO, Nygren J, Thorell A, et al. Preoperative carbohydrate loading may be used in type 2 diabetes patients. *Acta Anaesthesiol Scand* 2008; **52**:946–951.
- 34 Henriksen MG, Hesson I, Dela F, et al. Effects of preoperative oral carbohydrates and peptides on postoperative endocrine response, mobilization, nutrition and muscle function in abdominal surgery. *Acta Anaesthesiol Scand* 2003; **47**:191–199.
- 35 Lobo DN, Hendry PO, Rodrigues G, et al. Gastric emptying of three liquid oral preoperative metabolic preconditioning regimens measured by magnetic resonance imaging in healthy adult volunteers: a randomised double-blind, crossover study. *Clin Nutr* 2009; **28**:636–641.
- 36 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.
- 37 Soop M, Nygren J, Myrenfors P, et al. Preoperative oral carbohydrate treatment attenuates immediate postoperative insulin resistance. *Am J Physiol Endocrinol Metab* 2001; **280**:E576–E583.
- 38 Soop M, Nygren J, Thorell A, et al. Preoperative oral carbohydrate treatment attenuates endogenous glucose release 3 days after surgery. *Clin Nutr* 2004; **23**:733–741.
- 39 Nygren J, Soop M, Thorell A, et al. Preoperative oral carbohydrate administration reduces postoperative insulin resistance. *Clin Nutr* 1998; **17**:65–71.
- 40 Wang ZG, Wang Q, Wang WJ, Qin HL. Randomized clinical trial to compare the effects of preoperative oral carbohydrate versus placebo on insulin resistance after colorectal surgery. *Br J Surg* 2010; **97**:317–327.
- 41 Yuill KA, Richardson RA, Davidson HI, et al. 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.
- 42 Bisgaard T, Kristiansen VB, Hjortso NC, et al. Randomized clinical trial comparing an oral carbohydrate beverage with placebo before laparoscopic cholecystectomy. *Br J Surg* 2004; **91**:151–158.
- 43 Hausel J, Nygren J, Thorell A, et al. 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.
- 44 Faria MS, de Aguiar-Nascimento JE, Pimenta OS, et al. Preoperative fasting of 2 h minimizes insulin resistance and organic response to trauma after video-cholecystectomy: a randomized, controlled, clinical trial. *World J Surg* 2009; **33**:1158–1164.
- 45 Helminen H, Viitanen H, Sajanti J. Effect of preoperative intravenous carbohydrate loading on preoperative discomfort in elective surgery patients. *Eur J Anaesthesiol* 2009; **26**:123–127.
- 46 Meisner M, Ernhofer U, Schmidt J. Liberalisation of preoperative fasting guidelines: effects on patient comfort and clinical practicability during elective laparoscopic surgery of the lower abdomen [German]. *Zentralbl Chir* 2008; **133**:479–485.
- 47 Noblett SE, Watson DS, Huong H, et al. Preoperative oral carbohydrate loading in colorectal surgery: a randomized controlled trial. *Colorectal Dis* 2006; **8**:563–569.
- 48 Mathur S, Plank LD, McCall JL, et al. Randomized controlled trial of preoperative oral carbohydrate treatment in major abdominal surgery. *Br J Surg* 2010; **97**:485–494.
- 49 Splinter WM, Schreiner MS. Preoperative fasting in children [review]. *Anesth Analg* 1999; **89**:80–89.
- 50 Cook-Sather SD, Litman RS. Modern fasting guidelines in children [review]. *Best Pract Res Clin Anaesthesiol* 2006; **20**:471–481.
- 51 Søreide E, Ljungqvist O. Modern preoperative fasting guidelines: a summary of the present recommendations and remaining questions [review]. *Best Pract Res Clin Anaesthesiol* 2006; **20**:483–491.
- 52 Shime N, Ono A, Chihara E, Tanaka Y. Current practice of preoperative fasting: a nationwide survey in Japanese anesthesia-teaching hospitals. *J Anesth* 2005; **19**:187–192.
- 53 Flick RP, Schears GJ, Warner MA. Aspiration in pediatric anesthesia: is there a higher incidence compared with adults? *Curr Opin Anaesthesiol* 2002; **15**:323–327.
- 54 Litman RS, Wu CL, Quinlivan JK. Gastric volume and pH in infants fed clear liquids and breast milk prior to surgery. *Anesth Analg* 1994; **79**:482–485.
- 55 Nicolson SC, Schreiner MS. Feed the babies [editorial]. *Anesth Analg* 1994; **79**:407–409.
- 56 Cook-Sather SD, Gallagher PR, Kruge LE, et al. Overweight/obesity and gastric fluid characteristics in pediatric day surgery: implications for fasting guidelines and pulmonary aspiration risk. *Anesth Analg* 2009; **109**:727–736.
- 57 Billeaud C, Guillet J, Sandler B. Gastric emptying in infants with or without gastro-oesophageal reflux according to the type of milk. *Eur J Clin Nutr* 1990; **44**:577–583.
- 58 Van der Walt JH, Foate JA, Murrell D, et al. A study of preoperative fasting in infants aged less than three months. *Anaesth Intensive Care* 1990; **18**:527–531.
- 59 Bricker SR, McLuckie A, Nightingale DA. Gastric aspirates after trauma in children. *Anaesthesia* 1989; **44**:721–724.
- 60 Green SM, Roback MG, Miner JR, et al. Fasting and emergency department procedural sedation and analgesia: a consensus-based clinical practice advisory. *Ann Emerg Med* 2007; **49**:454–461.
- 61 Green SM, Krauss B. Pulmonary aspiration risk during emergency department procedural sedation: an examination of the role of fasting and sedation depth [review]. *Acad Emerg Med* 2002; **9**:35–42.
- 62 Kearney R, Mack C, Entwistle L. Withholding oral fluids from children undergoing day surgery reduces vomiting. *Paediatr Anaesth* 1998; **8**:331–336.
- 63 Schreiner MS, Nicolson SC. Pediatric ambulatory anesthesia: NPO – before or after surgery? [review]. *J Clin Anesth* 1995; **7**:589–596.
- 64 Radke OC, Biedler A, Kolodzie K, et al. The effect of postoperative fasting on vomiting in children and their assessment of pain. *Paediatr Anaesth* 2009; **19**:494–499.
- 65 Scrutton MJ, Metcalfe GA, Lowy C, et al. Eating in labour. A randomised controlled trial assessing the risks and benefits. *Anaesthesia* 1999; **54**:329–334.
- 66 Kubli M, Scrutton MJ, Seed PT, O'Sullivan G. An evaluation of isotonic 'sport drinks' during labor. *Anesth Analg* 2002; **94**:404–408.
- 67 O'Sullivan G, Liu B, Hart D, et al. Effect of food intake during labour on obstetric outcome: randomised controlled trial. *BMJ* 2009; **338**:b784.
- 68 Porter JS, Bonello E, Reynolds F. The influence of epidural administration of fentanyl infusion on gastric emptying in labour. *Anaesthesia* 1997; **52**:1151–1156.
- 69 Wong CA, Loffredi M, Ganchiff JN, et al. Gastric emptying of water in term pregnancy. *Anesthesiology* 2002; **96**:1395–1400.
- 70 Mangesi L, Hofmeyr GJ. Early compared with delayed oral fluids and food after caesarean section [review]. *Cochrane Database Syst Rev* 2002:CD003516.
- 71 Orji EO, Olabode TO, Kuti O, Ogunniyi SO. A randomised controlled trial of early initiation of oral feeding after caesarean section. *J Mater Fetal Neonatal Med* 2009; **22**:65–71.
- 72 Mulayim B, Celik NY, Kaya S, Yanik FF. Early oral hydration after caesarean delivery performed under regional anesthesia. *Int J Gynaecol Obstet* 2008; **101**:273–276.
- 73 Teoh WH, Shah MK, Mah CL. A randomised controlled trial on beneficial effects of early feeding post-Caesarean delivery under regional anaesthesia. *Singapore Med J* 2007; **48**:152–157.
- 74 Vanner RG, Goodman NW. Gastro-oesophageal reflux in pregnancy at term and after delivery. *Anaesthesia* 1989; **44**:808–811.
- 75 Murray FA, Erskine JP, Fielding J. Gastric secretion in pregnancy. *J Obstet Gynaecol Br Empire* 1957; **64**:373–381.
- 76 Davison JS, Davison MC, Hay DM. Gastric emptying time in late pregnancy and labour. *J Obstet Gynaecol Br Commonw* 1970; **77**:37–41.

- 77 Nimmo WS, Wilson J, Prescott LF. Further studies of gastric emptying during labour. *Anaesthesia* 1977; **32**:100–101.
- 78 Nimmo WS, Wilson J, Prescott LF. Narcotic analgesics and delayed gastric emptying during labour. *Lancet* 1975; **1**:890–893.
- 79 Wright PM, Allen RW, Moore J, Donnelly JP. Gastric emptying during lumbar extradural analgesia in labour: effect of fentanyl supplementation. *Br J Anaesth* 1992; **68**:248–251.
- 80 Kelly MC, Carabine UA, Hill DA, Mirakhur RK. A comparison of the effect of intrathecal and extradural fentanyl on gastric emptying in laboring women. *Anesth Analg* 1997; **85**:834–838.
- 81 Wong CA, McCarthy RJ, Fitzgerald PC, *et al*. Gastric emptying of water in obese pregnant women at term. *Anesth Analg* 2007; **105**:751–755.
- 82 Lewis M, Crawford JS. Can one risk fasting the obstetric patient for less than 4 h? *Br J Anaesth* 1987; **59**:312–314.
- 83 Rocke DA, Murray WB, Rout CC, Gouws E. Relative risk analysis of factors associated with difficult intubation in obstetric anesthesia. *Anesthesiology* 1992; **77**:67–73.
- 84 Dammann HG, Muller P, Simon B. Parenteral ranitidine: onset and duration of action. *Br J Anaesth* 1982; **54**:1235–1236.
- 85 Francis RN, Kwik RS. Oral ranitidine for prophylaxis against Mendelson's syndrome. *Anesth Analg* 1982; **61**:130–132.
- 86 Maile CJ, Francis RN. Preoperative ranitidine. Effect of a single intravenous dose on pH and volume of gastric aspirate. *Anaesthesia* 1983; **38**:324–326.
- 87 Levack ID, Bowie RA, Braid DP, *et al*. Comparison of the effect of two dose schedules of oral omeprazole with oral ranitidine on gastric aspirate pH and volume in patients undergoing elective surgery. *Br J Anaesth* 1996; **76**:567–569.
- 88 Yau G, Kan AF, Gin T, Oh TE. A comparison of omeprazole and ranitidine for prophylaxis against aspiration pneumonitis in emergency caesarean section. *Anaesthesia* 1992; **47**:101–104.
- 89 O'Sullivan G, Sear JW, Bullingham RE, Carrie LE. The effect of magnesium trisilicate mixture, metoclopramide and ranitidine on gastric pH, volume and serum gastrin. *Anaesthesia* 1985; **40**:246–253.