Clear fluids three hours before surgery do not affect the gastric fluid contents of children

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This prospective, randomized, single-blind study of 121 healthy children aged 2 to 12 yr investigated the effect of clear fluids on gastric contents. Gastric fluid volume and pH were measured immediately following the induction of general anaesthesia and were not significantly affected by the ingestion of unlimited clear fluids up to three hours preoperatively. After a prolonged fast (mean fast 14 hr), gastric fluid volume was 0.39 ± 0.37 ml · kg^{-1} and gastric pH was 1.7 ± 0.4; after unlimited clear fluids (203 ± 109 ml) up to three hours before surgery gastric fluid volume was 0.34 ± 0.28 ml · kg^{-1} and gastric pH was 1.8 ± 0.7 (mean ± SD). Gastric fluid volume (ml · kg^{-1}) increased in both the control and study groups as age increased, $P < 0.005$. It is concluded that drinking clear fluid up to three hours before scheduled surgery does not have a measurable effect on gastric volume and pH of healthy children of ages 2 to 12 yr.

Cette étude prospective randomisée à simple insu chez 121 enfants en bonne santé âgés de 2 à 12 ans a étudié les effets de l'administration de liquide clair sur le contenu gastrique. Le volume gastrique et son pH ont été mesurés immédiatement après l'induction de l'anesthésie générale et n'étaient pas significativement affectés par l'ingestion d'une quantité illimitée de liquide clair jusqu'à trois heures avant la chirurgie. Après un jeûne prolongé (jeûne moyen = 14 heures), le volume du liquide gastrique était de 0,39 ± 0,37 ml · kg^{-1} et le pH gastrique était de 1,7 ± 0,4; après une quantité illimitée de liquide clair (203 ± 109 ml) jusqu'à trois heures avant la chirurgie, le volume du liquide gastrique était de 0,34 ± 0,28 ml · kg^{-1} et le pH gastrique était de 1,8 ± 0,7 (moyenne ± SD).

Key words
ANAESTHESIA: paediatric;
COMPLICATIONS: aspiration, prophylaxis;
GASTROINTESTINAL TRACT: gastric emptying, gastric pH, gastric volume, preoperative fluids.

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Le volume du liquide gastrique (ml · kg^{-1}) augmenta tant chez le groupe contrôle que le groupe étudié en fonction de l'âge, $P < 0,05$. On conclut que l'ingestion de liquide clair jusqu'à trois heures avant la chirurgie n'affecte pas d'une façcon mesurable le volume du liquide gastrique et son pH chez les enfants en bonne santé et âgés de 2 à 12 ans.

Patients are required to abstain from food and drink before surgery. In younger patients the resulting fast of 6 to 18 hours leads to thirsty, hungry and irritable children.[1,2] In order to minimize these discomforts, the optimum length for this fast must be established.

Previous studies have demonstrated the safety and efficacy of administering specific volumes (2–10 ml · kg^{-1}) and types (water, apple juice, five per cent dextrose water and 20 per cent Poly-Joule) of clear fluids to children two to three hours before surgery.[1–5] This study of healthy children compared the effect of an overnight fast with the effect of permitting unlimited clear fluids up to three hours before surgery on gastric fluid volume and pH.

Methods

This study was approved by the Hospital Ethics Committee and parental consent was obtained. Patients were excluded from the study if there was a history of gastrointestinal disease or if the patient was receiving medication known to affect gastric contents.

One hundred and twenty-one healthy children aged 2–12 yr scheduled for elective surgery were randomly assigned to one of two groups. Children in Group A fasted from midnight. Children in Group B did not consume solid food on the day of their operation but were instructed to ingest unlimited volumes and types of clear fluids up to three hours before their scheduled surgery. For the purpose of this study clear fluids were defined as aqueous solutions, which are liquids at 37° C.[6,7] Non-clear fluids, suspensions and emulsions, such as milk and most broths, were not permitted. Parents or nursing staff were asked to monitor accurately the amount of fluid ingested on the day of surgery.

TABLE I Patient characteristics mean ± SD (range)

Group	n	Age (yr)	Weight (kg)	Duration of fast (hr)	Volume ingested (ml)
A	64	5.7 ± 2.5	21 ± 8	13.9 ± 2.5	nil
B	57	5.6 ± 2.7	23 ± 12	3.3 ± 0.9	203 ± 109 (30–630)

The following protocol was used in all patients:

a Anaesthesia was induced IV with thiopentone or by inhalation of halothane and nitrous oxide/oxygen. A tracheal tube was inserted when indicated.

b After the establishment of an adequate and stable level of anaesthesia, a 16 Fr. Salem® oro-gastric tube was passed by the same investigator, who was unaware of the patient's fasting status. The position of the tube was confirmed by auscultation. Stomach contents were consistently aspirated with the gastric tube in several positions and with the patient supine, tilted to the right, left, head down and head up positions. Gastric contents were visually inspected for particles; the volume was measured by syringe; and pH was evaluated with pH paper (Merck pH 0–14 and pH 0–2.5). An acceptable correlation between the results determined by Merck paper and various pH electrodes has been noted.[8] Gastric volumes less than 1 ml were assigned the value of 0.5 ml.

For the purpose of this study "risk" factors for aspiration pneumonia were defined as (1) intragastric pH $\geq$ 2.5 and fluid volume $\leq$ 0.4 ml·kg^{-1} and (2) intragastric fluid voluid volume $\geq$ 1.0 ml·kg^{-1}.

Comparisons between groups were made using an unpaired Student's t test for parametric data (e.g., weight, age) and Mann-Whitney-U tests for non-parametric data (e.g., sex, gastric pH and gastric volume). The differences between the groups' risk factors for pulmonary acid-aspiration syndrome were assessed by Fisher's exact test or Chi-square analysis. The potential relationship between gastric fluid volume and pH versus gender, age, weight, in-patient/out-patient status, volume ingested and length of fast was evaluated by linear regression analysis. Differences were considered statistically significant if $P < 0.05$. Sample size was determined by assuming the standardized difference would be 0.6 and by setting the power at 0.90.

TABLE II Gastric contents mean ± SD (range)

Group	Volume (ml·kg^{-1})	pH
A	0.39 ± 0.37 (0.04–1.97)	1.7 ± 0.4 (1.1–4.0)
B	0.34 ± 0.28 (0.03–1.53)	1.8 ± 0.7 (1.2–5.0)

Results

There were no sigificant differences between the groups' gender, age, weight or ASA physical status (Table I). The timing and volume of fluid ingested varied among the patients in Group B. Children in Group B drank 203 ± 109 ml (10.4 ± 6.7 ml·kg^{-1}) of clear fluids up to 3.3 ± 0.9 hr before induction of anaesthesia. (Values are listed as mean ± SD.) Fluids ingested on the day of surgery included clear fruit juices, water, soda pop, Popsicles®, Kool Aid® and Jello®. Various fasting times occurred because of changes in operating room schedules or because the child did not wish a drink three hours before surgery as they had recently ingested fluids and thus were not thirsty. The volume of fluids ingested on the day of surgery varied considerably. This was primarily due to the different appetites of children. Also, bias may have been induced by previous warnings to parent and child about the "risks" of drinking on the day of surgery so that the volumes ingested may have been reduced.

Neither gastric fluid volume nor pH were affected by the ingestion of clear fluids (Table II). Patients drinking clear fluids had a decreased incidence of gastric fluid volume >1.0 ml·kg^{-1} (Table III). Two patients in each group had particulate matter in their gastric juice.

Linear regression analysis indicated that neither gastric fluid volume nor pH varied with gender, in-patient/out-patient status, volume ingested and length of fast, but as age increased gastric volume (ml·kg^{-1}) increased, $P < 0.005$, R^2 = 12 per cent.

Discussion

In this study, the gastric fluid volume and pH of healthy children determined immediately after induction of anaes-

TABLE III Per cent of patients with "risk" factors for pulmonary acid-aspiration syndrome

Group	Gastric volume > 0.4 ml·kg^{-1} and pH < 2.5	Gastric volume > 1.0 ml·kg^{-1}
A	33	11*
B	32	2

*$P < 0.05$, Fisher exact test.

thesia was not altered by permitting the ingestion of clear fluids up to three hours before elective surgery. Based on previous investigations of gastric emptying of clear fluids in adults,[9–11] and the results of studies of the ingestion of a preset volume at a specific time by children[1–5] our results were expected.

Clear fluids rapidly empty from the stomach of healthy patients. This emptying follows first-order kinetics, being primarily a function of the pressure gradient between the stomach and the duodenum.[9,10] It is also altered by the composition of the fluid consumed.[9] Isotonic solutions which do not interact with duodenal osmotic receptors (e.g., normal saline and 33 mM trisodium citrate) have gastric half-lives of only three to five minutes.[10] Aqueous solutions containing glucose, protein and lipids have gastric half-lives of about ten minutes.[9] With a half-life of ten minutes the percentage of clear fluid consumed which was present after a three-hour fast would be 0.0004 per cent, assuming a continuation of first-order kinetics. To augment further gastric emptying of clear fluids, it has been demonstrated in healthy adults that the terminal phases of gastric emptying of clear fluids is faster than expected.[11] Alternatively, one can consider the expected volume of retained fluids if the gastric emptying rate is at the lower limit of "normal" instead of the average normal value. Recovery of >200 ml of gastric fluid 30 min after a 750 ml saline load test is considered abnormal gastric retention.[9] After a three-hour fast, the percentage of retained fluid (saline) at the lowest limit of normal gastric emptying would be 0.04 per cent.

Solid food has markedly different gastric emptying. It is normal to find a portion (about 10–30 per cent) of a solid-food meal still in the stomach six to eight hours after a large meal.[12] This investigation described the effect of clear fluid ingestion on the day of surgery on gastric contents of healthy children. The results of this study cannot be applied to the gastric emptying of solid food.

Gastric emptying may be adversely affected by disease and medication.[9] Drugs that inhibit gastric emptying include opiates, anticholinergics, beta-adrenergic agonists, L-dopa and tricylic antidepressants.[8] The results of this study should not be extrapolated to children receiving these medications.

The model used in this study to classify patients at increased "risk" of pulmonary acid-aspiration syndrome was based upon the standard criteria of gastric volume >0.4 $ml \cdot kg^{-1}$ and gastric pH levels >2.5.[13] This "standard" predicts that a large number (about 40 per cent) of children are at risk of pulmonary acid-aspiration syndrome. However, the actual incidence of aspiration pneumonitis is only 1–6 per 10,000 adult surgical cases.[14] (The incidence of perioperative aspiration pneumonia among healthy children undergoing elective surgery has not been reported.) This standard overestimates risk. Markedly elevated gastric fluid volume, increased intra-abdominal pressure and gastroesophageal reflux are factors of greater clinical relevance.[13,14]

An unexpected finding was the significant increase in gastric fluid volume as age increased. This may represent a normal physiological occurrence, or a chance event or our technique of gastric fluid volume estimation may underestimate small gastric volumes to a greater extent than it underestimates larger volumes. Further study is indicated.

The technique used to measure the volume of gastric contents is a valid and accepted method,[15] although it underestimates gastric volume. Dye-dilution techniques are cumbersome and of unknown precision in children.

In summary, gastric fluid contents immediately after the induction of anaesthesia of healthy 2- to 12-yr-old children were not adversely affected by the ingestion of unlimited types and volumes of clear fluids up to three hours before their operation. Thus, the policy of restricting clear fluid intake more than three hours before surgery does not benefit children and may lead to thirst, hunger and poor behaviour. The effect on gastric contents of the ingestion of unlimited clear fluids less than three hours before anaesthesia, or if they are ingested by patients who are younger or older than those studied herein is unknown.

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