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REVIEW

Fasting in pediatric anesthesia: the art of making simple things complex

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Abstract

Prolonged preoperative fasting times for children scheduled for general anesthesia and surgery continue to be reported despite a plethora of recent studies suggesting that fasting for clear fluids can be shortened without increasing the risk of pulmonary aspiration. The aim of this narrative review was to summarize knowledge about the known benefits and potential consequences of prolonged fasting in pediatric anesthesia and to discuss the difficult implementation of reduced fasting times in clinical practice. This narrative review is based on fifteen studies published in the databases PubMed, EMBASE and Cinahl from October 2009 to June 2020. Outcome measures assessed were divided into 4 overall domains: metabolism and hemodynamics (1), patient comfort and patient/parent satisfaction (2), gastric volume and/or emptying time (3) and risk of pulmonary aspiration (4). While incidences of pulmonary aspiration remain low after implementation of less restrictive recommendations, the duration of fasting times relates to negative outcomes (low post-induction blood pressure, increase of blood ketones, poor patient/parent satisfaction). Preoperative fasting times must balance the risk of aspiration during anesthesia against children's wellbeing and metabolic homeostasis. Based on the current evidence on preoperative fasting in children, liberal fasting times with nil-per-mouth for solids and formulas, breast milk and clear fluids corresponding to 6, 4 and 1 hours respectively, are safe. However, a reduction in real fasting times is pending and requires a multifactorial approach.

Keywords

Children; Preoperative fasting; General anesthesia

1. Introduction

In children, regurgitation of gastric content to the lower airways (= pulmonary aspiration) may cause hypoxia or respiratory insufficiency, and is hence a serious but rare event with reported incidences of 0.6–9.3/10,000 [1, 2]. In order to prevent PA, preoperative fasting of 6 hrs for solids and formulas, 4 hrs for breast milk and 1 hr for clear fluids is recommended, and endorsed by many societies (e.g., the Association of Paediatric Anaesthetist of Great Britain and Ireland (APAGBI), the European Society for Paediatric Anaesthesiology (ESPA) and L'Association des Anesthésistes-Reánimateurs Pédiatriques d'Expression Française) [3–5]. In clinical practice, however, it has proven difficult to comply with these recommendations and prolonged fasting times are repeatedly reported [6, 7]. This may come as a surprise, since eating and drinking are basic human instincts. Inherently, it should be an easy task to satisfy the natural cravings of children. However, even at our own institution, a tertiary hospital with an annual case load of 4500 children undergoing anesthesia, we continuously fail to reduce preoperative nil-per-mouth durations. Just recently, we audited the fasting times of all children aged 0–16 yrs. Scheduled to undergo elective (n = 47) and acute (n = 26) orthopedic interventions. During five consecutive weeks from September 7th 2020, fasting times of these 73 children for clear fluids (mean = 4.2 hrs) and solids (mean = 13.9 hrs) were registered (**Supplements 1 and 2**). In this small sample, only eight children complied with the current recommendations of clear fluids up to one hour prior to anesthesia induction, while five children received solids less than 7 hrs before. Obviously, these results leave room for improvement. At the same time, patient safety must be ensured. The objective of this narrative review was to obtain a broad perspective on current knowledge about the known benefits and potential consequences of prolonged fasting in pediatric anesthesia. Based on this it will be discussed, why reduction of real fasting times in clinical practice remains a challenge.

2. Material and methods

Studies investigating the effect of fasting prior to elective surgery on children were identified non-systematically searching the databases PubMed, EMBASE and Cinahl, with the

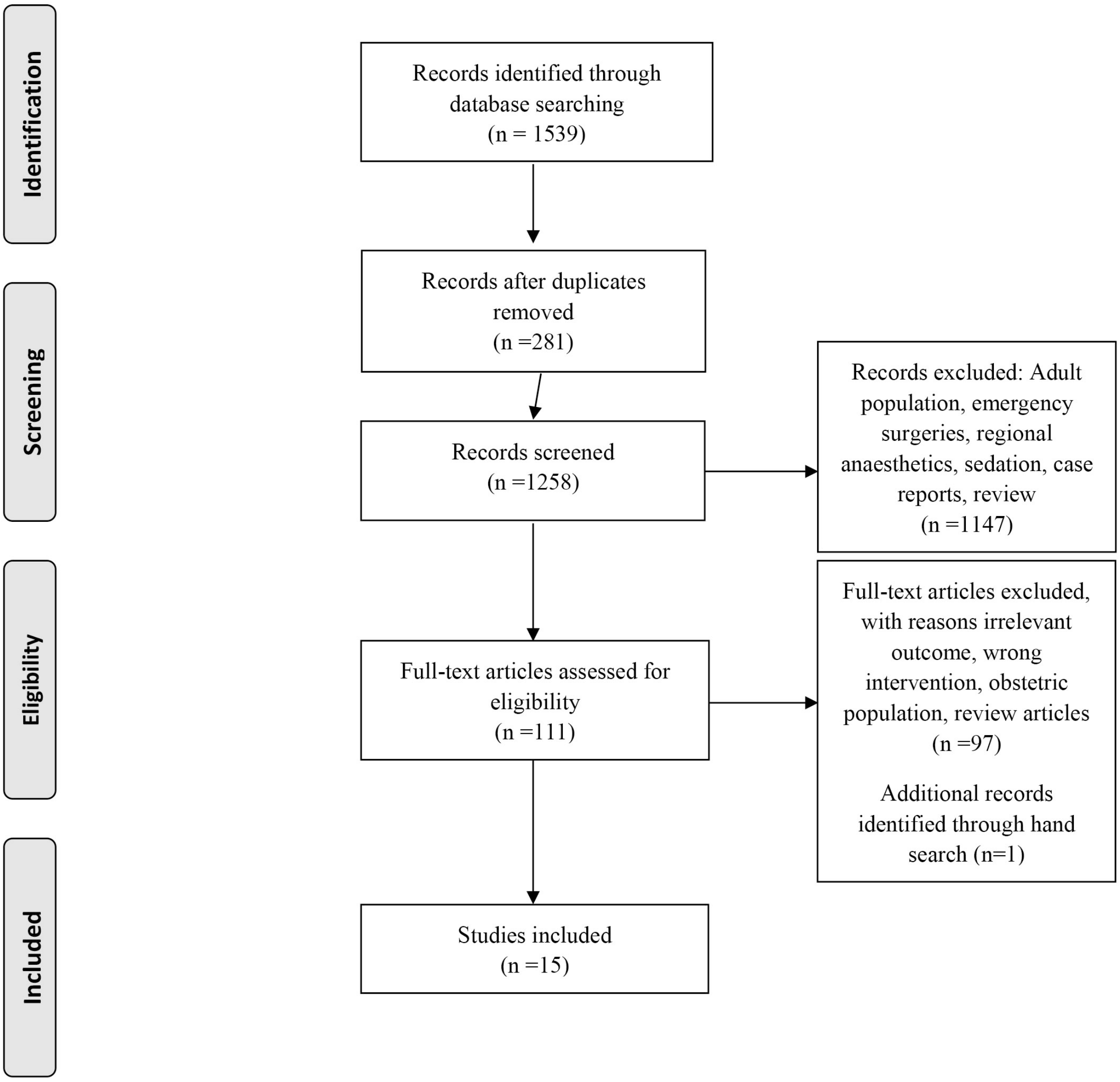

FIGURE 1. Selection of studies — flowchart.

last search conducted on February 27th, 2021. Search terms are provided in **Supplement 3**. After approval by one author (NGC), first author (NBV) conducted the literature search in accordance with recommendations made by the Librarians at the University of Southern Denmark, Odense. Study screening and selection is illustrated in Fig. 1. Articles were not restricted to English language or publication date. Articles addressing adult populations, emergency surgeries, studies on procedures not performed under general anaesthesia (use of regional anesthesia or sedation only) were considered not relevant.

Based on the selection of studies, a schematic summary was completed, listing for each title the year and country of publication, study design, sample size, age and classification according to American Society of Anesthesiologists physical status, indication for general anesthesia and outcome measure assessed.

3. Results

Data extraction was based on 15 studies (Table 1, Ref. [2, 7–19]). These include studies on children ranging in age from preterm neonates at 28 weeks gestation to 18 years. Overall, the studies originated from five different countries published from 2009 to 2020. Ten studies were designed as prospective observational trials; the remaining study designs were retrospective observational (one study), two randomized controlled trials, and one systematic review and meta-analysis, respectively. The annual publication rate has increased over time, with ten out of fifteen studies published in the last five years.

Outcome measures were divided into 4 overall domains: metabolism and hemodynamics (1), patient comfort (2), gastric volume and/or emptying time (3) and risk of pulmonary aspiration (4). All the studies assessing gastric volume (GV) or mean gastric emptying (GE) time used ultrasound and children were examined in the right lateral decubitus position, ensuring

TABLE 1. Summary of study characteristics.

Study ID	Study design	Study size/number of exposed	Non-exposed controls	Age and ASA* classification	Exposure/Intervention	Outcome measures
Country of origin, publication			Yes/no			
(1) Metabolism and hemodynamics						
Simpao *et al*. USA 2020 [9]	Retrospective cohort study, based on patient charts	n = 15,543	No	≤18 yrs ASA I – IV	Clear fluid fasting as per protocol	Low systolic blood pressure
Dennhardt *et al*. Germany 2016 [8]	Observational prospective cohort	n = 100	Yes	≤36 months ASA I, II, III	Preoperative fasting as per protocol (6/4/2) compared to optimized fasting times regime	Ketone bodies, hypotension, MAP[1], glucose, lactate, bicarbonate, base excess, anion gap
(2) Patient comfort						
Engelhardt *et al*. UK 2011 [11]	Observational prospective cohort	n = 1350	No	≤16 yrs	Preoperative fasting as per protocol	Subjective feeling of hunger and thirst; real fasting times
(3) Gastric volume and/or emptying time						
Beck *et al*. Germany 2020 [15]	Observational prospective cohort	n = 24	No	4–16 yrs ASA I, II, III	Overnight fasting of solids, drinking allowed 2 hrs prior to induction	GAA[3], GE[5]
Andersson *et al*. Sweden 2019 [13]	Observational prospective, cohort	n = 20	No	≤6 yrs ASA I, II, III	Free intake of gruel or yoghurt 4 hrs prior to anaesthesia induction	GAA[3], GV[4]
Beck *et al*. Germany 2019 [17]	Observational prospective non-interventional cohort	n = 22	No	Postmenstrual age 32 to 40 weeks Respiratory and circulatory (stable)	Preoperative fasting of breast milk or formula as per protocol	GAA[3], GE[5]
Beck *et al*. Germany 2018 [14]	Observational prospective, cohort	n = 22	No	≤13 yrs Healthy children	One slice of buttered toast with jam or chocolate spread pr. 10 kg	GAA[3], GE[5]

TABLE 1. Continued.

Study ID	Study design	Study size/number of exposed	Non-exposed controls	Age and ASA* classification	Exposure/Intervention	Outcome measures
Country of origin, publication			Yes/no			
Schmidt *et al*. Switzerland 2018 [10]	RCT**	n = 162	Yes	≤16 yrs ASA I, II	Preoperative fasting of clear fluids	Gastric pH, GV[4], blood gas analysis, patient behaviour
Sümpelmann *et al*. Germany 2017 [16]	Observational prospective cohort	n = 30	No	≤5.5 yrs Healthy children	Free intake of bread, fruits, cereals, milk, tea or water	GAA[3], GV[4], GE[5]
Bonner *et al*. UK 2015 [18]	Meta-analysis	n = 1132	No	Preterm neonates at 28 gestational weeks through adults	Peroral intake of liquids and/or solids	Mean Gastric residence time of solid and fluid food
Schmidt *et al*. Switzer land 2014 [7]	RCT	n = 131	Yes	≤16 yrs ASA I, II	Preoperative fasting of clear flu ids	Gastric pH and GV[4] Hunger, thirst, blood gas analysis, nausea and POV
(4) Incidence of pulmonary aspiration						
Pfaff *et al*. USA 2020 [2]	Retrospective, register-based study	n = 2,440,810	No	≤18 yrs	Preoperative fasting as per local protocols	Incidence of pulmonary aspiration
Beck *et al*. Germany 2019 [19]	Observational prospective cohort, multicentre	n = 3324	No	0–17 yrs ASA I, II, III, IV	Preoperative fasting as per protocol	Real fasting times; incidence of pulmonary aspiration and regurgitation
Andersson *et al*. Sweden 2015 [4]	Retrospectve, register-based study	n = 10,015	No	≤16 yrs ASA I, II, III, IV	Free intake of watery fluids until call to operation theatre	Pulmonary aspiration incidence
Brady *et al*. UK 2009 [12]	Cochrane Systematic Review	n = 2543	No	≤18 yrs ASA I, II	Different fasting regimens (duration, type and volume of permitted intake)	Aspiration, regurgitation, related morbidity, thirst, hunger, pain, comfort, behaviour, nausea and vomiting

[1]*Mean arterial pressure;* [2]*Postoperative vomiting;* [3]*Gastric antral area;* [4]*Gastric volume;* [5]*Gastric emptying.*
**ASA = American Society of Anesthesiologists physical status classification system.*
*** RCT = Randomized controlled trial.*

comparable assessment of outcome. The intervention, however, differed between studies. In some of the studies, children were included based only on assumed adherence to recommended fasting times. Similarly, when the association between 'light meals' or clear fluids were investigated, the meal content or fluid volumes were not standardized across studies.

3.1 Metabolism & hemodynamics

Dennhardt *et al*. [8] evaluated duration of clear water fasting and the concentration of blood ketones and post-anaesthesia-induction blood pressure in n = 100 children aged <36 months. The first 50 children in the cohort followed institutional fasting protocol, which comprising individual instructions for fasting times 1 day before the operation date (6 hrs for solid foods, 4 hrs for breastfeeding or infant formula, and 2 h for clear fluids prior to the estimated time of induction of anaesthesia). In addition to standard protocol, the second half of the cohort followed an optimized preoperative protocol: on surgery day, the anesthesiologists were encouraged to call the wards timely to confirm or adjust fasting orders. Furthermore, ward nurses and surgeons were educated about the importance of short fasting times to improve children's comfort and metabolic stability. Children in the optimized group had lower blood ketones, higher mean arterial blood pressure at induction, and lower incidences of hypotension [8]. Simpao *et al*. [9] also noted an association between clear fluid fasting times and low systolic arterial blood pressure after induction of anaesthesia and during surgical preparation.

In contrast, according to results by Schmidt *et al*. [7, 10] there was no difference in blood ketones between children, who were allowed to drink clear fluid without restriction compared to children who stopped drinking two hours prior to anesthesia.

3.2 Patient comfort

Engelhardt *et al*. [11] described the subjective feelings of hunger and thirst in children compliant to the 6-4-2 fasting rule prior to elective outpatient surgery. 56% of the children reported to be 'very hungry' or 'starving', 26.7% felt 'very thirsty' and 21.3% were both severely hungry and thirsty.

In a randomized clinical trial, Schmidt *et al*. compared 'liberal fasting for clear fluids (= 60 min) with a standard-regimen (= 120 min) by allocating 180 children (ASA group 1 + 2, age 1–16 yrs.) to one of the two groups. At the time of induction, children in the liberal group reported they were less thirsty and their parents were more satisfied with the preoperative experience [7, 10].

Brady *et al*. [12] systematically assessed how different fasting regimens affected 2543 children's wellbeing. Children following a liberal fasting regimen compared to a prolonged period of nil-per-mouth were less thirsty, less hungry, less irritable and generally felt more comfortable [12].

3.3 Gastric volume and/or emptying time

In three studies, children were allowed a light breakfast after overnight fasting. Their gastric volume (GV) was then examined by ultrasound using the method described by Van De Putte *et al*. [20]. Andersson *et al*. found that 15 of 20 children had an empty stomach 3 to 5 hrs after ingesting a free intake of yoghurt or gruel. Liquid volume of <0.5 mL/kg was present in four children. One child had solid gastric content after ingesting twice the volume of the other children [13]. Three studies investigated the mean gastric emptying (GE) time in healthy children. Beck *et al*. [14] estimated the mean GE time to be 211 min in children age less than 13 yrs and found GV to be significantly lower 4 hrs after a light breakfast than after an overnight fast. In a similar setting assessing GE time to the duration of clear fluid fasting, children were allowed to drink up to 5 mL kg^{-1}; still the GE time was less than an hour [15]. Sümpelmann *et al*. [16] reported a mean GE time of 236 min in preschool children who were allowed an unrestricted breakfast.

A recent study, investigated the GE mean time for breast milk and formula milk in preterm infants. The mean GE time was 218 min (3 hrs, 38 min) for GAA 0.45 cm^2 and there was no significant difference in the GAA 3 h after either breast milk or formula [17].

Bonner *et al*. [18] investigated whether age had an impact on mean gastric residence time (MGRT) in premature neonates up to adulthood. Interestingly, age did not correlate with GE but the type of meal did. MGRT time, modelled using a non-linear mixed-effect approach, was 98 min for solids, 87 min for semi-solids, 64 min for formulas, 57 min for breast milk and 45 min for clear fluids [18].

In children scheduled to undergo elective surgery, Schmidt *et al*. assessed gastric pH and GV after a clear fluid fasting time of 2 hrs compared to one hour or free intake until premedication (mean time 48 min prior to induction of anesthesia). While pH was similar in all groups, GV was largest in children allowed to drink until 1 h before induction [7, 10]. Overall, the total volume of fluid intake during the last 6 h prior to the induction of anesthesia correlated slightly with GV [10].

3.4 Risk of pulmonary aspiration

In 10,015 children classified as ASA I or II, the incidence of pulmonary aspiration remained low (3/10,000), even if the children were allowed to drink until they were called to the operating theatre [4]. These results were similar to findings of a multicentre study, where the incidence of pulmonary aspiration was 6/10,000, with clear fluid fasting regimens of 1 or 0 h and semi-solid regimen of 6 or 4 hrs [19]. Recently, the Wake-Up Safe Collaboration, a registry of serious adverse events associated with children receiving anesthetic care, reported 135 cases of pulmonary aspiration among 2,440,810 anesthetics administered. This corresponds to an incidence as low as 0.006% [2]. Interestingly, 63% of PAs occurred in the operating room during in- or extubation or intraoperatively, whereas 37% occurred in 'other areas', e.g., at the PACU or during transfer.

4. Discussion

Fasting guidelines in pediatric anesthesia aim to streamline children's preoperative intake of fluids and foods according to a sound practice. These guidelines, however, cannot replace assessment of individual pulmonary aspiration risk. Regardless of fasting times, some patients will remain at high risk of regurgitation and pulmonary aspiration of gastric content in relation to anesthesia since various factors influence gastric emptying and intestinal motility [21–24]. Firstly, mechanical obstruction due to pathologies (e.g., pyloric stenosis, malrotation with volvulus, intestinal atresia or stenosis) cause retention of intestinal content [25]. Obstructions may be intraluminal (e.g., accidently swallowed objects) or extraluminal (tumors, adhesions). Secondly, intestinal motility is likely impaired by gastro intestinal (GI) infectious and non-infectious inflammation, biochemical disorders (e.g., diabetes, hypothyroidism, electrolyte imbalance) and postsurgical paralysis of the bowels [26]. Thirdly, intestinal hypomotility is associated with several neuromuscular disorders. Finally, delay of gastric emptying might be drug-induced (e.g., by opioids) [23]. Based on this, the aspiration risk level should be assigned individually for infants and children scheduled for surgery and anesthesia.

Preoperative fasting has wide-ranging implications for children and parents. Children report starvation and thirst, leading to poor well-being, bad behaviour and negative perioperative experiences for both children and parents. At institutions, where children were allowed to drink clear fluids until they were called to the operating theatre, the incidence of pulmonary aspiration did not increase [1, 2, 20]. Hence, offering clear fluids to children prior to anesthesia induction seems to improve well-being of patients and increase parent satisfaction without compromising the child's safety. Encouraged by these findings, several authors advocate for a more liberal preoperative fasting regimen, that is reduced fasting times for solids, breast milk and formula [13, 14, 16, 17].

Yet, in many clinical setting it remains challenging to comply with fasting recommendations. The reasons may be various. Firstly, the child will not comply with a fasting regimen, just because a guideline says so. If the child is anxious, distracted by unfamiliar surroundings or simply not thirsty, he or she will not drink, even if fluids are readily available. This group of children should not pose any problem, since they are likely to be well hydrated. On the other hand, if the child spontaneously seeks to drink he or she elicits a correct response to thirst, a physiological signal to facilitate water intake. While adults drink for many reasons also covering social habits and a mere desire to taste or consume a fluid that will give a warming or cooling sensation, especially young children are more likely to respond to a genuine physiological need for fluids. As the child becomes increasingly dehydrated, the sensation of thirst will intensify. These children are actively prevented from fluid intake by either parents or hospital staff, in an attempt to comply with obsolete fasting recommendations — for no good reason, it appears. Parents in particular should be informed that compliance with updated fasting guidelines supports maintenance of metabolic balance during anesthesia in addition to improving their child's wellbeing prior to and after surgery [27, 28].

If the argument for prolonged fasting is organisational, e.g., out of consideration to tight theatre schedules, the child's best interest is disrespected. Those who plan and control the efficiency of operating theatres must take these special needs of pediatric patients into account. Theatre staff and anesthetists must provide feedback about delays or schedule changes in order to avoid unnecessary fasting. Due to busy and dynamic theatre schedules, these chains of communication are difficult to maintain but must become a priority. The bulk of evidence should convince even vehement protectors of prolonged fasting durations of the opposite. Instead, those involved in hospital admission and preparation of the child for operation should encourage intake of fluids until one hour prior to anesthesia induction. Finally, children must not be thirsted because of institutionally settled habits based on obsolete fasting regimens. If children want to drink, let them drink.

5. Conclusions

Based on the current evidence on preoperative fasting in children, liberal fasting times with nil-per-mouth for solids and formula, breast milk and watery fluids corresponding to 6, 4 and 1 h respectively, are generally considered to be safe. However, a reduction in the real and actual fasting times requires a multifactorial approach and the engagement of parents, clinical staff and operating theatre management.

AUTHOR CONTRIBUTIONS

NGC and TGH conceived the original idea; NV and NGC reviewed the literature; NB and NGC audited fasting times referred to in Supplement 1 and 2. TGH contributed to the interpretation of results; NV and NGC wrote the manuscript with inputs from NB.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

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CONFLICT OF INTEREST

The authors declare no conflict of interest. Tom G. Hansen is the Guest Editor of the journal.

SUPPLEMENTARY MATERIAL

Supplementary material associated with this article can be found, in the online version, at https://oss.signavitae.com/mre-signavitae/article/1430094435113156608/attachment/Supplementary%20materials.docx.

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