Effect of Oral Liquids and Ranitidine on Gastric Fluid Volume and pH in Children Undergoing Outpatient Surgery


Eighty-eight children (mean age 5.6 yr, range 1–14 yr) about to undergo elective outpatient surgery were randomly assigned to four groups. All children were given phenolsulfonphthalein (PSP) orally 2–3 h before the scheduled time of surgery as a marker dye to assess gastric emptying. Immediately after receiving PSP they were given: group A—liquids, up to 5 ml/kg + placebo (glucose water 0.2 ml/kg); group B—liquids, up to 5 ml/kg + ranitidine 2 mg/kg in glucose water 0.2 ml/kg; group C—placebo only; group D—ranitidine only. Gastric contents were aspirated after induction of anesthesia. Mean volume (range) in ml/kg of aspirated gastric fluid in each group was: group A—0.34 (0.1–0.8); group B—0.17 (0–0.7); group C—0.25 (0–1.1); group D—0.16 (0–0.6). The pH mean (range) value was: group A—1.83 (0.9–3.6); group B—4.76 (2.0–7.7); group C—2.10 (1.2–4.1); group D—3.97 (1.3–7.3). PSP could not be detected in the gastric samples from children in whom the ingestion-sampling interval was more than 2.25 h. In comparison with prolonged starvation, administration of oral liquids without ranitidine 2–3 h preoperatively did not produce a significant increase in mean volume of gastric aspirate, and there was no increase in the number of patients with gastric aspirate greater than 0.4 ml/kg. Administration of ranitidine with or without fluids resulted in a decrease in both volume and acidity of gastric contents. (Key words: Anesthesia: outpatient; pediatric. Fluid balance: preoperative. Gastrointestinal tract: gastric emptying; pH. Pharmacology: Ranitidine.)

Patients are fasted prior to anesthesia to ensure the absence of particulate matter in the stomach, and a reduced volume of fluid in the stomach. It is generally believed that this practice should limit the severity of complications, in the event of aspiration of gastric contents. Unfortunately, the traditional fast does not ensure the above at induction of anesthesia. Clinical studies in adults1,2 have shown that many fasting patients have gastric fluid volumes in excess of 0.4 ml/kg and pH less than 2.5. Animal studies show these levels to be associated with increased mortality,3 although similar data in humans are obviously not available. The incidence (of increased gastric fluid volume and decreased gastric fluid pH) is higher in children, up to 80%,4,5 indicating that prolonged restriction of oral intake of liquids may not be beneficial in decreasing the risk from pulmonary acid aspiration at the time of induction of anesthesia. Despite this knowledge, restriction of oral liquid intake is an accepted standard of practice, and even young children may fast for 6 h or more. This study was therefore undertaken in children to assess both the effect of preoperative orange juice on gastric fluid volume and pH and the effectiveness of oral ranitidine in reducing gastric fluid volume and increasing gastric fluid pH at the time of induction of anesthesia.
For groups A and C, the placebo was glucose water 0.2 ml/kg; for groups B and D parenteral ranitidine 2 ml/kg was given orally in the solution.

The anesthetic was administered by an anesthesiologist not involved in the study. General anesthesia was induced with an inhalational or intravenous technique, according to the usual practice of the anesthesiologist.

Within 5 min following induction of anesthesia, a 14 G multiorifice orogastric tube was passed into the stomach, and its position was confirmed by auscultation of insufflated air over the epigastrium. Using a 60 ml syringe, the stomach was emptied thoroughly and the volume of aspirate was recorded. The pH of the aspirate was immediately measured using a Fisher Accumet 150 pH/ion meter which had been calibrated at pH 2–7. A portion of the sample was then frozen subsequent PSP concentration was measured spectrophotometrically\(^6\) at an alkaline pH from absorbance at 560\(\mu\)m, corrected for background absorbancies at 520 and 600\(\mu\)m.

The concentration of PSP was determined from the corrected absorbancy by reference to a standard curve; by then multiplying the PSP concentration by the volume of gastric aspirate, the percentage recovery of the administered dose was calculated.

Statistical differences between the groups were determined using analysis of variance, Mann-Whitney U-test or Fisher’s Exact Test, as appropriate. Where no gastric aspirate was obtained, volumes were recorded as 0. \(P < 0.05\) was considered statistically significant.

**Results**

Fifteen children were excluded from analysis because their ingestion-surgery interval was less than 90 min, as the interval was too short to expect a reliable effect from the ranitidine. This left 21 patients in group A, 18 in group B, 19 in group C, and 15 in group D.

There were no statistically significant differences between groups with regard to duration of fast, age, or weight (table 2). The ingestion to surgery intervals were significantly different between group A and group C only (\(P < 0.05\)).

Several children did not fulfil the requirements of the experimental protocol. No gastric sample could be obtained from one subject in group A, three subjects in group B, two subjects in group C, and one subject in group D. Six of the children in group A would not drink orange juice and accepted water as a substitute, and a further two children in group A refused to complete their drink, and consumed less than 3 ml/kg but more than 1 ml/kg. All eight of these children were excluded from subsequent comparison of gastric fluid volume and pH.

The volume of gastric sample obtained was expressed in ml/kg (table 3). There was no significant difference

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**Table 1. Details of Pretreatment Groups to which the Patients were Randomized**

<table>
<thead>
<tr>
<th>Group</th>
<th>Pretreatment</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Juice (5 ml/kg) + placebo</td>
<td>21</td>
</tr>
<tr>
<td>B</td>
<td>Juice (5 ml/kg) + ranitidine (2 mg/kg)</td>
<td>18</td>
</tr>
<tr>
<td>C</td>
<td>Placebo</td>
<td>19</td>
</tr>
<tr>
<td>D</td>
<td>Ranitidine (2 mg/kg)</td>
<td>15</td>
</tr>
</tbody>
</table>

All patients also received 1 ml of phenol red solution.

**Methods**

This study was approved by the University of Calgary Conjoint Medical Ethics Committee, and by the Alberta Children’s Hospital Research Committee. One of the investigators interviewed parents at the time of the child’s orientation visit to the hospital a few days before surgery or by telephone the day before surgery to explain the purpose of the study. On the day of surgery, written consent was obtained.

Eighty-eight children, ASA PS I or II, ages 1–14 yr participated in the study. Any child with a history of gastrointestinal disorder was excluded. All children were admitted to hospital on the day of surgery for elective ENT, urology, or minor general surgical procedures. No preanesthetic medication was given to any patients enrolled in this study, in accordance with the usual practice of the institution.

Patients were assigned into four groups for pretreatment (table 1), using a table of random numbers. All pretreatment was administered under supervision, with every child receiving 1 ml of phenolsulphophthalein solution (PSP) as a marker of the ingested liquid, and all agents were given orally, 2–3 h before the scheduled time of surgery. The concentration of PSP was adjusted to ensure a minimum concentration of 50 \(\mu\)g/ml in the total liquid load. The dose varied from 1–10 mg, according to the child’s weight, and the total volume of liquid administered.

Patients in groups A and B were offered pulp-free reconstituted, unsweetened, orange juice (Golden Grove Brand, Golden Grove Products, Calgary, Alberta) in a volume of 5 ml/kg. An upper limit of 150 ml liquid per patient was used for patients over 30 kg.

**Table 2. Characteristics of Each Subject Group**

<table>
<thead>
<tr>
<th>Group</th>
<th>(n)</th>
<th>Age (yr) (mean ± SD)</th>
<th>Weight (kg) (mean ± SD)</th>
<th>Fast to Ingestion (h) (mean ± SD)</th>
<th>Ingestion—Surgery (h) (mean ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>21</td>
<td>5.8 (0.75)</td>
<td>21.9 (2.74)</td>
<td>8.6 (0.65)</td>
<td>2.60 (0.17)*</td>
</tr>
<tr>
<td>B</td>
<td>18</td>
<td>5.8 (0.69)</td>
<td>22.0 (2.78)</td>
<td>8.8 (0.45)</td>
<td>2.25 (0.10)</td>
</tr>
<tr>
<td>C</td>
<td>19</td>
<td>5.2 (0.55)</td>
<td>21.0 (2.17)</td>
<td>8.6 (0.64)</td>
<td>2.02 (0.10)*</td>
</tr>
<tr>
<td>D</td>
<td>15</td>
<td>5.8 (0.79)</td>
<td>21.9 (2.40)</td>
<td>8.2 (0.72)</td>
<td>2.57 (0.25)</td>
</tr>
</tbody>
</table>

All values are mean (standard error).

\* = \(P < 0.05\).
between the two ranitidine groups, B and D. Although the mean of group A was higher than group C, this was not statistically significant using the Mann-Whitney U-test. There was a significant difference between the two groups given liquids, the gastric fluid volume being lower in group B (the ranitidine group) than in group A (P < 0.05). Using two-way analysis of variance, in which all the subjects who received liquids are compared with all the subjects who did not receive liquids, a statistically significant difference emerged between these sets of patients (P < 0.001). This indicates a significantly higher gastric fluid volume in the patients who received liquids, although the magnitude of the difference is small.

Mean pH values were significantly higher in subjects who received ranitidine (group A vs. group B, P < 0.001; group C vs. group D, P < 0.01) and there was no demonstrable effect of fluid administration on pH. There were, however, six patients who received ranitidine and had pH values of gastric aspirate of 2.5 or less, despite a pretreatment to induction interval of greater than 90 min. In three of these children, the ingestion-surgery interval was less than 2 h.

There were no patients in group D with both gastric fluid volume of >0.4 ml/kg and gastric fluid pH < 2.5 (table 4).

No dye was identified in any sample when the ingestion-surgery interval exceeded 135 min (32 patients). PSP retrieval was less than 5% in gastric fluid samples from all others, except for two patients in whom the ingestion-surgery interval was 1 h. In these children, dye retrieval was 33% in the group C patient, and 12% in the group B patient.

Orange juice used for this study was analyzed as having a pH of 3.9 and an osmolality of 547 mOsm/l. These values are similar to those measured for grape juice (pH 3.0 and 816 mOsm/l) and apple juice (pH 3.7 and 616 mOsm/l) used in our institution.

**Discussion**

Preoperative fasting is generally disliked by children, but anesthesiologists agree that some restriction of oral intake is necessary in the preoperative period. How long the period of fasting should be has not been determined. A recent survey (unpublished) of pediatric anesthesiologists who are members of the American Academy of Pediatrics demonstrated that feeding guidelines for children vary widely among institutions in the United States and Canada, and that fluid restriction is an accepted standard of practice—young children may have fluids restricted for 6 h or more. Experience in our institution has been that fluid restriction occasionally results in young patients receiving no oral intake for 12 h or more. To better establish the need, if any, of prolonged fluid restriction, this study was undertaken to determine if the administration of clear fluid preoperatively would alter gastric fluid pH and volume, and if an H2 receptor blocker would adequately reduce acid secretion and thus reduce preoperative risk from aspiration of gastric contents.

Studies on gastric physiology show that, under normal conditions, gastric emptying is relatively rapid. Following a fluid load, the stomach empties in an exponential manner: over 80% of the contents is cleared within the first hour. Since gastric emptying should be normal in the unmedicated patient without gastrointestinal disease, a fast of 2 h after fluids should be adequate to clear ingested liquids.

PSP was used in this study to assess the extent to which the sample obtained at induction reflected the liquids given earlier. The results are consistent with those of Miller et al., substantiating the existence of a dynamic gastric environment—despite starvation, the stomach continues to secrete and to reabsorb and eliminate liquid, and oral liquids are completely cleared by the stomach within 2.25 h. As there was no residual PSP, the gastric fluid sample obtained after this interval must reflect endogenous gastric secretion. The addition of ranitidine significantly reduced the volume of gastric aspirate in subjects who received ranitidine as well as fluids, suggesting a reduction in gastric secretion.

Several previous studies have investigated the effects of preoperative liquid administration in surgical patients. Miller et al. and Maltby et al. demonstrated that in adults, reducing the fasting time to 2–4 h and administering 150 ml of juice (approximately 2 ml/kg) did not

**Table 3. Results of Gastric Fluid Volume and pH Measurements**

<table>
<thead>
<tr>
<th>Group</th>
<th>Absolute Volume ml/kg</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.34 (0.1–0.6) [18]*</td>
<td>1.85 (0.9–3.6) [12]*</td>
</tr>
<tr>
<td>B</td>
<td>0.17 (0–0.7) [18]*</td>
<td>4.76 (2.0–7.7) [15]*</td>
</tr>
<tr>
<td>C</td>
<td>0.25 (0.9–1.1) [19]</td>
<td>2.10 (1.2–4.1) [10]*</td>
</tr>
<tr>
<td>D</td>
<td>0.16 (0–0.6) [18]</td>
<td>2.97 (1.3–7.3) [14]*</td>
</tr>
</tbody>
</table>

Mean ± S.E.

* P < 0.05 A versus B.
† P < 0.01 A versus B.
‡ P < 0.001 C versus D.

**Table 4. Incidence, by Group, of Patients with a Gastric Volume Greater than 0.4 ml/kg and pH Less than 2.5**

<table>
<thead>
<tr>
<th>Group</th>
<th>Volume &gt; 0.4 ml/kg</th>
<th>pH &lt; 2.5</th>
<th>Volume &gt; 0.4 ml/kg and pH &lt; 2.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5 (38%)</td>
<td>10 (83%)</td>
<td>5 (38%)*</td>
</tr>
<tr>
<td>B</td>
<td>2 (11%)</td>
<td>9 (20%)</td>
<td>1 (5.5%)*</td>
</tr>
<tr>
<td>C</td>
<td>6 (31%)</td>
<td>12 (53%)</td>
<td>6 (31%)*</td>
</tr>
<tr>
<td>D</td>
<td>1 (7%)</td>
<td>5 (21%)</td>
<td>0 (0%)*</td>
</tr>
</tbody>
</table>

* P < 0.05 A versus B.
** P < 0.05 C versus D.
result in an increase in gastric volume at induction of anaesthesia. Conversely, in children, Meakin et al. found that fasting for less than 4 h led to significantly higher gastric volumes. These conflicting results may have been due to differences in the study populations, the amount of fluids given, or aspiration technique. The major difference in reviewing these studies would appear to be in the amount and constitution of preoperative fluids. Miller et al. gave patients a light breakfast with a cup of liquid. Malby et al. gave their patients 150 ml of liquid alone. As a result, the relative volume of liquid given to the adults was 2–2.5 ml/kg whereas the children received 10 ml/kg. In the study by Meakin, a larger volume of liquid (10 ml/kg), and inclusion of subjects who received solids (cereal and milk) on the day of surgery, may account for results that are inconsistent with the present study.

We have demonstrated that preoperative administration of up to 5 ml/kg of liquid will result in clinically insignificant increased gastric fluid volume in children 1–14 yr of age, as measured 90–285 min after liquid administration. The orange juice used in this study had a high osmolality, and could have contributed to an increased gastric aspirate in those patients who received liquids. Hyperosmolar solutions containing glucose as a nonpenetrating solute will normally result in a prolongation of gastric emptying time as follows: gastric emptying is regulated by the osmotic pressure sensed in duodenal contents, and emptying would therefore be delayed until gastric secretions normalize the tonicity of gastric contents. In this study, administration of orange juice did not result in a clinically important increase in gastric fluid volume—the gastric fluid samples obtained were primarily related to gastric secretion, and were not associated with an increase in gastric acidity. The lack of clinical importance is emphasized by the observation that the proportion of patients in the high-risk group (table 4) was no different in groups A and C.

Our results confirm the findings of Goudouznian et al. that ranitidine 2 mg/kg produces a significant increase in gastric pH in children, although it did not raise the pH above 2.5 in every case. Out of a total of 33 patients who received ranitidine, six subjects failed to achieve a gastric fluid pH greater than 2.5. In four of these patients, the ingestion-surgery interval was less than 105 min, and this may have been inadequate time for a response to ranitidine to occur. In the remaining two patients, however, the ingestion-surgery intervals were over 2.5 h, indicating a failure of ranitidine to reduce gastric acidity in some patients.

We have shown that the intravenous preparation of ranitidine may be administered in combination with a simple sugar syrup and have an acceptable patient response.

For Day Surgery admissions, anesthesiologists should review the practice of prolonged preoperative fasting of children and consider the planned administration of fluids in the preoperative period to reduce patient discomfort and to eliminate the necessity for intraoperative intravenous rehydration. The results from this study suggest it is unnecessary to deprive unpremedicated children of oral fluids for more than 2.25 h before surgery, as all fluids administered in our study were cleared from the stomach by that time. Complications from gastric aspiration, should it occur, are unlikely when juice is administered 2.25 h prior to induction of anaesthesia.

The use of prophylactic H2 antagonists in pediatric outpatients undergoing anaesthesia should also be considered.

The authors wish to thank the Day Surgery nursing staff and anaesthesia colleagues for their cooperation in helping with the study; the Alberta Children's Hospital Pharmacy for preparation and provision of the ranitidine and sugar syrup; Ms. D. Aardv for statistical assistance; and Dr. Leo Strunin for his encouragement.

References