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GUIDELINES

Pre-operative fasting in children

A guideline from the European Society of Anaesthesiology and Intensive Care

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Current paediatric anaesthetic fasting guidelines have recommended conservative fasting regimes for many years and have not altered much in the last decades. Recent publications have employed more liberal fasting regimes with no evidence of increased aspiration or regurgitation rates. In this first solely paediatric European Society of Anaesthesiology and Intensive Care (ESAIC) pre-operative fasting guideline, we aim to present aggregated and evidence-based summary recommendations to assist clinicians, healthcare providers, patients and parents.

We identified six main topics for the literature search: studies comparing liberal with conservative regimens; impact of food composition; impact of comorbidity; the use of gastric ultrasound as a clinical tool; validation of gastric ultrasound for gastric content and gastric emptying studies; and early postoperative feeding. The literature search was performed by a professional librarian in collaboration with the ESAIC task force.

Recommendations for reducing clear fluid fasting to 1 h, reducing breast milk fasting to 3 h, and allowing early postoperative feeding were the main results, with GRADE 1C or 1B evidence. The available evidence suggests that gastric ultrasound may be useful for clinical decision-making, and that allowing a 'light breakfast' may be well tolerated if the intake is well controlled. More research is needed in these areas as well as evaluation of how specific patient or treatment-related factors influence gastric emptying.

List of Abbreviations

2D	Two dimensional
3D	Three dimensional
6-4-2	6 hours (solids), 4 hours (breast milk), 2 hours (clear fluids)
6-4-1	6 hours (solids), 4 hours (breast milk), 1 hour (clear fluids)
6-4-0	6 hours (solids), 4 hours (breast milk), < 1 hours (clear fluids)
ASA	American Society of Anesthesiology
AUC ROC	Area under the curve receiver operating characteristic
BW	Body weight
CI	Confidence interval
CSA	Cross-sectional area
CT	Computed tomography
EHF	Extensively hydrolysed formula

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ESAIC	European Society of Anaesthesiology
GAA	Gastric Antral Area (synonym: gastric CSA)
GCV	Gastric content volume
GE	Gastric emptying
GERD	Gastro-oesophageal reflux disease
GFV	Gastric fluid volume (equals GCV if there are no solids in the stomach)
GUS	Gastric ultrasound
IPF	Intact protein formula
MAP	Mean arterial pressure
MRI	Magnetic resonance imaging
NPO	Nil per os
NUD	Non-ulcer dyspepsia
PACU	Post anaesthesia care unit
PHF	Partially hydrolysed formula
PICO	Population, Intervention, Comparison, Outcome
POV	Post-operative vomiting
RCT	Randomised controlled trial
RLD	Right lateral decubitus
SPECT	Single photon emission tomography
SUBE	Supine position with upper body elevated
US	Ultrasound

Introduction

Current paediatric anaesthetic fasting guidelines have recommended conservative fasting regimes for many years and have not altered much in the last decades.[1–3] In this first solely paediatric European Society of Anaesthesiology and Intensive Care (ESAIC) pre-operative fasting guideline, we aim to present aggregated and evidence-based summary recommendations to assist clinicians, healthcare providers, patients and parents.

Most commonly, the published literature advocates minimum fasting times of 6 h for food and formula, 3 to 4 h for breast milk and 2 h for clear fluid. These protocols have a good safety record in terms of low aspiration and regurgitation rates but often come at the cost of excessive fasting times, thirst and distress.[4] Furthermore, several articles have demonstrated that a 2-h clear fluid fasting rule translates into real-world median fasting times of 6 to 13 h.[5,6]

Recent publications have employed more liberal fasting regimens with no evidence of increased aspiration or regurgitation rate.[7–9] Pulmonary aspiration of gastric content per se is a rare event in children. When aspiration of clear fluids does occur, whatever the fluid fasting regimen, the clinical consequence is rarely beyond the need for prolonged monitoring and sometimes antibiotic therapy.[10–14]

Lately, there has been an increased interest in the use of MRI and ultrasound to examine the nature, volume and emptying rate of gastric contents. This has the potential for a more scientific appraisal of residual gastric contents under various fasting conditions in children.[15]

International consensus has been shifting towards a more liberal policy of 1 h for clear fluids and 1 h is endorsed by several national societies in Europe, North America (Canada) and Australasia.[16–19]

In this document, we critically appraise the current literature in the field and provide a graded and evidence-based set of pre-operative fasting guidelines for paediatric patients.

Materials and methods

The European Society of Anaesthesiology and Intensive Care appointed a core panel of experts, including members from the European Society for Paediatric Anaesthesiology, the Canadian Pediatric Anesthesia Society and the Society for Pediatric Anesthesia to develop guidelines for pre-operative fasting in children. Clinical queries were developed in the form of six Population/Intervention/Comparison/Outcome (PICO) groups and then further into 17 elements for the search strategy (see Appendix 1, http://links.lww.com/EJA/A615).

The complete list of PICOs was then revised and approved by the task force. PICOs generated the research questions which have been addressed in this article. The main clinical queries were:

(1) What are the risks and benefits associated with a change from the current pre-operative fasting regimen, based on the guidelines published in 2011, to more liberal regimens?
(2) What is the impact of composition, amount and consistency of food or fluid on gastric emptying in a clinical or simulated fasting setting?
(3) What is the impact of comorbidity, medication and other environmental or patient factors in a clinical or simulated fasting setting?
(4) Can gastric ultrasound (GUS) be used as a clinical decision-making tool to evaluate the risk of pulmonary aspiration?
(5) Can GUS in children be validated as a diagnostic tool to determine gastric content and/or half-time of gastric emptying?
(6) What are the risks and benefits of early postoperative feeding in terms of patient comfort vs. the risk of adverse effects?

Criteria for considering studies for data analysis

Types of studies

Data analysis included all randomised, parallel and quasi-randomised studies (including cross-over studies) and observational studies performed in children that addressed any of the above queries. Both clinical studies of fasting times in various settings and experimental studies of gastric emptying were included. Prior meta-analyses were considered when available and meeting the inclusion criteria. Data from quasi-randomised and observational and large retrospective studies were included due to the small number of randomised controlled trials (RCTs). Reviews, case series and case reports as well as published abstracts from conference proceedings and registered but not completed studies were excluded.

Types of participants

The qualitative and quantitative analysis of the literature was confined to children in all age groups from premature

infants up to the age of 17 years, with or without specified comorbidity. Studies including a mix of paediatric and adult populations were reviewed if they included mostly paediatric patients. When data were lacking in the paediatric population, information was in some cases extrapolated from relevant adult studies.

Types of interventions

We included the following interventions: implementation of different fasting regimens, ingestion of a specified drink or foodstuff and/or specified volume with subsequent analysis of gastric emptying with ultrasound, MRI, radionuclide imaging or aspiration of gastric contents.

Types of comparators

Standard fasting regimens (in fasting time studies), imaging modalities other than ultrasound (in GUS validation studies), healthy children (in studies of the effect of comorbidity or extreme age groups).

Types of outcomes

Outcomes included the incidence of pulmonary aspiration or regurgitation, real fasting time and gastric emptying time.

Search methods for identification of studies

The list of PICO questions was sent to the core panel for discussion, amendment and approval. After recruiting 12 members to the panel, six task force groups typically consisting of one senior researcher and two junior researcher/clinicians were formed. Each task force group was allocated one of the research questions and set of PICOs described in Appendix 1, http://links.lww.com/EJA/A615.

The literature search strategy was developed by the trial search specialist (Janne Vendt) in close collaboration with author P.F. and the ESAIC group methodologist and Cochrane editor (A.A.). The literature search was conducted in MEDLINE (OvidSP), EMBASE (OvidSP), CINAHL and Cochrane Central Register of Controlled Trials (CENTRAL). All searches were restricted to the English language from 1990 to 2019. A similar search strategy was used for all the databases. The electronic database search was run in October 2019 by J.V. and repeated in September 2020 by trial search specialist Kazuko Gustavsson (Uppsala University, Uppsala, Sweden). The panel members were also encouraged to add any missing papers of interest of which they were aware and to conduct related searches themselves. The titles resulting from the searches were divided into 10 approximately equal parts and screened by authors H.A., C.B., E.C., E.E., A.K., D.Ro., D.Ru., R.I., D.S., A.R.S.

Search results

After removal of all duplicates, 10 of the authors first screened the titles and then relevant titles with abstracts in a two-stage procedure. In the first stage, a 'second opinion' option was possible, later to be reviewed by either P.S. or P.F. who also monitored the screening procedure. The resulting relevant articles were retrieved for full-text assessment and data extraction by the task force groups, who compiled and wrote the literature review text for their respective PICO groups. The methodologist was responsible for choosing topics for possible meta-analyses based on the quality of the available data, reliability of the search (sensitivity) and based on predefined inclusion and exclusion criteria. However, for this guideline, we found no data suitable for meta-analysis. From approximately 42 000 titles in the initial search, after duplicate removal, the remaining 28 000 titles were screened, resulting in 1200 abstracts, and from these, 400 relevant abstracts were used to select a total of 125 appropriate titles for the GRADE analysis. For a detailed description of the search strategy and PICO queries, the readers are referred to Appendix 2, http://links.lww.com/EJA/A616 and 3, http://links.lww.com/EJA/A617, respectively, in the electronic supplement.

Data collection and analysis

Selection of studies

All articles meeting inclusion criteria were included. At least two authors within each of the six task force groups assessed the relevant full-text articles [PICO 1 (H.A., .P.F, A.K.); PICO 2 (E.E., R.I., P.S.); PICO 3 (D.Ro., A.R.S., D.S.); PICO 4 (E.C., L.B., M.Q.); PICO 5 (J.H., F.K., A.Sz.); PICO 6 (C.B., D.R., R.S.). Disagreements were resolved by a third party within the group. The number of hits responding to key words for each PICO are reported in Appendix 3, http://links.lww.com/EJA/A617.

Data extraction and management

Each task force group entered data from relevant studies into a predesigned (by P.S.) RedCap database. All authors extracted data in a similar manner in relation to study design, population characteristics, interventions and outcome measures. Task force group authors reached consensus regarding extracted data through discussion, initially within the group, then with the whole panel.

Assessment of risk of bias in included studies

Review authors were supplied with literature for assessment of risk of bias by the ESAIC methodologist (A.A.), and then assessed the risk of bias of each of the studies selected for their PICO question. Risk of bias assessment was conducted in accordance with the Cochrane Handbook for Systematic Reviews of Interventions source.[7] The risk of bias was assessed for the following domains:

(1) Random sequence generation (selection bias)
(2) Allocation concealment (selection bias)
(3) Blinding of outcome assessors (performance and detection bias)
(4) Incomplete outcome data, intention-to-treat (attrition bias)
(5) Selective reporting

Trials were assessed as having a low risk of bias if all of the domains were considered adequate and as having high risk of bias if one or more of these domains were considered

Table 1 GRADE definitions

Grade of recommendation	Clarity of risk/benefit	Quality of supporting evidence
1A Strong recommendation, high quality evidence	Benefits clearly outweigh risk and burdens, or vice versa.	Consistent evidence from well performed randomised, controlled trials or over-whelming evidence of some other form. Further research is unlikely to change our confidence in the estimate of benefit and risk.
1B Strong recommendation, moderate quality evidence	Benefits clearly outweigh risk and burdens, or vice versa.	Evidence from randomised, controlled trials with important limitations (inconsistent results, methodologic flaws, indirect or imprecise), or very strong evidence of some other research design. Further research (if performed) is likely to have an impact on our confidence in the estimate of benefit and risk and may change the estimate.
1C Strong recommendation, low quality evidence	Benefits appear to outweigh risk and burdens, or vice versa.	Evidence from observational studies, unsystematic clinical experience, or from randomised, controlled trials with serious flaws. Any estimate of effect is uncertain.
2A Weak recommendation = suggestion, high quality evidence	Benefits closely balanced with risks and burdens.	Consistent evidence from well performed randomised, controlled trials or overwhelming evidence of some other form. Further research is unlikely to change our confidence in the estimate of benefit and risk.
2B Weak recommendation = suggestion, moderate quality evidence	Benefits closely balanced with risks and burdens, some uncertainly in the estimates of benefits, risks and burdens.	Evidence from randomised, controlled trials with important limitations (inconsistent results, methodologic flaws, indirect or imprecise), or very strong evidence of some other research design. Further research (if performed) is likely to have an impact on our confidence in the estimate of benefit and risk and may change the estimate.
2C Weak recommendation = suggestion, low-quality evidence	Uncertainty in the estimates of benefits, risks and burdens; benefits may be closely balanced with risks and burdens.	Evidence from observational studies, unsystematic clinical experience, or from randomised, controlled trials with serious flaws. Any estimate of effect is uncertain.

inadequate or unclear. Disagreement regarding assessment of risk of bias was settled in discussion with the methodologist (A.A.).

Assessment of quality of the evidence

In accordance with ESAIC policy, GRADE methodology (Grading of Recommendations, Assessment, Development and Evaluation) was used for assessing the methodological quality of the included studies and for formulating the recommendations.[20,21]

Decisions to downgrade the level of evidence for a recommendation were based on the quality and type of the included literature, observed inconsistencies, indirectness or directness of the evidence, overall impression and the presence of publication bias as indicated by GRADE. Decisions to upgrade the level of evidence for recommendations were based on study quality and magnitude of effect ratio, dose-response gradient and plausible confounding. The GRADE definitions are summarised in Table 1. A more detailed account of GRADE (https://www.uptodate.com/home/grading-guide) is available in Appendix 4, http://links.lww.com/EJA/A618.

Development of recommendations

Each group developed recommendations relevant to their PICO and clinical questions (Appendix 1, http://links.lww.com/EJA/A615). These were then discussed and re-discussed as required with the entire expert panel in light of the data synthesis (when available), the risk of bias and the quality of the evidence.

A three-step Delphi process was used to produce expert recommendations and to discuss the methodological quality of the supporting literature when the quality of evidence was low or when rephrasing of recommendations was needed. Every single recommendation, suggestion or statement was subject to the voting and consensus process. Of note, during the initial Delphi process, some additional supplementary questions were defined that were considered highly relevant to the PICOs. For these new questions, if considered to be adequately covered by the literature search, the supporting evidence was also subject to GRADE and continued Delphi process.

First round

At the first round, the task force groups' statements were discussed and refined at a videoconference. A set of 23 statements were identified for further development.

Second round

For the second round, a survey (SurveyMonkey.com) was used to ask the task force members to indicate approval or rejection of each of the resulting set of 23 statements, with the option of suggesting changes. In the survey, three reached full agreement, 11 reached at least 75% consensus (the predefined level for consensus) and for the remaining nine, one or more changes were proposed for the next round. There were 20 respondents.

Third round

For the final round, all statements with consensus and alternative phrasings suggested by members were compiled and incorporated into a second survey sent to the task force members two weeks before a final Delphi videoconference at which the complete set of recommendations were fixed. The survey contained two parts. In part one, 18 statements with one or more alternative phrasings suggested by the members were offered. In part two, four statements with several suggested alternatives were broken down into multiple choice questions, to enable indication of, for example, which type of fluid should be included in the clear fluid category, or if breast milk should be allowed or encouraged. The resulting 23 revised statements were compiled into a list of 12 recommendations with consensus (none with full agreement) and 11 with disagreement regarding details. At the final Delphi videoconference, each statement without consensus was briefly discussed and voting by the hand wave function resulted in 21 recommendations or statements with consensus of which two reached full agreement, and two were moved to the discussion (Appendix 5, http://links.lww.com/EJA/A619)

The recommendations were merged into a shared document by one author (P.F.). The final version of the document was composed by the authors (P.F., N.D., A.A. and M.T.) and subsequently reviewed and endorsed by all members of the expert panel.

SUMMARY OF RECOMMENDATIONS (R) AND SUGGESTIONS (S)

R1	Prolonged fasting time should be avoided in all children, whenever possible.	**1C**
R2	We recommend that healthy children are encouraged to drink clear fluids (including water with or without sugar, pulp-free juice and milk-free tea or coffee) up to 1 h before anaesthesia induction for elective procedures.	**1C**
S3	Avoid prolonged fasting, as it may be associated with ketone body accumulation.	**2C**
S4	Avoid prolonged pre-operative fasting, as it may be associated with lower SBP during anaesthesia.	**2C**
S5	There is conflicting evidence of reduced incidence of hunger, thirst or discomfort with more liberal fasting regimens.	**2B**
S6	There is conflicting evidence regarding gastric content volume if pre-operative clear fluid fasting is reduced to less than 2 h.	**2B**
R7	We recommend pre-operative fasting regimens with less than 2 h of clear fluid fasting, as they provide reduced real-world fasting times.	**1B**
R8	For infants, breast milk feeding should be encouraged until 3 h before anaesthesia induction.	**1C**
R9	Fortified breast milk does not delay gastric emptying in a clinically significant manner compared with breast milk and can therefore be encouraged for infants until 3 h before anaesthesia induction	**1B**
S10	For infants, formula (or nonhuman) milk may be encouraged until 4 h before anaesthesia induction.	**2B**
R11	Solid food should be allowed until 6 h before anaesthesia induction.	**1C**
S12	A light breakfast of solids or nonclear fluids may be allowed up to 4 h prior to anaesthesia induction.	**2C**
S13	The presence of gastro-oesophageal reflux disease per se does not necessitate fasting instructions different from those for healthy children.	**2B**
S14	Gastric emptying in preterm infants may be slightly prolonged compared with term infants, but the clinical significance of this is unclear within this guideline's recommendations R8-S10.	**2C**
S15	The presence of functional/nonulcer dyspepsia *per se* does not necessitate fasting instructions different from those for healthy children.	**2C**
S16	The presence of congenital cardiac disease *per se* does not necessitate different fasting instructions from those for healthy children.	**2B**
S17	Obesity does not necessitate different fasting instructions from those for normal weight children.	**2C**
S18	The presence of repaired oesophageal atresia/trachea-oesophageal fistula without documented delayed gastric emptying or oesophageal stenosis does not necessitate fasting instructions different from those for healthy children.	**2C**
S19	Isolated type I diabetes *per se* does not necessitate different fasting instructions from those for healthy children.	**2C**
S20	There is insufficient evidence to recommend specific and different pre-operative fasting requirements with respect to the impact of medications or environmental factors.	
S21	Gum chewing does not increase gastric fluid volume enough to increase the risk of aspiration, but children should be questioned about the presence of gum in their mouth before anaesthesia induction and, if still present, asked to spit it.	**2B**
S22	Children on enteral tube or gastrostomy feeding should be fasted before anaesthesia according to the same guidelines as other children and according to the consistency and caloric content of the food administered (clear fluid, milk, thick semi-solid fluid).	**2C**
S23	Ultrasound assessment of gastric contents and volume may be used in children scheduled for elective surgery when fasting instructions have not been applied, and in children undergoing emergency surgery.	**2C**
S24	Cross-sectional area (CSA) of the antrum can be used as the surrogate parameter of choice for gastric content. Sonographic images of the antrum can most reliably be taken in right lateral decubitus position, using a defined protocol.	**2B**
S25	Qualitative grading systems are preferred over calculating gastric volumes. A trained examiner can use qualitative interpretation of sonographic imaging to differentiate solids from fluids as well as larger volumes from smaller ones.	**2B**
R26	Unless contraindicated, an early and liberal postoperative fluid intake should always be encouraged in children.	**1B**

Clear fluid fasting

Recommendation 1: Prolonged fasting time should be avoided in all children, whenever possible. (**1C**)

Recommendation 2: We recommend that healthy children are encouraged to drink clear fluids (including water with or without sugar, pulp-free juice and milk-free tea or coffee) up to 1 h before anaesthesia induction for elective procedures. (**1C**)

Evidence summary: There were no RCTs assessing the risk of pulmonary aspiration. One prospective observational study included cohorts of children fasting according to the 6-4-2, the 6-4-1 or the 6-4-0 regimens, and reported a similar incidence in the three cohorts.[22] Two prospective observational studies included cohorts of children fasting according to either the 6-4-1 or 6-4-2 regimen.[8,9] All three studies included a large number of patients (range 12 093 to 16 000) but were underpowered to determine differences in the risk of pulmonary aspiration (Table 2). However, the first study shows indirect evidence for noninferiority regarding the risk of regurgitation without aspiration when clear fluid fasting times were less than 2 h.[22]

In one small RCT, the authors reported, as a secondary outcome, glucose levels in children receiving a glucose drink either 1 or 2 h before anaesthesia.[23] No large series have compared glucose levels when 2 or 1-h fasting regimens are implemented.

Table 2 Pulmonary aspiration

Study	Population	Study Design	Comments
1. Beck *et al.*[22]	12 093 children undergoing elective or emergency anaesthesia.	Prospective Observational Study of real fasting time and adverse events in 15 centres implementing either the 6-4-2, the 6-4-1 or the 6-4-0 regimen.	0.26% cases of regurgitation, 0.08% cases of suspected aspiration and 0.03% cases of confirmed aspiration. No difference in adverse events between the fasting regimen cohorts.
2. Newton *et al.*[8]	Children admitted to pre-operative ward. Exact number of individuals not stated (several thousand)	Prospective observational study of fasting times, rate of cancellation due to inadequate fasting before and after introducing a 6-4-1 regimen with a volume limit for ingestion.	The number of aspirations was 2 in 4828 patients (4 : 10 000) in the liberal fasting cohort, which was said to be similar to the incidence in the preceding period.
3. Isserman *et al.*[9]	Children undergoing general anaesthesia.	Prospective observational study ($n = 16\,000$) of fasting times before and after introducing a 6-4-1 regimen	Increased incidence of regurgitation from 0.1 to 0.29% after introducing 1 h clear fluid fasting, but noted that none of these cases were associated with pre-operative fasting < 2 h or led to pulmonary aspiration

Suggestion 3: Avoid prolonged pre-operative fasting, as it may be associated with ketone body accumulation. (**2C**).

Evidence summary: Two RCTs and one observational study were assessed. In the two RCTs comparing 6-4-2 with liberal fasting regimens, no differences in blood ketone body levels or venous pH and base excess were detected.[24,25] An observational study found lower ketone body concentrations in the cohort fasting a mean of 6 vs. 8.5 h in the historical controls[26] (Table 3).

Suggestion 4: Avoid prolonged pre-operative fasting, as it may be associated with lower SBP during anaesthesia. (**2C**)

Evidence summary: There were no randomised controlled studies nor any observational studies investigating the incidence of hypotension in children fasting less or more than 2 h for clear fluids. However, three observational studies with significant heterogeneity and in one case also imprecision indicate that long fasting times (more than 8 h) are associated with an increased risk of a reduction in systolic or mean arterial blood pressure after induction (Table 4).[26–28]

Suggestion 5: There is conflicting evidence for a reduced incidence of hunger, thirst or discomfort with more liberal fasting regimens. (**2B**)

Evidence summary: Three RCTs compared the incidence of hunger, thirst and discomfort as secondary outcomes when children were fasting at least (6-4-2) or less than 2 h for clear fluids (6-4-1 or 6-4-0) (Table 5).[23–25] Further research is needed in this area.

Suggestion 6: There is conflicting evidence regarding gastric content volume if pre-operative clear fluid fasting is reduced to less than 2 h. (**2B**)

Evidence summary: Three RCTs[23–25] compared gastric content volume (GCV) in children fasting according to the 6-4-2 regimen vs. either the 6-4-1 or the 6-4-0, two of them as the primary outcome. After intubation, all three studies used multiple position suctioning via a gastric tube for measuring the gastric content volume, a method that may underestimate the real volume. There were no significant differences in mean gastric content volume, but in two of the studies, there was an increased number of children with GCV in the high range (above threshold values of 1.5, 2 or 4 ml kg^{-1}) in children fasted 1 h or less (Table 6).

Recommendation 7: We recommend pre-operative fasting regimens with less than 2 h of clear fluid fasting, as they provide reduced real-world fasting times. (**1B**)

Evidence summary: Two RCTs and four prospective observational studies compared the effects on real fasting time in children fasting according to liberal fasting vs. 6-4-2 regimens (Table 7). One RCT reported median fasting time 76 min vs. 135 in the 6-4-1 vs. the 6-4-2

Table 3 Ketoacidosis

Study	Population	Study design	Comments
1.Schmidt *et al.*[24]	162 children aged 1.1-16 y undergoing elective procedures under general anaesthesia.	Single centre RCT. Children randomised to 6-4-2 or liberal clear fluid fasting (clear fluids allowed until premedication)	There was no difference in venous ketone body levels between the groups.
2. Schmidt *et al.*[25]	Children, 1-16 years, ASA I-II) undergoing elective procedures requiring general anaesthesia	Single-centre RCT of fasting according to 6-4-2 or 6-4-1.	There were no significant differences in venous pH or base excess.
3. Dennhardt *et al.*[26]	100 children aged 0 to 36 months scheduled for elective paediatric surgery	Prospective observational cohort. Intervention: information about optimizing fasting times given to parents and staff. Fasting times in 50 children after intervention compared with matched historical controls.	Ketone body concentration in blood was lower (0.2 ± 0.2 mmol l^{-1}) in children fasting effectively for a mean of 6.0 ± 3.9 h before induction compared with age and weight-matched controls fasting for a mean of 8.5 ± 3.5 h with levels slightly elevated (0.6 mmol l^{-1}) above the normal range.

Table 4 Hypotension

Study	Population	Study Design	Comments
1.Simpao *et al.*[27]	15 543 children undergoing elective procedures under general anaesthesia.	Single-centre, retrospective cohort study analysing fasting times and blood pressure readings after induction and during the surgical preparation phase.	Fasting 4 to 8 h (adjusted odds ratio, 1.33 (95% CI 1.07 to 1.64; $P=0.009$) and greater than 12 h (adjusted odds ratio, 1.28 (95% CI 1.04 to 1.57; $P=0.018$) were associated with higher odds of low SBP during the surgical preparation phase.
2. Friesen *et al.*[28]	250 children, 1 month to 12 years old, undergoing halothane induction.	Changes in heart rate and systolic and mean arterial blood pressure from pre-induction to 2 MAC were compared among fasting groups	In the 1 to 6-month age cohort ($n=6$), fasting for 8 to 12 h was associated with hypotension. No significant changes were found in the other age groups
3. Dennhardt *et al.*[26]	100 children aged 0 to 36 months scheduled for elective paediatric surgery	Prospective observational cohort. Intervention: information about optimizing fasting times given to parents and staff. Fasting times in 50 children after intervention compared with matched historical controls.	Incidence of hypotension (MAP <40 mmHg, 0 vs. 5) was significantly lower and MAP after induction was significantly higher (55.2 ± 9.5 vs. 50.3 ± 9.8 mmHg, $P=0.015$) as compared to children in the control group.

Table 5 Hunger, thirst and discomfort

Study	Population	Study Design	Comments
1.Schmidt *et al.*[24]	162 children aged 1 to 16 years undergoing elective procedures under general anaesthesia.	Single-centre RCT. Children randomised to 6-4-2 or liberal clear fluid fasting (clear fluids allowed until premedication)	Patients allowed to drink clear fluids until premedication reported less thirst before premedication (14 ± 18 vs. 30 ± 36%; $P=0.030$), and parents were more often satisfied or very satisfied with the clear fluid fasting in the liberal fasting group (81 vs. 55%, $P=0.006$)
2. Schmidt *et al.*[25]	Children, 4 to 12 years, ASA I-II) undergoing elective procedures requiring general anaesthesia	Single centre RCT of fasting according to 6-4-2 or 6-4-1.	There were no significant differences in thirst or hunger scores.
3.Huang *et al.*[23]	344 children < 4 years old with congenital cyanotic heart disease undergoing anaesthesia.	Single-centre RCT. Children randomized to drink 5 ml kg^{-1} glucose in water at 1 or 2 h before anaesthesia induction.	The 1-h fast group showed lower frequencies of crying (40 vs. 51.7%, $P=0.029$), thirst (20.6 vs. 33.3%, $P=0.008$) and hypoxia (5.3 vs. 11.5%, $P=0.039$) compared with the 2-h fast group, but there may be some imprecision in these measurements.

groups.[25] Another RCT reported median fasting time 48 min vs. 3.9 h in the 6-4-0 vs. the 6-4-1 groups.[24] Four observational cohort studies likewise found approximately 50% shorter fasting times when children were allowed clear fluids less than 2 h compared with more than 2 h.[8,9,22,29]

Semi-solids and solids

Recommendation 8: For infants, breast milk feeding should be encouraged until 3 h before anaesthesia. (**1C**)

Evidence summary: Nine observational studies investigated the gastric emptying after breast milk feeds in paediatric patients (five studies with preterm low birth weight patients, three studies with infants and one study with both populations) (Table 8).[30–38] A majority of the studies used a cross-over design to compare gastric emptying of breast milk with other fluids (e.g. clear liquids, fortified breast milk). Three studies found gastric volumes at baseline in under 2 h,[31–33] four studies reported baseline values at 3 h of fasting[34–36,38] and two presented data after 2 h of breast milk fasting.[30,37]

Table 6 Gastric content volume

Study	Population	Study Design	Comments
1.Schmidt *et al.*[24]	162 children aged 1 to 16 years undergoing elective procedures under general anaesthesia.	Single-centre RCT. Children randomised to 6-4-2 or liberal clear fluid fasting (clear fluids allowed until premedication)	No difference in mean gastric content volume, but significantly more patients had a residual gastric volume of more than 1 ml kg^{-1} (30 vs. 13%; $P=0.008$), 2 ml kg^{-1} (15 vs. 1%; $P=0.001$) and 4 ml kg^{-1} (5 vs. 0%; $P=0.038$) in the liberal fasting group.
2. Schmidt *et al.*[25]	Children, 4 to 12 years, ASA I-II) undergoing elective procedures requiring general anaesthesia	Single-centre RCT of fasting according to 6-4-2 or 6-4-1.	No difference in the mean gastric content volume in the two groups but content volume above 1 ml kg^{-1} occurred in 13 (20%) and five (7.6%) children in groups 1 vs. 2 h fasting, respectively ($P=0.039$).
3.Huang *et al.*[23]	344 children < 4 years old with congenital cyanotic heart disease undergoing anaesthesia.	Single-centre RCT. Children randomised to drink 5 ml kg^{-1} glucose in water at 1 or 2 h before anaesthesia induction.	Gastric content in the 1-h fast group was 0.34 ± 0.35 ml kg^{-1} (95% CI: 0.29 to 0.39), smaller than in the 2-h fast group, 0.43 ± 0.33 ml kg^{-1} (95% CI: 0.38 to 0.48; $P=0.011$)

Table 7 Fasting time

Study	Population	Study design	Comments
Schmidt *et al.*[24]	162 children aged 1 to 16 years undergoing elective procedures under general anaesthesia.	Single centre RCT. Children randomised to 6-4-2 or liberal clear fluid fasting (clear fluids allowed until premedication)	Median fasting time was 48 min (range 12 min to 16.3 h) in the liberal fasting group and 3.9 h (range 2 to 18.3 h) in the standard fasting group ($P < 0.001$).
Schmidt *et al.* [25]	Children, 4 to 12 years, ASA I-II) undergoing elective procedures requiring general anaesthesia	Single-centre RCT of fasting according to 6-4-2 or 6-4-1.	Median fasting time 76 vs. 135 min in the 6-4-1 and the 6-4-2 groups respectively
Newton *et al.*[8]	Children admitted to pre-operative ward. Exact number of subjects not stated (several thousand)	Prospective observational study of fasting times, rate of cancellation due to inadequate fasting before and after introducing a 6-4-1 regimen	Mean fluid fasting time decreased from 6.3 ± 4.5 to 3.1 ± 2.3 h with the 6-4-1 regimen.
Andersson *et al.*[29]	130 children (age < 15 years) scheduled for ENT or plastic surgery in two cohorts.	Prospective observational cohort study. Fasting times were recorded before and after transition from 6-4-2 ($n = 66$) to 6-4-0 ($n = 64$) fasting regimens.	Median fasting time for clear fluids were 4.0 h in the 6-4-2 cohort vs. 1.0 h in the 6-4-0 fasting cohort. The incidence of fasting more than 6 h decreased from 33 to 6.3%.
Isserman *et al.*[9]	Children scheduled for general anaesthesia ($n = 16\,000$).	Prospective observational study of fasting times before and after introducing 1 h clear fluid fasting	The proportion of children fasting less than 4 h prior to induction increased from 20 to 63%.
Beck *et al.*[22]	12 093 children undergoing elective or emergency anaesthesia.	Prospective Observational Study of real fasting time and adverse events in 15 centres implementing either the 6-4-2, the 6-4-1 or the 6-4-0 regimen.	The median [range] clear fluid fasting time with the 6-4-0 regimen was 1.8 [0.9 to 3.8] h, 2.5 [1.6 to 5.1] h with the 6-4-1 regimen and 3.7 [2.3 to 11] h with the 6-4-2 regimen; $P < 0.0001$ between all.

Recommendation 9: Fortified breast milk does not delay gastric emptying in a clinically significant manner compared with breast milk and can therefore be encouraged for infants until 3 h before anaesthesia. (**1B**)

Evidence summary: Five studies (all cross-over, four randomised)[31,32,36,38,39] investigated the impact of breast milk fortifier on gastric emptying in preterm, low birth weight infants. All studies suggested that fortifying breast milk does not affect gastric emptying in a clinically concerning manner following breast milk fasting times of 3 h. Table 9 summarises these findings.

Suggestion 10: For infants, formula (or nonhuman) milk may be encouraged until 4 h before anaesthesia. (**2B**)

Evidence summary: Three studies (one observational, one randomised and one double-blinded randomised cross-over)[37,40,41] investigated gastric emptying of formula in preterm newborn infants (Table 10). On the basis of the results, there is evidence that 4 h of fasting after formula can be considered well tolerated.

These are small studies and are not large enough to be confident of the safety in regard to aspiration or regurgitation risk. There was some disagreement amongst the DELPHI group on this recommendation. Several large institutions in Europe have used this 4-h rule for many years and have no increase in aspiration or regurgitation rates (anecdotal).

Recommendation 11: Solid food should be allowed until 6 h before anaesthesia induction. (**1C**)

Suggestion 12: A light breakfast of solids or nonclear fluids may be allowed up to 4 h before anaesthesia induction. (**2C**)

Evidence summary for nonclear fluids: Four studies investigated gastric emptying for specific liquids (Table 11).[34,42–44] Two studies suggest that with the carbohydrate-containing fluids investigated, up to a volume of 10 ml kg^{-1} may be well tolerated to ingest up to 2 h before anaesthesia induction.

Evidence summary for solids ingestion (Table 12): Four studies (two cross-over observational, two observational) investigated the gastric emptying of solids in children: these included two studies with healthy volunteers, one with cerebral palsy patients and one with gastric reflux patients).[45–48] The two studies investigating gastric residual volume (Schmitz *et al.*[45] and Beck *et al.*[46]) showed a return to gastric baseline volumes 4 h after eating. In studies calculating gastric emptying half-time, Braden *et al.*,[47] using scintigraphy, reported a half-time under 90 min and under 60 min in 82% and Brun *et al.*[48] reported mean half-times under 90 min except for a meal with 100% casein protein content (a protein known to be digested slowly). On the basis of the existing data, there is sufficient evidence that 4 h of fasting after a light meal (defined as cereal with milk or buttered toast with jam) is well tolerated in healthy children.

Again, there was disagreement amongst the DELPHI group on this weak recommendation. Although there is a long experience of this regimen in several large institutions in Europe, there are no large audits confirming a lack of increase in aspiration or regurgitation rates. It is

Table 8 Studies on breast milk

Study	Population	Study Design	Comments
Sethi *et al.*[34]	15 healthy children under 5 years of age	Prospective Observational Study comparing gastric emptying time and gastric residual volume with an orange flavoured glucose solution, 3% milk and breast milk.	Gastric emptying time ± SD [range] of 1.53 ± 0.25 [1.00 to 1.75] h for the glucose solution, 2.32 ± 0.31 [1.75 to 2.75] h for milk, and 2.43 ± 0.27 [2.00 to 2.75] h for breast milk.
Litman *et al.*[30]	Eight healthy infants	Observational blinded study	Litman *et al.* postulated 2 h of fasting for breast milk is not well tolerated based on their findings of elevated gastric residual volumes in 33% of the breast-fed infants
McClure *et al.*[31]	22 low birth weight infants	Blinded cross-over study	The gastric antral area evaluated with ultrasound had dropped to 10% of the max area after 100 min in their study, suggesting 2 h of fasting for breast milk is sufficient
Ewer *et al.*[32]	11 consecutively recruited preterm infants	Randomised blinded cross-over study using ultrasound to compare gastric emptying rates of breast milk and fortified breast milk	Gastric antral area on ultrasound returned to baseline after less than 120 min. However, the reported gastric emptying half-time was much lower with 21 min for breast milk, compared with other studies. The median feeding volume of the preterm infants was 19 [range, 15 to 21] ml kg^{-1}
Gridneva *et al.*[33]	27 healthy term babies	Observational study using ultrasound to determine gastric emptying	In almost all cases gastric residual volume returned to baseline after 120 min. Higher feed volumes were associated with longer gastric emptying time and higher residual volumes. The average feeding volume was 14 ml kg^{-1}
Perrella *et al.*[35]	40 preterm infants (33.3 ± 1.4 weeks gestational age	Observational cross over study comparing intra-individual gastric emptying for paired meals of 100 and 75% prescribed volume and identical composition of mother's own milk and pasteurised donor human milk	Perrella reported complete gastric emptying was more common in infants fed at 3-h intervals compared with those fed every 2 h ($P = 0.002$). The feed volumes were 13 [range, 10 to 15] ml kg^{-1} in the 2 h and 20 [18 to 23] ml kg^{-1} in the 3-h group
Yigit *et al.*[36]	20 preterm infants (nine boys and 11 girls) with a birth weight less than 1500 g	Randomised blinded cross-over study determining gastric emptying using ultrasound	Gastric antral area dropped to 10% of the max area after 150 min for breast milk and the average gastric emptying half-time was 49 min
Van Den Driessche *et al.*[37]	29 newborn infants, gestational age 34.5 (range 27 to 41) weeks, weight 2148 g (range 960 to 4100)	Prospective observational study comparing gastric emptying time after breast milk and formula milk	Mean gastric emptying half-time was 47 [range, 16 to 86] min in the breastfed infants vs. 65 [27 to 98] min in the formula-fed infants
Perrella *et al.*[38]	25 preterm infants (14 girls, 11 boys) birth gestation 30.1 weeks [range 28 to 32.9], birth weight 1331g [range 910 to 1910] and postnatal age 21 days [range 10 to 42]	Randomised crossover study	They reported empty stomachs in 83% of cases after 3 h of breast milk feeds ($n = 12$) with residual volume 0.4 ± 1 ml). Empty stomachs were less frequent for 2-hourly feeds (33%), residual volume 1.7 ± 1.6 ml). The feed volumes were 13 [12 to 15] ml kg^{-1} in the 2 h and 19 [18 to 22] ml kg^{-1} in the 3-h group

also worth noting that the definition of a light breakfast may be a challenge to deliver consistently.

Comorbidity, medications and prematurity

With regards to the impact of coexisting disease, medications and prematurity, due to the paucity and low quality of evidence, we were unable to make specific recommendations for any of the populations for which there was only one relevant study.

Suggestion **13**: The presence of gastro-oesophageal reflux disease per se does not necessitate fasting instructions different from those for healthy children. (**2B**)

Evidence Summary: There were eight retrospective/observational studies, and one RCT (Table 13).[49–57] The studies were generally small, with a sample size range of 6 to 108. There was significant heterogeneity in the ages of the studied participants, and many studies recruited patients from a wide age range. All of the studies had a measure of gastric emptying as a primary outcome. There was inconsistency in the findings in the studies regarding the relationship between the presence and severity of gastro-oesophageal reflux disease and gastric emptying measures. Nearly all studies examined outcomes following ingestion of milk, formula or a solid meal. The clinical significance and implications of the studies' findings on pre-operative fasting in children are unclear. The available evidence contained heterogeneous patient populations, small sample sizes and the methodologic quality was low. The findings were inconsistent across studies, and the clinical significance of the observed magnitudes of differences of gastric emptying times or half-times is unclear.

Suggestion 14: Gastric emptying in preterm infants may be slightly prolonged compared with term infants, but the

Table 9 Studies on breast milk fortifier

Study	Population	Study Design	Comments
McClure *et al.*[31]	22 low birth weight infants	Blinded cross-over study	The gastric antral area evaluated with ultrasound dropped to 10% of the max area after about 100 min. The median (range) feed volume was 20 ml kg^{-1} (range 13 to 33). There was no significant difference between breast milk or breast milk with fortifier in the half emptying time (46.0 ± 5.5 vs. 47.2 ± 5.4 min)
Ewer *et al.*[32]	11 consecutively recruited preterm infants	Randomised blinded cross-over study using ultrasound to compare gastric emptying rates of breast milk and fortified breast milk	Similar gastric emptying half-times for fortified breast milk (48 ± 4.0 min). However, the gastric emptying half time they reported for unfortified breast milk was only 21 ± 3.6 min. Median feed volume 19 ml kg^{-1} (range 15 to 21). The gastric antral area after fortified breast milk was back to baseline after 150 min
Yigit *et al.*[36]	20 preterm infants (11 girls and nine boys) with a birth weight less than 1500 g	Randomised blinded cross-over study determining gastric emptying using ultrasound	Average gastric emptying half-times: 49 ± 23, 54 ± 29 and 65 ± 36 min, respectively. The differences between feeding groups were not statistically significant. Gastric antral area was similar after 180 min between all three groups.
Perrella *et al.*[38]	25 preterm infants (14 girls, 11 boys) birth gestation 30.1 [range, 28 to 32.9] weeks, birth weight 1331 [range, 910 to 1910] g and postnatal age 21 [range, 10 to 42] days	Randomised cross over study Infants alternatively fed breast milk without fortifier or with two different fortifiers (S-26 is casein/whey-based, FM 85 to 100% whey) in a randomised cross-over design. Stomach volume calculated from ultrasound scans every 30 min until the next feeding time (which was after 2 or 3 h depending on clinical needs)	After accounting for differences in feeding volume, S-26 fortified feed residuals for 2-h feeds were similar to those of unfortified feeds ($P = 0.179$), and FM 85 fortified feed residuals were significantly higher (average 2 ml higher, $P = 0.015$). Similarly, FM 85 fortified feed residuals were significantly higher (average 1.1 ml higher, $P = 0.040$) for 3-hourly feeds.
Perrella *et al.*[39]	32 preterm infants (13 girls and 19 oys) birth gestation 29.6 [range, 28 to 32.9] weeks, birth weight 1271 [range, 895 to 1860] g and postnatal age 20 [range, 7 to 42] days	Randomised cross over study	Fortification slows gastric emptying minimally and is unlikely to cause clinical concern with regards to feeding tolerance

clinical significance of this is unclear within this guideline's recommendations R8-S10. (**2C**)

Evidence Summary: There were five retrospective/observational studies, and two RCTs (Table 14).[58–64] The studies were generally small with sample size ranging from 7 to 49.

The interventions included cisapride administration and the two randomised control trials included had contradictory findings regarding the effect of cisapride on gastric emptying time.

The study outcome measures included gastric half emptying time in six of the studies and gastric antrum area in

Table 10 Studies on formula milk

Study	Population	Study design	Comments
Van Den Driessche *et al.*[37]	29 newborn infants 34.5 weeks gestational age (27 to 41) and 2148 g (960 to 4100)	Prospective observational study comparing gastric emptying time after breast milk and formula milk	Mean (range) emptying half-time of 65 [range, 27 to 98] min for formula milk
Riezzo *et al.*[40]	36 preterm newborn, 32.2 ± 2.3 weeks gestational age	Randomised trial	Gastric emptying of standard formula or hydrolysed formula (20 ml kg^{-1}, 70 calories 100^{-1} ml, 55.9% carbohydrate, 24.5% fat and 12.9% protein). The median gastric emptying half-time reported was 74 and 66.4 min, respectively. Gastric antral area was similar to baseline after 180 min. There was no difference in gastric emptying between the formulae
Staelens *et al.*[41]	Newborns (age 28 to 40 weeks gestational age)	Double-blinded, randomised cross-over study, using 13C spectrometry to compare gastric emptying of three types of infant formula: intact protein formula (IPF), partially hydrolysed formula (PHF) and extensively hydrolysed formula (EHF).	Consumed volumes of each formula were similar (resulting mean volume 20 ml kg^{-1}). The EHF emptied significantly faster than IPF or PHF, with a median gastric emptying half-time of 46 [interquartile range (IQR), 30 to 58] min vs. 55 [IQR, 52 to 83], and 53 [IQR, 43 to 75] min respectively

Table 11 Gastric emptying of nonclear fluids

Study	Population	Study design	Comments
Song *et al.*[42]	79 healthy children ages 1 to 11 years.	Prospective observational study using ultrasound to evaluate gastric emptying of a carbohydrate-rich drink	After 2 h, there was a significantly decreased gastric volume compared with baseline.
Zhang *et al.*[44]	16 healthy children ages 3 to 7 years	Randomised crossover study comparing gastric emptying of a carbohydrate-rich drink with electrolytes compared with 5% glucose solution	Gastric antral area returned to baseline after 30 min for the 5% glucose solution and after 90 min for the carbohydrate-rich drink with electrolytes.
Du *et al.*[43]	48 healthy children ages 8 to 14 years	Prospective observational study investigating gastric emptying with ultrasound of three liquids: apple juice, 2% milk and high protein drink (Ensure Clear)	The ranges of gastric emptying times were 90 to 180 min for apple juice, 90 to 210 min for milk and 90 to 240 min for Ensure Clear
Sethi *et al.*[34]	15 healthy children under 5 years of age	Prospective observational study comparing gastric emptying time and gastric residual volume with an orange flavoured glucose solution, 3% milk and breast milk.	Mean gastric emptying time ± SD [range] of 1.53 ± 0.25 [1.00 to 1.75] h for the glucose solution, 2.32 ± 0.31 [1.75 to 2.75] h for milk and 2.43 ± 0.27 [2.00 to 2.75) h for breast milk.

the seventh. Two of the studies also evaluated electrogastrography. Three studies suggest that gastric emptying time is longer in early preterm infants and normalises to full term values in later preterm infants.

Suggestion 15: The presence of functional/nonulcer dyspepsia per se does not necessitate fasting instructions different from those for healthy children. **(2C)**

Evidence Summary: There were five retrospective/observational studies, and no RCTs (Table 15). The studies were generally small with sample sizes ranging from 10 to 52 children. The ages of the studied participants ranged between 4 and 19 years. All of the studies had a measure of gastric emptying as a primary outcome. Two studies with a total of 74 individuals found that gastric emptying time for a solid meal is faster in nonulcer dyspeptic patients with *Helicobacter pylori*, but their fasting times differed substantially from each other.[65,66] There were two studies in patients with functional or nonulcer dyspepsia.[67,68] Both studies found slower gastric emptying in patients with functional or nonulcer dyspepsia, but they used different test meals for the individuals: liquid (nonclear, chicken soup), and a solid meal. The remaining study found no change in gastric emptying time for individuals who had been treated with cisapride.[69]

Suggestion **16**: The presence of congenital cardiac disease per se does not necessitate different fasting instructions from those for healthy children. **(2B)**

Table 12 Gastric emptying of solids

Study	Population	Study design	Comments
Schmitz *et al.*[45]	18 healthy children: median age [range], 9.0 [6.8 to 12.2] years	Randomised crossover observational study. Investigating the difference between 4 and 6 h of fasting for a light meal (cereal with milk).	They found similar gastric residual volumes after 4 and 6 h, respectively. Gastric emptying half time was around 90 min for solids
Beck *et al.*[46]	22 healthy children (median age 7.8 years)	Prospective observational study. Investigated gastric emptying after a light breakfast measuring the gastric antral area using ultrasound.	Four hours after intake of the light breakfast (one slice of buttered toast with jam or chocolate spread per 10 kg body weight) the gastric antral area was lower than baseline: median difference (95% confidence interval) -0.54 (-1.00 to -0.07) cm^2, $P < 0.05$.
Braden *et al.*[47]	26 children with typical clinical symptoms of gastro-oesophageal reflux disease: median [range], 9 [4 to 16] years	Prospective observational study. ^{13}C breath test and scintigraphy to evaluate the gastric emptying after intake of semisolid oatmeal (5 g oat flakes and 3 g sugar in 75 ml milk).	The average gastric emptying half time was 45 min, six of 26 patients showed prolonged gastric emptying with an average gastric emptying half-time > 60 min. However, even with a gastric emptying half time of 60 min gastric residual volume should be low after 4 h
Brun *et al.*[48]	15 children with cerebral palsy	Cross-over study. Standardised carbohydrate and fat based meals with four protein sources (100% casein, hydrolysed whey, amino acids and 40% casein/60% whey) were given to the children on four different days via gastrostomy.	All except for the 100% casein protein source showed gastric emptying half-time under 90 min.

Table 13 Gastro-oesophageal reflux disease

Study	Population	Design	Comments
Aktas *et al.*[49]	28 children under 2 years old with GERD symptoms	Prospective observational study	Gastric emptying half time for milk longer in children with high-grade reflux compared with children without reflux or with low-grade reflux (49.1 ± 12.3 vs. 24.0 ± 6.8 vs. 20.5 ± 4.7 min), respectively
Argon *et al.*[50]	108 children ages 3 months to 5 years	Prospective observational study	Gastric emptying half time after ingestion of cow's milk was longer in grade 2 GERD (50 ± 13 min) vs. negative GERD scintigraphy group (39 ± 16 min). When looked at in aggregate, there was no difference between positive GERD group (grade 1 and 2) vs. negative GERD group.
Cunha Cruvinel *et al.*[51]	38 children undergoing oesophagogastroduodenoscopy, mean age 47.7 and 55.5 months in GERD and non-GERD groups, respectively	Prospective observational study	Residual gastric volumes after pre-operative fasting in children with and without GERD were found not to be different
Knatten *et al.*[52]	51 children ages 0.1 to 15.4 years, with and without neurologic injury, presenting for Nissen fundoplication or gastrostomy tube	Prospective observational study	In patients given whole milk after overnight fast, no difference in gastric emptying between healthy patients and patients with GERD. There were widely varying rates of gastric emptying
Livoti *et al.*[53]	52 infants less than 6 months of age with confirmed reflux	Prospective observational study	In infants fed milk formula after a 4 h fast, 20% of GERD patients had a normal gastric emptying time, and 'frankly' delayed emptying was present in 15%
Okada *et al.*[54]	13 children ages 2 to 16 years with GERD, with and without neurologic impairment	Prospective observational study	Study suggests gastric emptying of liquid formula was delayed in children with GERD. Small study; heterogeneous age range, differences between control and neurologically impaired children unclear
Omari *et al.*[55]	30 healthy children ages 2 to 17 years, treated with and without baclofen	Randomised controlled trial	Gastric emptying time and radiolabelled CO_2 excretion was shorter in children that received baclofen; gastric emptying half time in baclofen subjects was 55 (31 to 72) min vs. 90 (60 to 147) min in controls
Pacilli *et al.*[56]	Eight children enrolled, six analysed. Children ages 3.3 ± 3 years presenting for Nissen funduplication	Prospective observational study	Gastric emptying was accelerated following Nissen fundoplication surgery for GERD (59 ± 17 vs. 45 ± 4 min pre and postop, respectively). Very small study
Carroccio *et al.*[57]	24 infants (12 with and 12 without GERD).	Prospective observational study GERD patients had measurements before and after 8 weeks of treatment with cisapride	After milk formula, GERD infants had longer final gastric emptying time compared with normal controls. GERD infants treated with cisapride had gastric emptying time that was not different from the control group

Evidence Summary: There were two RCTs (Table 16).[23,70] One trial compared gastric residual volume following a standard volume of clear liquids 1 or 2 h before induction and found no difference. The other trial evaluated gastric residual volume following a liberalised clear fluid fasting regime (ad lib up to 2 h before induction) and a stricter regime, and found no differences between the two groups.

Suggestion 17: Obesity does not necessitate different fasting instructions from those for normal-weight children. **(2C)**

Evidence Summary: There were two prospective observational studies (Table 17). This recommendation is primarily based on one large prospective observational study of good methodological quality that is directly relevant to pre-operative fasting.[71] A second prospective observational study examining a liquid and solid meal had results whose relevance to standard pre-operative fasting regimes is unclear.[72]

Suggestion 18: The presence of a repaired oesophageal atresia/trachea-oesophageal fistula without documented delayed gastric emptying or oesophageal stenosis does not necessitate fasting instructions different from those for healthy children. (**2C**)

Evidence Summary: There were two prospective studies that included a total of 21 individuals (Table 18).[73,74]

The interventions included administration of a radiolabelled solid meal and assessment of gastric emptying by scintigraphy. One study assessed gastric motility via gastric manometry. No study assessed gastric emptying of clear liquids.

Suggestion 19: Isolated type I diabetes per se does not necessitate different fasting instructions from those for healthy children. (**2C**)

Evidence Summary: There were two prospective studies (Table 19).[75,76] In both studies, a standardised pancake meal was given after an overnight fast. The recommendation is based on two small studies in children with type-1 diabetes that did not demonstrate delayed gastric emptying.

Statement 20: There is insufficient evidence to recommend specific and different pre-operative fasting requirements with respect to the impact of medications or environmental factors.

Evidence Summary: There were two retrospective/observational studies, and five RCTs. Four studies examined cisapride, one study examined oral baclofen, one study

Table 14 Gastric emptying in preterm neonates and infants

Study	Population	Design	Comments
Beck *et al.*[58]	22 stable preterm infants (postmenstrual age 32 to 40 weeks)	Prospective observational study. Gastric antrum area (GAA) was measured for each infant at various time periods following a formula or breast milk meal.	Baseline fasting time (FT) 0 was before first assessment was 194 ± 27 min after last meal and median initial GAA was 0.45 cm^2. At FT1 (60 ± 15 min), median GAA was 2.22 cm^2. At FT2 (138 ± 26 min) median GAA was 0.92. At FT3 (198 ± 16 min) median GAA was 0.57 cm^2 and not significantly different to baseline.
Costalos *et al.*[59]	20 premature infants with gestational age < 32 weeks and birth weight < 1500 g with feeding intolerance	Randomised controlled study	Gastric half emptying time was significantly shorter following cisapride administration: 40.9 ± 18.1 vs. 57.6 ± 16.1 min
Gounaris *et al.*[60]	36 very low birth weight infants, 16 on CPAP, 20 not requiring respiratory support	Prospective observational study	Mean gastric emptying time following milk via OG was 28 ± 12 min for CPAP group and 40 ± 17 min for non-CPAP group
Ramirez *et al.*[61]	Preterm infants born at 25 to 30 weeks gestational age. Study 1 included 10 infants and study 2 included seven infants	Prospective observational study	In preterm infants, independently changing osmolality, volume and energy density had no effect on gastric emptying rate (10 patients). Gastric emptying half time was 18% faster for the combined lower-osmolality/higher volume feed (7 patients). Gastric emptying half time decreased linearly with gestational age (17 patients)
Reddy *et al.*[62]	49 preterm neonates (29 to 34 weeks) during first week of life	Randomised controlled study. Babies were allocated either to cisapride or placebo	No difference in groups in terms of feed intolerance. Gastric emptying time between the groups was not significantly different. 58 ± 32 min in the study group compared to 53 ± 34 min in the placebo group ($P > 0.05$)
Riezzo *et al.*[63]	33 newborns at different gestational ages at birth	Prospective observational study	Preprandial antral area and half emptying time were greater in preterm newborns of 28 to 32 weeks compared with preterm newborns of 32 to 36 weeks and full-term newborns
Riezzo *et al.*[64]	18 healthy preterm infants born at 28 to 36 weeks (mean, 34 weeks), with birth weight >1800 g, normal Apgar score, and postnatal age ≤24 h	Prospective observational study. The half emptying time was calculated at days 3, 7, 15 and 30 after birth in order to evaluate the time changes	There was no significant difference in gastric emptying time over time. Population: 18 healthy preterm infants born at 28 to 36 weeks (mean, 34 weeks), with birth weight >1800 g, normal Apgar score, and postnatal age ≤ 24 h

examined oral acetaminophen, one study examined nizatidine, and one study examined metoclopramide and erythromycin (Table 20).[55,57,59,62,69,77–79] Study outcome measures included gastric emptying time and gastric fluid volume.

Suggestion 21: Gum chewing does not increase gastric fluid volume enough to increase the risk of aspiration, but children should be questioned about the presence of gum in their mouth before anaesthesia induction and, if still present, asked to spit it out. (**2B**)

Table 15 Gastric emptying in functional/nonulcer dyspepsia

Study	Population	Design	Comments
Sykora *et al.*[66]	21 *H. pylori* positive and 26 *H. pylori* negative children	Prospective observational study. Gastric emptying following a solid food meal was compared in using scintigraphy	Gastric emptying was accelerated in H. pylori positive patients: emptying half time 43.6 ± 12.3 vs. 59.6 ± 12.9 min
Strehl Machado *et al.*[65]	27 female patients (mean age 13.38 ± 2.81 years) with functional dyspepsia	Prospective observational study. A C-octanoic breath test was performed after a test meal	Gastric emptying time was shorter in *H. pylori* positive patients compared with *H. pylori* negative patients
Devanarayana *et al.*[67]	41 children age 4 to 14 years, mean 7.5 years	Prospective observational study	Liquid gastric emptying rate and antral motility index were significantly impaired in those with functional dyspepsia compared with controls
Riezzo *et al.*[68]	52 children with nonulcer dyspepsia (NUD) and 114 healthy children	Prospective observational study. Electrogastrography measures were compared in the pre and postprandial periods (solid food, standardised meal)	The NUD/dyspeptic children had a statistically significant slowing of gastric emptying. The NUD children also had altered electrogastrogram patterns. The clinical significance of the delayed emptying finding vis-a-vis anaesthesia fasting is unclear
Riezzo *et al.*[69]	10 children tested at baseline and after 8 weeks of cisapride treatment	Prospective observational study. EGG and ultrasound assessment of gastric emptying were performed for 20 min during fasting and at 30-min intervals for 240 min after a standard solid-liquid meal.	Cisapride changed the EGG. A statistically significant reduction in gastric emptying was not observed after cisapride treatment

Table 16 Gastric emptying and congenital heart disease

Study	Population	Design	Comments
Nicolson *et al.*[70]	101 children presenting for elective cardiac surgery. Control group (strict NPO) 3.3 ± 3.9 years, study group (ad lib to 2 h clear liquids) 3.1 ± 4.1 years	Randomised controlled trial	Both comparator groups had cardiac disease therefore no comparisons relative to patients without cardiac disease can be made. Within children with cardiac disease, the study found no evidence that consumption of clear liquids until 2 h of surgery resulted in adverse effects on residual gastric fluid volume or pH
Huang *et al.*[23]	44 children ages 0 to 3 years with congenital cyanotic heart disease	Randomised controlled trial. 5 ml kg^{-1} of oral glucose water given 1 or 2 h pre-operatively. Gastric contents aspirated after induction of anaesthesia	There were no differences in the gastric residual volume between the two groups

Table 17 Children with obesity

Study	Population	Design	Comments
Chiloiro *et al.*[72]	114 normal weight and obese children ages 6 to 11 years	Prospective observational study. Following a liquid and solid meal, gastric emptying was compared over a 4-h period in normal weight, obese and severely obese children	Severely obese subjects had higher antral areas at three of the eight time points after the meal. The clinical implications of this in a pre-operative fasting setting relative to current guidelines is unclear
Cook-Sather *et al.*[71]	1000 children ages 2 to 12 years presenting for day surgery	Prospective observational study. Gastric fluid volumes measured by orogastric suctioning after intubation.	Gastric fluid volumes were not different between overweight, obese and nonoverweight children. Emesis on induction was not associated with BMI status

Table 18 Gastric emptying and oesophageal atresia

Study	Population	Design	Comments
Montgomery *et al.*[73]	10 children, ages 5 to 10 years with repaired oesophageal atresia compared with 11 healthy controls	Prospective observational study	After a pancake meal gastric emptying time was slower in 10 children with a history of repaired oesophageal atresia. The clinical significance is unclear
Romeo *et al.*[74]	11 adolescents and young adults, ages 13 to 23 years with oesophageal atresia/ trachea-oesophageal fistula	Prospective observational study	Delayed gastric emptying after a solid meal was present in four out of 11 individuals (three out of six adolescents)

Table 19 Gastric emptying and diabetes

Study	Population	Design	Comments
Perano *et al.*[75]	30 adolescents (15 ± 2.5 years) with type 1 diabetes and 20 age and sex- matched controls	Prospective observational study. Gastric emptying was assessed using a ^{13}C-octanoate breath test after a standardised pancake meal	The median [IQR] gastric half-emptying time was shorter in subjects with type 1 diabetes than controls: 78 [61 to 99] min vs. 109 [71 to 124] min, $P = 0.02$]
Porter *et al.*[76]	19 children ages 7 to 15 years with type 1 diabetes and 15 age and sex-matched controls	Prospective observational study. Gastric emptying was assessed using a ^{13}C-octanoate breath test after a standardised pancake meal	The mean gastric emptying half-time in the cases was 99 ± 52.1 vs. 103 ± 27.5 min in the controls ($P = 0.8$)

Evidence summary: One meta-analysis based on four RCTs (among which one was paediatric) suggests that chewing gum during the pre-operative fasting period neither increases gastric volume to a clinically significant degree nor changes gastric pH (Table 21).[80,81]

Suggestion 22: Children on enteral tube or gastrostomy feeding should be fasted before anaesthesia according to the same guidelines as other children and according to the consistency and caloric content of the food administered (clear fluid, milk, thick semi-solid fluid). (**2C**)

Evidence summary: We detected one observational study in 34 children 1.4 to 5.6 years old who underwent laparoscopic gastrostomy.[82] The authors reported that the median gastric half emptying time increased from 45 to 71 min three months after the gastrostomy ($P = 0.03$). The longest emptying times were observed

Table 20 Influence of pharmacologic agents

Study	Population	Design	Comments
Omari *et al.*[55]	30 children 2 to 17 years old with GERD	Randomised controlled study. Children received either a single oral dose of baclofen or placebo. Lower oesophageal relaxation, oesophageal pH and gastric emptying were assessed using manometry and a radiolabelled breath test following two full-cream milk drinks	Gastroesophageal reflux was reduced in the baclofen group. Gastric half-emptying time and was shorter in subjects receiving oral baclofen
Carroccio *et al.*[57]	24 infants ages 3 to 13 months, 12 with GERD and 12 normal controls	Prospective observational study. Infants with GERD were treated with oral cisapride for 8 weeks. Controls without cisapride. Blinded observer assessed gastric ultrasound	No difference in gastric emptying between cisapride-treated GERD patients and healthy controls
Costalos *et al.*[59]	20 infants with birth weight < 1500 g born at < 32 weeks gestation	Randomised controlled study. Gastric emptying time calculated from ultrasound antral area measurements in two groups of infants-one receiving oral cisapride and the other placebo	Gastric emptying time was shorter in infants receiving cisapride
Reddy *et al.*[62]	49 preterm infants born at 29 to 34 weeks gestation	Randomised controlled study. Gastric emptying time between infants treated with cisapride compared with placebo	No difference in gastric emptying times observed
Riezzo *et al.*[69]	10 children ages 4 to 14 years with nonulcer dyspepsia	Prospective observational study. Gastric emptying and electrogastrogram assessed at 20-min intervals following a standard solid-liquid meal, before and after 8 weeks of cisapride treatment	A statistically significant reduction in gastric emptying was not observed after cisapride treatment
Burke *et al.*[77]	37 healthy children ages 1 to 14 years undergoing MRI	Randomised controlled study. Children randomised to oral acetaminophen (mean volume 8.55 ml) 1 h prior to induction of anaesthesia or fasting. Gastric volume and pH were measured immediately after intubation	Gastric residual volume between the two groups was not statistically different
Mikawa *et al.*[78]	104 healthy children, ages 4 to 11 years (4 groups of 26), presenting for anaesthesia and surgery	Randomised controlled study. Each child ingested 10 ml kg^{-1} apple juice 3 h before the estimated anaesthesia induction time after an overnight fast. Four groups based on administration of drug the night before and morning of surgery: Placebo/Placebo, Placebo/Nizatidine, Nizatidine/Placebo, Nizatidine/Nizatidine	pH higher in patients who received Nizatidine on the morning of surgery, regardless whether an evening dose was also given. Gastric fluid vol (orogastric suction) was less for children who received nizatidine on morning of surgery, but still greater than 0.4 ml kg^{-1} on average. Residual GFV too low for aspiration in 23/104 patients (not further described)
Zatman *et al.*[79]	80 children ages 4 to 15 years undergoing tonsillectomy	Randomised controlled study. The effects of premedication with metoclopramide compared with erythromycin were compared. No control group	There was no difference in gastric volume after induction/intubation

pre and postoperatively in the neurologically impaired patients.

Gastric ultrasound

Suggestion 23: Ultrasound assessment of gastric contents and volume may be used in children scheduled for elective surgery when fasting instructions have not been applied and in children undergoing emergency surgery. (**2C**)

Evidence summary: Prospective observational studies performed in volunteers and in children scheduled for elective surgery reported that ultrasound examination of gastric antrum with qualitative, quantitative or both

Table 21 The impact of gum chewing

Study	Population	Design	Comments
Ouanes *et al.*[80]	Four RCTs with a total of 287 individuals (46 children)	Meta-analysis of four randomised controlled trials Gum chewing for 20 to 240 min before anaesthesia, gum removed at 0 to 30 min before induction	Gum chewing increased GFV: mean difference between gum chewing and controls = 0.21 (95% CI, 0.02 to 0.39) ml kg^{-1}. No effect on gastric pH: mean difference = 0.11 (95% CI, -0.14 to 0.36). No significant difference between sugared and sugarless gum. Significance of GFV difference unclear as gastric clear fluid volume is not a defined risk factor for pulmonary aspiration
Schoenfelder *et al.*[81]	46 healthy children 5 to 17 years of age undergoing elective outpatient surgery	Randomised controlled study. Three groups of children: no chewing gum, sugared, or sugarless chewing gum. Intervention (chewing) for 30 min before induction. Gastric suctioning after induction	GFV lower in children without chewing gum: 0.35 [IQR, 0.2 to 0.5] ml kg^{-1}) compared with 0.88 [0.6 to 1.4] ml kg^{-1} and 0.69 [0.4 to 1.6] ml kg^{-1} for sugared and sugarless gum respectively, $P = 0.0001$. Neither differences in GFV nor pH were clinically relevant.

Table 22 The use of gastric ultrasound in clinical situations

Study	Population	Design	Comments
Bouvet *et al.*[83]	200 children scheduled for elective surgery	Prospective observational study	1 (95% CI, 0.2 to 3.9)% of children had solid contents or clear fluid volume > 1.25 ml kg^{-1}
Desgranges *et al.*[84]	66 children scheduled for elective ear, nose and throat surgery	Prospective observational study	All children had low gastric contents and volume (<1.5 ml kg^{-1})
Spencer *et al.*[88]	100 children undergoing elective upper gastrointestinal endoscopy	Prospective observational study	91/100 children had Grade 0 or 1 antrum and volume of fluid content significantly < 1.5 ml kg^{-1}
Van de Putte *et al.*[90]	33 adults and four children	Retrospective cohort study	When fasting instructions were not followed, the rate of increased gastric contents was 62%. Gastric ultrasound led to changed risk assessment and anaesthetic management in 24/37 (65%) patients
Gagey *et al.* [86]	143 children undergoing nonelective surgery	Prospective observational study	Pre-operative ultrasound assessment of gastric contents led to change the planned induction technique in around 50% of children. The incidence of increased gastric content volume (thick fluid, solid content or fluid volume > 0.8 ml kg^{-1} was 46%,
Leviter *et al.*[87]	107 children undergoing nonelective procedural sedation	Prospective observational study	74/107 (69%) children undergoing nonelective procedural sedation had solid contents or calculated fluid volume > 1.2 ml kg^{-1}
Gagey *et al.*[92]	34 infants undergoing pyloromyotomy	Prospective observational study	Ultrasound monitoring useful to appropriately guide the choice of the anaesthetic induction technique. It allowed a nonrapid sequence induction technique to be used in 30/34 (88%) infants with an empty stomach

qualitative and quantitative analyses, was conclusive in 88 to 98% of children for the identification of increased or low gastric content and volume (Table 22).[83–88]

In two studies investigating gastric content volume and fasting duration, the median fasting duration ranged from 5.8 to 13 h and some children were still found to have residual gastric content.[86,87] These results are supported by studies performed in adults undergoing nonelective surgery, which reported rates of increased gastric contents and volume ranging from 35 to 56%, without any association between fasting time and gastric content status.[89,91,92]

In order to perform the correct induction sequence appropriate to the risk of aspiration, three observational studies in children undergoing nonelective procedures assessed the change in the planned induction technique (either rapid sequence vs. routine inhalational or intravenous) when it was guided by the ultrasound assessment of gastric contents.[86,87,92]

Suggestion 24: Cross-sectional area (CSA) of the antrum can be used as the surrogate parameter of choice for gastric content. Sonographic images of the antrum can most reliably be taken in right lateral decubitus position, using a defined protocol. (**2B**)

Evidence summary: Eleven prospective cohort studies with a total population of 503 compared GUS to a second method of measurement of gastric content (Table 23).[86,88,93–101] CSA of the antrum was used as surrogate parameter in 2-D ultrasound scans, either being compared to gastric volumes or being used to calculate gastric emptying half-time through repeated measurements. Out of these studies, four used suctioning (endoscopically controlled/blind) of gastric contents, which showed the best correlation between gastric volume and CSA. A further three studies compared GUS CSA with MRI and one with computed tomography (CT) scans.

Suggestion 25: Qualitative grading systems are preferred over calculating gastric volumes. A trained examiner can use qualitative interpretation of sonographic imaging to differentiate solids from fluids as well as larger volumes from smaller ones. (**2B**)

Evidence summary: Five studies (two randomised clinical trials, three prospective cohort studies) transforming sonographic measurements into clinical grading systems (Table 24). These allow straight forward clinical decisions by integrating complex data into grading systems.

In addition to the aforementioned studies using mathematical models, three prospective cohort studies found a positive correlation between age and gastric volume (in adult and paediatric populations). A mathematical model including weight to calculate gastric volumes was found to show inferior correlation compared with a model using age (Table 24).[86,88,95,97,102–104]

Postoperative fasting

Recommendation 26: Unless contraindicated, an early and liberal postoperative fluid intake should always be encouraged in children. (**1B**)

Evidence Summary: Five RCTs and three randomised cohort studies investigated the effects of either liberal, mandatory or restricted oral fluid intake.

In summary, a liberal postoperative fluid intake in accordance with the children's own needs was found to increase the postoperative well being [105,106] with less

Table 23 Studies investigating the validity of gastric ultrasound estimation of gastric content volume

Study	Population	Design	Comments
Schmitz *et al.*[93]	16 children aged 9.2 (6.4 to 12.8) years	Prospective cohort study	Correlations between Gastric antral area (GAA) and total gastric volume corrected for body weight or gastric fluid volume corrected for bodyweight in children were best in the right lateral decubitus position ($r = 0.79$; $P < 0.01$ and $r = 0.78$; $P < 0.01$) using MRI as control.
Schmitz *et al.*[94]	18 children aged 9.8 (8.8 to 12.2) years	Prospective cohort study Comparison of GCV assessed by US in different patient positions for measuring CSA, using magnetic resonance imaging (MRI) as reference.	R between CSA and GCV was 0.76 (95% CI, 0.76 to 1) and 0.57 (95% CI, 0.41 to 0.88) for the RLD and SUBE positions, respectively
Perlas *et al.*[95]	108 adult patients (19 to 82 years) undergoing gastroscopy	Prospective cohort study Right lateral CSA was measured by a blinded sonographer and volume of fluid calculated.	GCV from gastric US was correlated with gastric fluid suctioned under gastroscopic vison. (Pearson's correlation coefficient $R^2 = 0.731$
Bouvet *et al.*[96]	108 adults (49 ± 18 years)	Prospective cohort study Relationship between the antral area and the volume of aspirated gastric contents was analysed, performance of ultrasonographic measurement of antral area for the diagnosis of 'at risk stomach'.	Correlation coefficient 0.72, diagnosis of 'at risk stomach' with sensitivity of 91% and a specificity of 71%. AUC ROC for the diagnosis of 'at risk stomach' was 90%
Spencer *et al.*[88]	100 children aged 11 to 216 months	Prospective cohort study investigating the relationship between gastric antral CSA and endoscopically suctioned volume.	Gastric antral CSA correlated with total gastric volume in supine ($\rho = 0.63$) and right lateral decubitus ($\rho = 0.67$) positions. Increasing gastric antral grade (0 to 2) was associated with increasing gastric fluid volume.
Gagey *et al.*[86]	143 children aged 2 months to 16 years	Prospective cohort study Predicting a stomach at risk for aspiration by measuring antrum cross sectional area, controlled by suctioning contents through a gastric tube	Sensitivity of 94% (95% CI, 84 to 98), specificity of 83% (95% CI, 71 to 91), negative predictive value 93% (95% CI, 82 to 98), positive predictive value 85% (95% CI, 74 to 92)
Manini *et al.*[97]	35 adults and adolescents	Prospective cohort study	Comparison of 3D-GUS witch SPECT found an average difference of less than 100 ml in volume measurements
Okada *et al.*[98]	39 adults aged 34 to 68 years	Prospective cohort study Comparison between gastric content volumes measured with US and CT, determination of 'high risk stomach' from antral CSA measurements.	Spearman rank-order correlation 0.420 ($P = 0.01$), sensitivity 85%, negative predictive value 53%, AUC ROC = 0.670 ($P = 0.03$)
Gentilcore *et al.*[99]	10 adults aged 23.5 ± 1.5 years	Prospective cohort study Measurements of gastric emptying by scintigraphy and 3D ultrasonography after ingestion of 500 ml beef soup or 300 ml dextrose labelled with 20 MBq 99mTc-sulphur colloid.	Close correlation between the ScT50 and UT50 for both soup ($r = 0.92$, $P = 0.0005$) and dextrose ($r = 0.88$, $P = 0.0007$)
Liu *et al.*[100]	20 adults aged 25.5 ± 2.5 years	Prospective cohort study Concurrent measurements of gastric emptying by scintigraphy and 3D ultrasound were performed after ingestion of 350 ml of a cellulose-based gastric contrast agent (TUS-OSCA) labelled with 20 MBq 99mTc-sulfur colloid.	Good correlation between the gastric 50% emptying times determined by scintigraphy (89.4 ± 1.8 min) and TUS-OSCA (92.5 ± 1.7 min). Correlation coefficient r 0.922 ($P = 0.000$)
Buisman *et al.*[101]	14 adults, median age 27 [range, 21 to 32] years	Prospective cohort study Comparison of gastric volume measured by 3D matrix ultrasound compared to dynamic MRI.	Correlation for gastric content volume $r = 0.998$ and for total gastric volume $r = 0.995$

opioid,[107] an equal or lower incidence of vomiting[105–112] and a shorter postanaesthesia care unit or hospital stay (Table 25).[107,108,110] On the contrary, the postoperative vomiting incidence was found to be increased when children were forced to drink.[108]

Final remarks and discussion

We developed new guidelines on pre-operative fasting in children. For healthy children, the authors conclude that the new 6-4-3-1 regimen (6 h for solids, 4 h for formula and nonhuman milk, 3 h for breast milk, 1 h for clear fluids) can be safely recommended. The list of suggestions and statements, obtained through Delphi consensus, is primarily aimed at helping clinicians to develop institutionally approved fasting protocols, including 'special' cases.

The driving force to update the previous guidelines was the increasing body of evidence of unnecessarily

Table 24 Gastric ultrasound for estimation of gastric content in clinical situations

Study	Population	Design	Comments
Kruisselbrink *et al.*[102]	40 adults (37 ± 10 years)	Randomised clinical trial. Antral ultrasound in fasted individuals and after ingesting either clear fluids (250 ml of apple juice) or a solid meal (one muffin and a cup of coffee with cream)	Ultrasound had a sensitivity of 1.0 (95% CI, 0.925 to 1.0), a specificity of 0.975 (95% CI, 0.95 to 1.0), a positive predictive value of 0.976 (95% CI, 0.878 to 1.0) and a negative predictive value of 1.0 (95% CI, 0.92 to 1.0)
Mackenzie *et al.*[103]	45 adults (median 32 years)	Randomised clinical trial. Test performance of emergency physician ultrasound for the identification of gastric contents in randomised individuals after fasting for at least 10 h or consuming 50 g of carbohydrates and 300 ml of water	Very good inter-rater agreement for the overall interpretation ($\kappa = 0.64$, 95% CI, 0.5 to 0.78)
Moser *et al.*[104]	100 patients (11 to 216 months) (Cohort from Spencer *et al.* 2014)	Prospective observational study. Sensitivity and specificity of a single CSA cut-off measurement in supine and right lateral decubitus positions in paediatric patients	CSA cut-off measurement of 3.07 cm^2 in the RLD position has 76% sensitivity and 67% specificity in the ability to discriminate an empty antrum
Spencer *et al.*[88]	100 children (11 to 216 months)	Prospective cohort study	Gastric antral CSA correlated with total gastric volume in supine ($\rho = 0.63$) and RLD ($\rho = 0.67$) positions. Mathematical best-fit model to predict gastric volumes RLD CSA and age ($R^2 = 0.60$). Increasing gastric antral grade (0 to 2) was associated with increasing gastric fluid volume.
Gagey *et al.*[86]	143 children 2 months to 16 years	Prospective cohort study. Predicting a stomach 'at risk' of aspiration by measuring antrum cross-sectional area. Controlled by suctioning contents through a gastric tube	Sensitivity 94 (95% CI, 84 to 98)%, specificity of 83 (95% CI, 71 to 91)%, negative predictive value 93 (95% CI, 82 to 98)%, positive predictive value 85 (95% CI, 74 to 92)%
Perlas *et al.*[95]	108 adult patients (19 to 82 years)	Prospective cohort study. Patients randomised to ingest one of six predetermined volumes of apple juice after an 8-h fasting period. A cross-sectional area of the antrum in the right lateral decubitus position (Right lat CSA) was measured by a blinded sonographer	A new best fit mathematical model to predict gastric fluid volume based on measurements of Right lat CSA was presented
Manini *et al.*[97]	35 adults and adolescents	Prospective observational study	Comparison of 3D-GUS witch SPECT found an average difference of less than 100 ml in volume measurements. Large coefficients of variation reflect the learning stage of operators

prolonged and potentially harmful fasting times in children, and recent studies suggesting safety with liberalised fasting regimens that result in shorter fasting times. Sufficient evidence (Grade 1) was found to recommend a minimum fasting time of 1 h for clear fluids and three hours for breast milk. There was weaker (Grade 2) evidence to suggest the option of allowing a light breakfast four hours before anaesthesia induction in children. Several specific patient factors and conditions for which clinicians may need guidance were also addressed.

Recommendations that did not reach full agreement in the final discussion were R8 concerning breast milk allowed until 3 h prior to anaesthesia, S10 concerning infant formula allowed until 4 h before anaesthesia and S12 concerning a 'light breakfast' 4 h before anaesthesia. One task force member argued that milk fortifiers and the variation in composition of available infant formula products could lead to some children having solid-type residual gastric contents due to reduced fasting intervals. Three members were concerned that allowing solids up to 4 h before anaesthesia could put children at risk of aspiration.

For some time, several centres in Europe have allowed a 'light breakfast' of, for example, buttered toast with jam or cereals with milk four hours before anaesthesia. There is, however, a lack of evidence to recommend less than a 6-h fasting interval for solids or nonclear fluids such as milk and protein-enriched fluids.

During the Delphi process, the panel voted for issuing an expert opinion after considering the arguments in a pro and con fashion. The main argument for allowing a light breakfast 4 h before anaesthesia is to increase the well-being of children scheduled for anaesthesia in the afternoon. Several paediatric centres in Europe have successfully implemented this practice without experiencing an increase of aspiration events during anaesthesia. Examples of light breakfast protocols are supplied in Appendix 6, http://links.lww.com/EJA/A620.

The main arguments against reducing the fasting interval for solids are:

(1) As long as children are allowed clear fluids to drink, they will not suffer the negative

Table 25 Postoperative fluid intake

Study	Population	Design	Comments
Radke *et al.*[105]	147 children, 4.8 ± 2.6 years scheduled for outpatient surgery	Randomised controlled study. Children randomised to liberal intake of food and drink or fasting for 6 h.	Liberal postoperative fluid intake was found to increase the postoperative well being
Yin *et al.*[106]	2000 children	Randomised controlled study. Early postoperative fluid intake $<5\,ml\,kg^{-1}$ vs. delayed fluid intake (4 h postoperatively)	Liberal postoperative fluid intake was found to decrease thirst, increase satisfaction, with equal incidence of vomiting.
Chauvin *et al.*[107]	231 children, 6 months to 4 years	Randomised controlled study. Liberal intake group offered apple juice $10\,ml\,kg^{-1}$	Early postoperative fluid intake was associated with a reduction in opioid use, vomiting and length of PACU stay
Schreiner *et al.*[108]	989 children, 1 month to 18 years	Randomised controlled study. Children randomised to mandatory or free drink before discharge	In the day surgery unit, only 14% of the elective drinkers vomited compared to 23% of the mandatory drinker group ($P < 0$ 0.001)
Mercan *et al.*[109]	237 children, 2 to 7 years	Randomised controlled study. Children randomised to clear fluid intake 1 or 2 h after emergence and randomised to drinks at room or body temperature.	Lower incidence in POV when the offered fluids were heated to body temperature
Messner *et al.*[110]	200 children undergoing tonsillectomy	Randomised cohort study. 100 children required to drink $20\,ml\,kg^{-1}$ before discharge, 100 children allowed free clear fluids	Shorter PACU or hospital stay after a liberal postoperative fluid intake
Tabaee *et al.*[111]	93 children, 2 to 12 years undergoing adeno-tonsillectomy	Randomised controlled study. Children either encouraged to drink 240 ml clear fluids or allowed clear fluids.	The incidence of emesis was higher in both the encouraged (41 vs. 14%) and voluntary group (40 vs. 26%) when the goal volume of 240 ml was reached.
Kearney *et al.*[112]	317 children undergoing day surgery	Randomised cohort study. Children randomised by cohort to either drink or withhold oral fluids 4 to 6 h postoperatively	Lower POV incidence in a restrictive compared with a liberal group but several confounding factors make the implications unclear

PACU, postanaesthesia care unit; POV, postoperative vomiting.

consequences of long fasting such as dehydration, hunger and thirst;

(2) A guideline must consider both cultural differences and individual food habits, which may pose a risk for some children ingesting large quantities of food if allowed, leading to gastric content of residual solids after 4 h;

(3) Aspiration of solids is more dangerous than aspiration of clear fluids, as they may cause lung injury *and* obstruct the airway.

(4) The interindividual variability of gastric emptying implies that some children having even a 'light' breakfast will not have an empty stomach after 4 h.[83,86,113,114] There is a paucity of safety studies with adequate sample sizes.

However, the panel agreed that institutions that have established a local protocol allowing a light breakfast could continue this practice (Appendix 6, http://links.lww.com/EJA/A620). These local protocols require a clear definition of a light breakfast, precise instructions to patients and/or parents, and ensure detailed questioning of the last oral intake. There should preferably be audits for the incidence of aspiration and regurgitation.

Before induction each child should be asked about volume, timing and type of food ingested. Furthermore, children with extreme eating habits are neither covered by the 6-h rule for solids nor the 4-h rule for nonclear fluids. Very large or fatty meals may take longer than 6 h for complete gastric emptying. When in doubt, the safest management plan should be used, including cancelling the case if necessary.

The literature review revealed large gaps in the evidence regarding pre-operative fasting in children. Although randomised controlled studies of safety regarding the risk of pulmonary aspiration may be difficult to perform, large cohort studies, if possible multicentre and international, would contribute to the evidence base. The authors recommend that paediatric anaesthesia practice is continuously audited regarding safety and peri-operative adverse events. This is especially so when more liberal fasting regimes are implemented. Large-scale observational studies are also needed to confirm the present guideline's expert opinion recommendations regarding the influence of comorbidity and the impact of specific medications. Large data sets, utilising the ever more common electronic patient records, will doubtlessly help in this endeavour.

In addition, there is much research needed to increase the understanding of well tolerated limits for intake of solids and milk-based products. Observational and even randomised controlled studies of gastric emptying of food with different caloric content or other characteristics could be designed to make it possible to liberalise fasting for nonclear fluids and food in future updates of this guideline. More research is needed to establish a better definition of a light breakfast, including an estimate of its caloric/fat content.

Furthermore, the benefits of ultrasound-guided anaesthetic strategy on patient outcome in terms of both reducing the frequency of pulmonary aspiration of gastric contents and the complications related to rapid sequence induction in children have not been assessed. Further research is required to make specific recommendations regarding the quality of data acquired with GUS and the use of GUS in clinical decision making.

The main goal of previous and the present guidelines for pre-anaesthetic fasting was to reduce the risk of aspiration. Whatever the fasting regimen followed and the child's actual fasting time, we should keep in mind that the risk of regurgitation or aspiration is present in any sedation/general anaesthesia procedure, and the risk is increased in emergency cases and in any child with gastrointestinal obstruction. Other major causes of regurgitation or aspiration at the time of induction are inadequate anaesthesia depth or airway problems; anaesthesiologists must be trained to recognise and manage these rare events adequately.

Addendum: during the publication process for this guideline, additional publications supporting some of the recommendations and suggestions have been published.[115,116]

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