Ingestion of Liquids Compared with Preoperative Fasting in Pediatric Outpatients

Mark S. Schreiner, M.D.,* Andrew Triebwasser, M.D.,† Thomas P. Keon, M.D.‡

The preoperative fast is often an unpleasant preoperative experience that might be alleviated by allowing children to drink clear liquids. The authors compared gastric fluid volume and pH in two groups of children, one of whom was permitted clear liquids until 2 h before surgery (study group) and the other followed routine preoperative fasting orders (control group). The study group was not limited in the quantity of clear liquid allowed with the exception that the last intake prior to surgery was limited to 2 ounces. The study group (n = 53) averaged 5.9 ± 5 yr and weighed 23.6 ± 17 kg, while the control group averaged 7.3 ± 4.6 yr and weighed 29 ± 17.7 kg (P = NS). Gastric contents were aspirated following induction of anesthesia. Gastric fluid volume averaged 0.44 ± 0.51 ml/kg for study group and 0.57 ± 0.51 ml/kg in the control group (P = 0.12). Of the study patients, 48% had a measured gastric fluid volume ≥ 0.4 ml/kg compared with 58% of the control patients (P = 0.77). Eighty-three patients had sufficient gastric fluid for pH determination; of these 34/35 (97%) in the study group and 44/48 (92%) in the control group had a gastric fluid pH ≤ 2.5. Using a linear analog scale parents rated the children in the study group to be less irritable (P < 0.001) and to have had a better overall preoperative experience (P < 0.01) compared with the control patients. The authors conclude that drinking clear liquids up to 2 h prior to the induction of anesthesia is unlikely to substantially affect the volume of gastric fluid contents or the percentage of patients with a gastric fluid pH ≤ 2.5. Although not diminishing the risk of aspiration, clear liquids appear to add no additional risk for aspiration of gastric contents in normal healthy children and may provide some psychological benefit as evidenced by a decrease in irritability prior to induction of anesthesia. (Key words: Anesthesia: pediatric outpatient. Fluids, oral: preoperative. Gastrointestinal tract: gastric fluid volume; gastric pH; preoperative fluids.)

THE PREOPERATIVE FAST is often an unpleasant perioperative experience for children. The purpose of an overnight fast is to reduce the risk of pulmonary aspiration of stomach contents by reducing the volume, content, and increasing pH of the stomach’s fluids. Patients whose gastric fluid volume is ≥0.4 ml/kg at a pH ≤ 2.5 are believed to be at increased risk.1 Despite prolonged fasting prior to the induction of anesthesia, the majority of children have these combined risk factors.2 Fortunately, clinically important aspiration of gastric stomach contents remains an uncommon complication of anesthesia in children.3 Solid food and milk products prolong gastric emptying.4

Studies in adults and in animals have demonstrated that clear liquids are emptied from the stomach with a halftime of 10–20 min.5-7 Therefore, clear liquids if ingested more than 2 h prior to surgery should be completely emptied from the stomach prior to induction of anesthesia. Therefore, we examined the effects of liberal intake of clear liquids up to 2 h prior to induction of anesthesia, on gastric fluid volume and pH.

Methods

With the permission of our institutional review board and written informed consent from parents, we examined the effects of clear oral liquids on gastric fluid volume and pH in 121 ASA physical status 1 or 2 children, aged 1–18 yr. All patients were admitted on the day of surgery or underwent surgery as outpatients. Tracheal intubation was planned in all cases. Patients taking medications or having a disease known to delay gastric emptying or increase acid production were excluded. Patients were randomized at the time of their preoperative visit to either a control or study group by selecting a sealed envelope containing standard or study feeding instructions. No solid foods, milk products, orange juice, or other juices containing pulp were allowed after 8 P.M. in both groups. In the control group, children 1–5 yr were permitted unlimited quantities of clear liquids (apple juice, water, jello,
or soda) until 6 h before the scheduled time of surgery; for children older than 5 this interval was increased to 8 h. The study group was allowed to consume water, apple juice, popsicles, clear broth, weak tea, or jello in unlimited quantities until 2 h prior to the induction of anesthesia. However, at the request of the participating surgeons the final liquid ingestion was limited to 8 ounces.

On the day of surgery, children in both groups were treated in an identical manner. Most children received a preanesthetic medication consisting of meperidine (1.5 mg/kg), diazepam (0.15 mg/kg) and atropine (0.02 mg/kg) taken orally in a volume of 0.25 ml/kg. Anesthetic technique was not dictated by the study; in most patients anesthesia was induced with a mixture of halothane, nitrous oxide, and oxygen. The quality of the inductions were assessed. If no complications ensued then the induction was rated as uneventful; coughing, laryngospasm, or vomiting were noted by their presence or absence.

Following tracheal intubation, gastric fluid samples were obtained through a 16- or 18-Fr Argyle Salem Sump® catheter by gentle aspiration with a 60-ml syringe. The researcher performing the aspiration was unaware of the patient’s preoperative feeding status. The tube position was confirmed by auscultation over the stomach, and aspirations were attempted with the child supine and in both lateral positions to maximize gastric emptying. Gastric fluid volume was noted, and a 2–3-ml sample was preserved under mineral oil for pH determination on a Fisher Accumet® Digital pH/Ion Meter that was calibrated prior to each use. The age, weight, fasting interval, gastric fluid volume, and pH were recorded for each patient.

Parents were asked to quantify the amount and type of liquid most recently consumed by their child and they were asked whether the printed feeding instructions were easy to understand. Immediately after their child’s departure for the operating room, the parents were asked to fill out a questionnaire. They were asked to respond to three statements: 1) “The fasting instructions were easy to comply with”; 2) “My child was irritable when he/she went into surgery”; and 3) “Overall, the preoperative experience was well tolerated by my child.” Responses were indicated by making a mark across a 10-cm line. At one end of the line was the statement “agree strongly” and at the other “disagree strongly.” A score from 0–10 was assigned to each response with 0 being the least desirable and 10 representing best possible score. Parents of children in the study group were asked to respond “Yes,” “No,” or “No opinion” to the following statement: “If your child had prior surgery at The Children's Hospital of Philadelphia the overall experience was improved because of the revised fasting interval.”

Interval data were compared using an unpaired Student’s t test. The linear analogue scores and gastric fluid volumes were compared using the Mann-Whitney U test for nonparametric data. A chi-square analysis was used for nominal data. Differences were considered significant when P < 0.05.

**Results**

There were no significant differences between the groups with regard to age, weight, sex, or mean interval between oral preanesthetic medication and induction of anesthesia (table 1). Induction of anesthesia was more than 4 h after the last ingestion of liquids in one study patient and therefore no sample of gastric fluid was obtained. The mean ± SD fasting interval for the remaining study patients (n = 52) was 2.6 ± 0.7 h (range 2–4 h), while the mean ± SD fasting interval for control patients (n = 68) was 13.5 ± 3.1 h, with a range of 6–23 h (P < 0.01). Of 53 parents of study patients, 52 were able to quantitate the volume of their child’s last liquid intake and recall the type of liquid. The average volume consumed was 8.2 ± 6.5 ml/kg; 29 drank apple juice, ten had jello, and 13 had water. Forty-five of the 53 (85%) study patients received the oral preanesthetic medication as did 59 of 68 (87%) of the control patients (P = 0.98).

Gastric fluid was obtained from 120 of the 121 children enrolled in the study. Because of mishandling, five specimens were lost and therefore only 115 samples could be analyzed. The parents of the six children for whom no sample could be analyzed were still requested to fill out questionnaires and provided data regarding the volume and type of liquid consumed prior to surgery. The gastric fluid volume was sufficient for pH determination in 83 of the 115 samples. In the remainder, an insufficient quantity of gastric aspirate precluded measurement; these small quantities of gastric fluid were assigned a residual volume of 0 ml.

There were no differences between groups in the volume of gastric fluid, the proportion of patients with a ≥0.4 ml/kg of gastric fluid, the proportion with a gastric fluid pH ≤ 2.5, or the proportion with a pH ≤ 2.5, and a volume ≥ 0.4 ml/kg (table 2). The mean ± SD gastric fluid volume was 0.44 ± 0.51 ml/kg (range 0–2.23 ml/kg) with a pH of 1.81 in the study group and 0.57 ± 0.51 ml/kg (range 0–2.09 ml/kg) with a pH of 1.77 in the

<table>
<thead>
<tr>
<th>TABLE 1. Demographic Data</th>
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<tr>
<td></td>
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<tr>
<td>Number</td>
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<tr>
<td>Age (yr)</td>
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<td>Weight (kg)</td>
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<tr>
<td>Male:Female (%)</td>
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<td>Fasting interval (h)</td>
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Mean ± SD.
TABLE 2. Gastric Fluid Analysis

<table>
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<tr>
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<th>Study</th>
<th>Control</th>
<th>P</th>
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<tbody>
<tr>
<td>Gastric fluid volume</td>
<td>0.44 ± 0.51</td>
<td>0.57 ± 0.51</td>
<td>0.12</td>
</tr>
<tr>
<td>Gastric fluid volume*</td>
<td>0.015 ± 0.008</td>
<td>0.017 ± 0.017</td>
<td>0.47</td>
</tr>
<tr>
<td>[H−] mean ± SD</td>
<td>23/48 (48)</td>
<td>39/67 (58)</td>
<td>0.77</td>
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<tr>
<td>(μmol/L)</td>
<td>(1.81)</td>
<td>(1.77)</td>
<td></td>
</tr>
<tr>
<td>Gastric pH ≤ 2.5 (%)†</td>
<td>34/35 (97)</td>
<td>44/48 (92)</td>
<td>0.57</td>
</tr>
<tr>
<td>volume ≥ 0.4 ml/kg</td>
<td>22/48 (46)</td>
<td>33/67 (48)</td>
<td>0.86</td>
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</table>

* Gastric fluid volume was not measured in five study patients and one control patient.
† An insufficient quantity of fluid was obtained for pH analysis in 15 additional study patients and 19 control patients.

Discussion

Fasting does not guarantee that the stomach will be empty or the pH of the gastric fluid high. Manchikanti et al. reported an average gastric fluid volume of 0.49 ml/kg in 25 children aged 1–12 who had been fasted for 480–780 min prior to induction of anesthesia. Of these, 60% had a volume greater than 0.4 ml/kg, 92% had a pH < 2.5, and 60% had both. Côté et al. reported similar findings in 51 children aged 3–17 yr who had an average gastric fluid volume of 0.78 ± 0.1 ml/kg and an average pH of 1.45 ± 0.03.

Splinter et al. reported that children who drank 3 ml/kg of apple juice 2.5 h prior to the induction of anesthesia had a decreased gastric fluid volume compared with children who had been fasted for a mean of 14.5 h. A drink of 5 ml/kg of pulp-free orange juice 2–3 h prior to induction of anesthesia caused no increase in gastric fluid volume and a dye marker (phenolsulphonphthalein) was not recovered from the stomach if 2.25 h had passed from the time of ingestion.

Our data are consistent with these previous studies in that we found no evidence that clear liquids consumed up until 2 h prior to induction of anesthesia adversely affected the volume or acidity of the residual gastric fluid compared with the gastric fluid volume and acidity in those who were fasted for more than 6 h. Thus, in none of these studies did clear liquids increase the gastric fluid volume compared with controls.

Although the fasting interval for control patients could have been as short as 6 or 8 h, this usually requires waking the child in the middle of the night or very early in the morning. This is rarely done, as evidenced by an average fast of 13.5 h in our control patients, similar to the duration of fast reported by others. We are not surprised, therefore, that many children appear irritable, presumably due to hunger or thirst, prior to operation.

There were no instances of noncompliance with feeding instructions during the study. One might caution that careful selection of parents is necessary to implement a more liberal preoperative fasting schedule. On the other hand, parents and patients who violate fasting instructions because of hunger or thirst are unlikely to judge correctly which foods or beverages are innocuous. Preoperative fasting instructions with explicit directions might minimize problems by providing families with a list of what is and is not allowed.

The parents of the study group children had less difficulty adhering to the preoperative feeding instructions, rated their children as less irritable, and rated the overall preoperative experience as better than did the parents of the control patients. Only 18 patients in the study group had a previous operation, but the parents of 14 children thought that the shorter period of fasting improved the overall preoperative experience.

We do not advocate the ingestion of milk, juices with
pulp, or solid food at these reduced intervals prior to induction of anesthesia. Meakin has shown that children fed orange juice with pulp, with or without biscuits, had increased gastric fluid volumes compared with controls.\textsuperscript{13} Hunt\textsuperscript{5} has identified several factors that slow gastric emptying of clear liquids including: increasing potassium, glucose, and sorbitol concentrations; and he has identified factors that increase gastric fluid emptying including: low concentrations of sodium chloride, bicarbonate, and urea. Although further work needs to be done to define which liquids allow optimal emptying from the stomach, reasonable choices appear to be water, apple juice, and pulp-free orange juice.\textsuperscript{11,12}

The majority of children have either a gastric fluid volume $\geq 0.4$ ml/kg or a pH $\leq 2.5$ and yet clinically apparent aspiration pneumonia following anesthesia and surgery is uncommon.\textsuperscript{3} Many of our patients, whether fasted or fed clear liquids, had gastric fluid volumes $\geq 0.4$ ml/kg and had a gastric fluid pH of $\leq 2.5$. Drinking clear liquids until 2 h prior to induction of anesthesia did not increase gastric fluid volume and thereby increase risk. In patients deemed to be at an increased risk of aspirating gastric contents during the induction of anesthesia, prophylaxis with H$_2$ antagonists has been shown effective in reducing gastric fluid acidity and volume.\textsuperscript{14,12} We did not include patients considered to be at an increased risk for regurgitation and aspiration in our study and do not advocate shortening the fasting interval for these patients.

While the optimal fasting interval and the optimal preoperative liquids remain to be defined, the authors believe that prolonged fasting is not necessary for the normal, healthy child. Furthermore, a child who inadvertently drinks clear liquids need have surgery delayed no longer than 2 h and children whose operation is delayed may be safely permitted to drink clear liquids while waiting, if the anticipated delay will be 2 h or greater.

We have now used a revised set of fasting instructions that allow children to drink the same clear liquids allowed in this study until 2 h prior to the induction of anesthesia in over 2,000 day surgery patients. Problems have been rare, and when they have occurred, they have not been serious. There have been no instances of clinically apparent aspiration. Most problems have involved drinking

score = 9 ± 1.2) than the control group feeding instructions (mean score = 7.5 ± 2.5, $P < 0.001$). B. Parents of children in the control group rated their children more irritable (mean score = 6.6 ± 2.5) than did parents of the study children (mean score = 8.7 ± 1.7) at the time of departure for the operating room ($P < 0.001$). C. Parents of study children rated the overall preoperative experience better tolerated by their children (mean score = 8.6 ± 1.8) than did the parents of the control children (mean score = 7.4 ± 2.6, $P < 0.01$). From the histograms one can see that for all three questions most of the lowest scores were attributable to the control group.
clear liquids less than 2 h prior to the planned induction of anesthesia resulting in 30–60 min delays. With our previous instructions a wait of 6–8 h would have been required and often would have resulted in cancellation of the proposed operation.

References