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ORIGINAL ARTICLE

Fasting times and gastric contents volume in children undergoing deep propofol sedation – an assessment using magnetic resonance imaging

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Summary

Aim: To investigate the effect of fasting times for clear fluids and solids/non-clear fluids on gastric content volume using magnetic resonance imaging (MRI).
Methods: Pediatric patients undergoing diagnostic MRI under deep propofol sedation, with the stomach located within the area of diagnostic study, were included in this clinical observational study. According to standard institutional guidelines, children were allowed to eat/drink until 4 h and to drink clear fluids until 2 h before scheduled induction time of anesthesia. Gastric content volume per kg body weight (GCV_w) was determined using MRI and compared with actual fasting times prior to induction.
Results: Overall 68 patients aged from 0.3 to 19.6 (2.8) years were investigated. Fasting time for clear fluids ranged from 1.1 to 15.5 (5.5) h, for non-clear fluids/solids from 4.0 to 20.2 (6.7) h. GCV_w ranged from 0.2 to 6.3 (0.75) ml·kg^{-1} and showed no significant negative correlation to fasting times for clear fluids (r = −0.07, P = 0.60) and non-clear fluids/solids (r = −0.08, P = 0.51).
Conclusions: Based on this preliminary data, GCV_w showed considerable variation but did not correlate with fasting times in children and adolescent patients. Recommended fasting times were often exceeded.

Introduction

While preoperative fasting is the main concept in anesthesia to prevent perioperative pulmonary aspiration of gastric contents in elective procedures, prolonged fasting has negative impact on intravascular volume status, blood glucose level, behavior, and patient/parent satisfaction (1). Discomfort resulting from hunger and thirst is clearly in favor of shorter fasting times of 2 h for clear fluids. Both comfort and safety aspects have been considered in currently used fasting guidelines, e.g., the fasting guidelines of the American Society of Anesthesiology (ASA) which recommend 2 h fasting for clear fluids, 4 h for human breast milk, and 6 h for food and other fluids (2). According to several surveys, liberalized fasting times seem to be generally applied, but with some variations in clinical practice (3–5). In the authors' institution, the concept of 2 h fasting for clear fluids and 4 h for other fluids and light meals has been established several years ago and is routinely applied in children undergoing general anesthesia or deep sedation with the preservation of spontaneous ventilation (6,7).

Modern magnetic resonance scanners produce high resolution images and allow accurate volume measurement of various organs (8,9). Magnetic resonance imaging (MRI) has been used in adults to examine gastric volume and emptying (10–15) and in a preoperative fasting context to measure gastric emptying after carbohydrate drinks (16).

The aim of this clinical observational study was to investigate fasting times and residual gastric volume in children undergoing elective diagnostic MRI in deep sedation.

Methods

After the approval of the local ethics committee, patients undergoing elective MRI in the pediatric radiology department were included within an 18-months period. Inclusion criteria were age from 3 months to 20 years, elective diagnostic MRI, stomach located within the area of the diagnostic MRI study, and need for deep propofol sedation. Patients with a gastric tube gastrostomy or known or probable gastrointestinal pathology that could influence gastric emptying were excluded, as well as patients requiring tracheal intubation and controlled ventilation with subsequent gastric suctioning. Patients undergoing repetitive diagnostic MRI during the study period were evaluated only once.

Parents were instructed to respect the following fasting guidelines for their children: 2 h for clear fluids and 4 h for other fluids and solids prior to hospital admission. Age, weight, length, ASA physical status classification, and starting time of MRI of each patient were recorded. Parents/legal guardians were explicitly asked for the time of last fluid and food intake of their children. Patients underwent deep sedation according to a routine protocol. Premedication with oral or rectal midazolam was optional according to the patients' or parents' preference. After intravenous induction using small doses of 1–2 $mg \cdot kg^{-1}$ propofol to allow maintenance of spontaneous ventilation, sedation was continued with 10 $mg \cdot kg^{-1}$ h propofol, supplemented by a single dose of 0.1 $mg \cdot kg^{-1}$ (max. 3 mg) midazolam if necessary, and 2 l oxygen per minute via nasal prongs. As alternative, inhalational induction was performed using sevoflurane in oxygen/nitrous oxide (1 : 1) until an intravenous line was established. Gastric suctioning was avoided. Routine monitoring consisted of continuous capnography from nasal prongs, pulsoxymetry, electrocardiogram, and noninvasive blood pressure measurement (AS5 Monitor; Datex-GE, Helsinki, Finland).

MRI was performed on a 1.5 Tesla scanner (Signa Twinspeed; GE Medical Systems, Milwaukee, WI, USA). Gastric volumes were measured on a workstation with standard post processing software. On contiguous axial steady state free precession images (slice thickness 6 mm) obtained as localizers and covering the entire stomach, liquid and solid contents (with bright signal) as well as gastric air and other gas (with dark signal) were traced manually on every slice (Figure 1), with slice volumes resulting from multiplication of area with slice thickness (6 mm). Total gastric volume, gastric contents volume (GCV; volume of fluids and solids), and gastric air volume (GAV; volume of air and other gas) were calculated by adding the respective slice volumes. Values were divided by body weight for weight corrected GCV (GCV_w) and GAV (GAV_w).

Microsoft Office Excel 2003 and SPSS Statistics 17.0 (SPSS Inc., Chicago, IL, USA) were used for data analysis. Data are presented as range (median). Subgroups were classified by duration of fasting. Descriptive statistics were applied with data that are not normally distributed presented as range (median). Pearson's correlation coefficients to detect relation between gastric volumes and fasting time or other independent variables were calculated. Mann–Whitney-*U*-test was applied for subgroup analysis. A *P*-value of <0.05 was considered to indicate statistical significance. Intra- and inter-observer reliability was tested by repeatedly measuring GCV in 10 patients with the calculation of Pearson's correlation coefficients, variation coefficients, and Bland–Altman analysis.

Results

Overall, 68 patients (33 female, 35 male) aged from 0.3 to 19.6 (2.8) years were investigated with 34 abdomen, 26 spinal column, 4 total body, and 4 chest MRI. Weight was 6–60 (14) kg, length ranged from 49 to 170 (97) cm. Thirteen patients were class I, 42 class II, and 13 class III according to the ASA physical status classification.

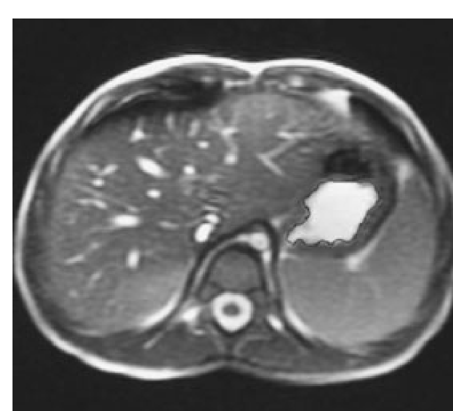

Figure 1 Manually traced liquid content on axial MRI slice.

Fasting time for clear fluids ranged from 1.1 to 15.5 (5.5) h, for nonclear fluids/solids from 4.0 to 20.2 (6.7) h. Minimal allowed fasting times of 2 h for clear fluids according to institutional guidelines were exceeded by 2 h or more in 50 patients (73.5%) and by 10 h or more in 11 patients (16.2%). Minimal allowed fasting times of 4 h for other fluids/solids according to institutional guidelines were exceeded by 2 h or more in 46 patients (67.6%) and by 10 h or more in 17 patients (25%). Twenty-seven patients (39.7%) had no food or nonclear fluids, and 11 patients (16.2%) even had no clear fluids overnight. Frequency distribution and quartiles of fasting times are shown in Figure 2.

Gastric contents volume was 1.6–86.5 (10.0) ml and showed weak correlation to weight, length, and age (r = 0.51/0.44/0.42, each with P < 0.01). Body weight corrected values (GCV_w) ranged from 0.2 to 6.3 (0.75) $ml{\cdot}kg^{-1}$ and did not correlate to age, weight, length, or ASA class (r = −0.06/−0.001/−0.02/−0.2). There was no significant negative correlation between GCV_w and fasting times for clear fluids (r = −0.07, P = 0.60) and nonclear fluids/solids (r = −0.08, P = 0.51). GCV_w values in 22 of 68 patients (32.4%) with < 6 h fasting time for solids/nonclear fluids (0.2–4.2 [0.70] $ml{\cdot}kg^{-1}$) were similar to GCV_w values in 46 of 68 patients (67.6%) fasting more than 6 h (0.3–6.3 [0.83] $ml{\cdot}kg^{-1}$) (P = 0.50). Subgroup analysis with further fasting time cutoffs (e.g., 6.7 h for food, 5.5 h for clear fluid, last meal/fluid before/after midnight) did not reveal significant differences. Scatter plots of GCV_w and fasting times are shown in Figure 3. In 3 of 68 patients (4.4%), GCV_w values > 4 $ml{\cdot}kg^{-1}$ were found: GCV_w was 4.1, 4.2, and 6.3 $ml{\cdot}kg^{-1}$, and the corresponding fasting times were 3.1/5.4, 2.8/4.8, and 4.0/6.1 h for clear fluids/solids and other fluids, respectively. Results of intra- and inter-observer re-tests are shown in Table 1.

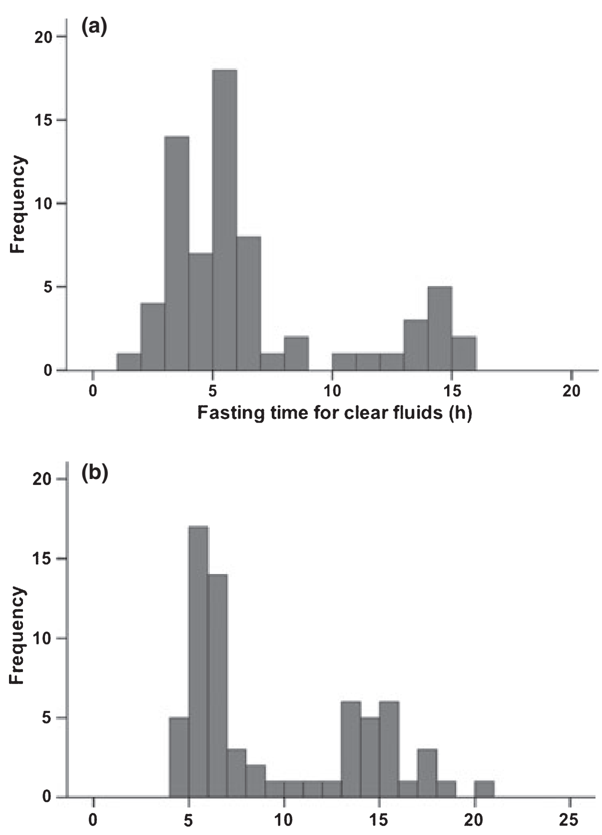

Figure 2 (a, b) Frequency distribution of fasting times for clear fluids (a) (25th, 50th, and 75th percentile: 3.8, 5.5, and 6.9 h) and solids/nonclear fluids (b) (25th, 50th, and 75th percentile: 5.7, 6.7, and 14.0 h) (n = 68 patients).

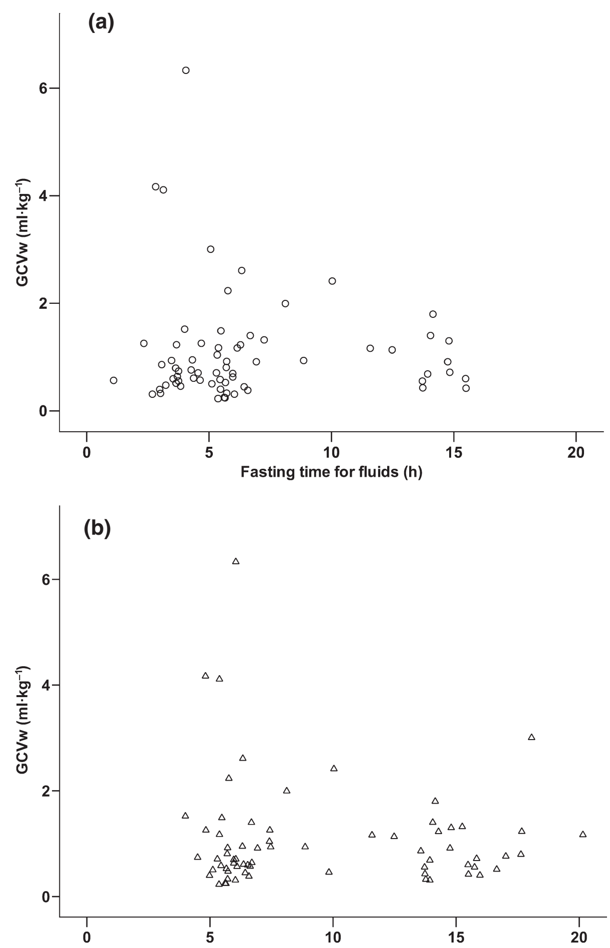

Figure 3 (a, b) Body weight-related gastric contents volume (GCV_w) and fasting time for clear fluids (circles) (a) and nonclear fluids/solids (triangles) (b) (n = 68 patients).

Table 1 Intra-observer and inter-observer reliability of volumetric assessment of gastric contents volume (GCV)

	Intra-observer	Inter-observer 1	Inter-observer 2
Number of subjects	10	10	10
Pearson's *r*	0.997	0.996	0.997
Median VC (min–max) [%]	5 (1–14)	6 (1–26)	10 (1–32)
Mean average (±SD) [ml]	18.3 (±20.8)	18.8 (±21.0)	18.7 (±20.9)
Mean difference [ml]	0.29	0.79	1.08
Lower–upper limit of agreement [ml]	−2.87 to 3.45	−3.1 to 4.6	−2.4 to 4.5

Bland–Altman analysis with bias as mean difference and limits of agreement as bias ±1.96 SD.
VC, variation coefficient (SD divided by mean) in %.

Absolute (GAV) and body weight corrected (GAV_w) gastric air volume ranged from 0 to 80.4 (13.9) ml and 0 to 13.4 (1.1) $ml \cdot kg^{-1}$, respectively. GAV_w showed a weak negative correlation with weight ($r = -0.27/P = 0.02$), length ($r = -0.36/P = 0.003$), and age ($r = -0.25/P = 0.04$) but did not correlate with fasting time for clear fluids ($r = -0.10/P = 0.41$) or nonclear fluid and solids ($r = -0.10/P = 0.39$). There was no significant difference in GAV_w whether mask ventilation was performed (in 10 of 68 patients or 14.7%, respectively) or not ($P = 0.61$).

Discussion

This observational study investigated fasting times for clear fluids, nonclear fluids/solids, and gastric volumes measured by means of MRI in pediatric patients undergoing elective MRI examination in deep propofol sedation.

The main findings were that GCV_w showed considerable variation irrespective of fasting time and that there was no significant correlation between GCV_w and fasting times. Furthermore, patients often had prolonged fasting times, in spite of a liberal fasting regimen.

Minimizing fasting times in pediatric patients is important for several reasons such as avoidance of dehydration, hypoglycemia, lack of compliance with risk of hidden eating or drinking, and lack of cooperation during induction of anesthesia, probably the most important factor to reduce the risk of aspiration during induction of anesthesia or sedation. So far, there are no studies investigating fasting times for nonclear fluids/solids less than the recommended 6 h according to the ASA Task Force on Preoperative Fasting (2), except for breast milk in infants. As preliminary results of this observational study, neither correlation nor subgroup testing showed an influence of the duration of fasting time on GCV_w. In our population, GCV_w shows a wide variation up to the extreme value of 6.3 $ml \cdot kg^{-1}$. Three outliers with a GCV_w of >4 $ml \cdot kg^{-1}$ had short but not extremely short fasting times, one being also fasted long enough according to ASA guidelines (2). The excessive GCV_w values in these patients cannot be explained by any gastrointestinal pathology, reduced physical status, or other medical condition. These findings also imply that anesthesiologists cannot rely on the fasting time because the residual gastric volume may vary a lot despite compliance with ASA guidelines and thus emphasize the importance of a smooth induction.

Similarly, GAV_w values showed wide variation. The outlying GAV_w of 13.4 $ml \cdot kg^{-1}$ can be explained by prolonged assisted mask ventilation in a patient in whom peripheral venous cannulation could not be performed within 30 min, and an intraosseous needle had to be placed.

Gastric contents volume determined by MRI in children with regard to preoperative fasting has to our knowledge not been published previously. Gastric volume as well as gastric pH has been investigated earlier, with an extensive review of randomized controlled trials published and recently updated by Brady *et al.* (17). They concluded that concepts with liberal fasting times, e.g., ASA guidelines (2), are not correlated with larger gastric fluid volume in children, and even overnight fasting does not reduce gastric contents, which is compatible with our findings. Most investigations used aspiration of gastric contents via gastric tube, a technique that may underestimate gastric volume (18). Correspondingly, values of gastric contents aspirated with a syringe via gastric tube, as reported in the review of Brady *et al.*, are generally lower than those presented here.

MRI offers the chance to evaluate gastric contents in sedated children noninvasively. Gastric emptying scintigraphy (GES) and not MRI is still claimed to be the gold standard to measure gastric emptying as a dynamic process (19), as it can discriminate between gastric secretions and nutrient emptying, but to the anesthetist, the sum of both is relevant in terms of aspiration or regurgitation risk. Furthermore, GES would be no alternative in children because it is rarely indicated in diagnostic routine and bears the risks of ionizing radiation. With the current MRI technique, gastric wall, gas and fluid contents can be discriminated, allowing direct tracing of intragastric volumes without geometric assumptions and with minimal deviation because of slice thickness. MRI has been shown to allow accurate volume measurement using phantoms (11), and studies in adult volunteers demonstrated that gastric volumes measured by MRI and a double indicator technique were similar (13). Day-to-day reproducibility of gastric volumes and volume changes in response to test meals in adults but not inter- and or intra-observer reliability have been reported (10,11). Re-tests for intra- as well as inter-observer reliability in the presented data showed acceptable results.

The value of gastric volume as risk parameter for pulmonary aspiration during anesthesia has been questioned (20). However, the low incidence of pulmonary aspiration, estimated between to be 1–10 in 10 000 with an even lower incidence of morbidity (21–25), makes the construction of randomized controlled trials with aspiration as primary outcome almost impossible. Cook-Sather has calculated that testing of a fasting protocol to reduce aspiration by half would require 200 000 subjects in each of two randomized study groups (1), and previous research focused on the surrogate parameters volume and pH of gastric contents as primary outcomes (17). Theoretically, sufficient amount of gastric contents seems to be a precondition to facilitate regurgitation. This is supported by a higher incidence of pulmonary aspiration in emergency surgery (22), but the direct impact of gastric volume on outcome has still not been proved.

Although parents were instructed to withdraw clear fluids for at least 2 h and other fluids or solids for at least 4 h before the scheduled sedation time, the recorded fasting times largely exceeded the minimum allowed fasting periods. The first patients scheduled in the morning were sometimes not woken up for a light meal or drinks after midnight, which is reflected in a bimodal form of the frequency distributions (Figure 2). Furthermore, prolonged fasting times may be explained by organizational or technical delay. Longer fasting times than those offered by guidelines have also been described by other investigators (26,27).

This investigation was designed as observational study with drinking and eating times recorded retrospectively, which may be regarded as a limitation. A type II error in subgroup testing cannot be excluded because the sample size is relatively small. Also, quantity and quality of nutrients or liquids could not be evaluated exactly, controlled or compared interindividually with regard to gastric emptying. The large variation of effective fasting times in our study, however, allowed investigation of fasting times and their impact on gastric content in a clinically representative population.

In conclusion, fasting times in clinical practice vary widely and often exceed institutional guidelines. Gastric content volumes also vary considerably but do not correlate with fasting times for clear fluids or nonclear fluids/solids. Shorter fasting times than those actually applied would help to improve patient comfort and to achieve more independence from organizational issues. Future controlled prospective trials investigating the impact of time, quality, and amount of food and/or fluid intake on gastric emptying in children using MRI are required.

Conflict of interest

None.

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