EFFECTS OF FASTING AND ORAL PREMEDICATION ON THE pH AND VOLUME OF GASTRIC ASPIRATE IN CHILDREN

G. MEAKIN, A. E. DINGWALL AND G. M. ADDISON

The aspiration of gastric contents remains a major cause of morbidity and mortality related to anaesthesia (Lunn and Mushin, 1982) and, in order to decrease the risk of pulmonary aspiration, it is customary to fast patients for at least 4 h before anaesthesia. However, it was claimed recently that a light meal 2–3 h before surgery did not alter the volume or pH of gastric aspirate in adults at the induction of anaesthesia (Miller, Wishart and Nimmo, 1983). If these results could be confirmed in children, a highly desirable decrease in the duration of fasting would be possible. Although fears that children are at increased risk of developing hypoglycaemia appear to have been unfounded (Redfern, Addison and Meakin, 1986), there is no doubt that they are more likely to become dehydrated or emotionally disturbed as a result of preoperative starvation.

Despite the widespread use of oral sedatives as premedicants in children, there have been no definitive studies of their effects on gastric function. Children in our hospital are routinely premedicated with trimeprazine (Vallergan) before inpatient surgery (Cope and Glover, 1959), although temazepam (Euhynpos) has been introduced recently as a premedicant for outpatients (Greenwood and Bradshaw, 1983). In the present study, the pH and volume of gastric aspirate were measured after the induction of anaesthesia in children to determine the effects of these premedicants, and of fasting for less than 4 h.

SUMMARY
The pH and volume of gastric aspirate were measured immediately after the induction of anaesthesia in 224 healthy children to determine the effects of decreasing the period of fasting and of giving oral premedicants before anaesthesia. Fasting for less than 4 h was found to increase the volume of gastric aspirate and the risk of developing pulmonary aspiration syndrome. Trimeprazine syrup was found to increase the pH of the gastric contents, and decrease the likelihood of the pulmonary aspiration syndrome. There was a significant increase in gastric volume in patients premedicated with temazepam elixir which did not occur in patients given temazepam capsules. These results support the custom of fasting patients for at least 4 h before anaesthesia and indicate that oral premedicants and their vehicles can have significant effects on the stomach.

PATIENTS AND METHODS
The design of the study was approved by the hospital Ethics Committee and parental consent was obtained. Two hundred and twenty-four healthy children undergoing elective surgery in the afternoon were studied. Approximately half were scheduled for tonsillectomy, whilst the remainder were to undergo minor surgical procedures on the body wall. For most the last main meal consisted of a breakfast of cereals and milk given before 8.00 a.m., after which all oral intake was recorded.

Patients were divided into five groups (table I). Children in group 1, the control group, fasted for a minimum of 4 h and received no premedication. Patients in group 2 received no premedication,
but were divided into subgroups A and B to receive either a drink of orange squash (10 ml kg\(^{-1}\), maximum 200 ml), or a drink and two plain biscuits, 2–4 h before anaesthesia. Patients in groups 3, 4 and 5 fasted for a minimum of 4 h and received oral premedication. Group 3 received trimeprazine syrup 3 mg kg\(^{-1}\) (max. 90 mg) 2 h, group 4 received temazepam elixir 1 mg kg\(^{-1}\) (max. 20 mg) 1 h, and group 5 received a similar dose of temazepam in capsule form 1 h, before operation.

Before the induction of anaesthesia, patients were asked to breathe 100% oxygen via an anaesthetic face mask for a few minutes. Anaesthesia was induced with thiopentone 6–8 mg kg\(^{-1}\). This was followed by atropine 0.02 mg kg\(^{-1}\), and suxamethonium 1–2 mg kg\(^{-1}\) to facilitate tracheal intubation. Firm sustained pressure was applied to the cricoid cartilage after the loss of consciousness until the tracheal tube was in situ. Once the tracheal tube had been fixed in position with adhesive strapping, a 12–14 gauge Ryles tube was passed through the mouth into the stomach. The position of the tube was verified by auscultation over the epigastrium during the insufflation of air, and the gastric contents were aspirated using a 20-ml syringe. Manual pressure was applied over the epigastrium during aspiration—which was repeated in the right and left lateral positions, and in the head down position, for maximal recovery of gastric contents. The Ryles tube was removed. The gastric aspirate was examined for the presence of particulate matter, and its volume was measured using a graduated cylinder. A sample was sent to the laboratory for determination of pH using a Radiometer electrode.

Patients whose gastric aspirate had a pH less than 2.5 and a volume greater than 0.4 ml kg\(^{-1}\) were considered at risk of developing the pulmonary aspiration syndrome (Teabeaut, 1952; Roberts and Shirley, 1974). Statistical differences were determined using the Mann–Whitney U test or the \(\chi^2\) test where appropriate. The null hypothesis was rejected when \(P < 0.05\).

**RESULTS**

The ages and weights of the patients in the control group and the major test groups were similar (table I). The ages and weights of those children who received temazepam capsules differed significantly from those in the control group, because of the inability of small children to swallow large gelatin capsules.

**Unpremedicated patients**

Data from the unpremedicated groups are summarized in table II. It will be seen that gastric

### Table I. Details of patient groups (mean values and range). Statistical differences from controls: *P < 0.05; ***P < 0.001

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Fasting period (h)</th>
<th>Age (yr)</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Control</td>
<td>55</td>
<td>7.1 (4.1–16.7)</td>
<td>6.6 (1–14)</td>
<td>26.1 (10–77)</td>
</tr>
<tr>
<td>2A. Drink</td>
<td>34</td>
<td>3.0 (2.1–3.8)***</td>
<td>8.1 (2–16)</td>
<td>28.1 (13–55)</td>
</tr>
<tr>
<td>2B. Drink and biscuits</td>
<td>32</td>
<td>3.1 (2.1–3.9)***</td>
<td>6.0 (1–12)</td>
<td>22.3 (10–41)</td>
</tr>
<tr>
<td>3. Trimeprazine syrup</td>
<td>48</td>
<td>7.2 (4.0–18.2)</td>
<td>5.7 (1–15)</td>
<td>23.8 (12–62)</td>
</tr>
<tr>
<td>4. Temazepam elixir</td>
<td>39</td>
<td>7.1 (4.1–17.1)</td>
<td>6.6 (2–16)</td>
<td>25.6 (12–66)</td>
</tr>
<tr>
<td>5. Temazepam capsules</td>
<td>16</td>
<td>8.8 (4.2–17.8)</td>
<td>9.1 (4–14)*</td>
<td>32.3 (18–59)*</td>
</tr>
</tbody>
</table>

### Table II. Data from unpremedicated children. Significant differences from controls: *P < 0.05, **P < 0.01

<table>
<thead>
<tr>
<th>Group</th>
<th>Volume of aspirate (ml kg(^{-1}))</th>
<th>“Dry” patients No. (%)</th>
<th>pH of aspirate Median (Range)</th>
<th>Aspirates with pH &lt; 2.5 and vol. &gt; 0.4 ml kg(^{-1}) No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Control</td>
<td>0.25 (0.04)</td>
<td>16 (29)</td>
<td>1.9 (1.1–2.5)</td>
<td>12 (22)</td>
</tr>
<tr>
<td>2A. Drink</td>
<td>0.39 (0.06)*</td>
<td>4 (12)*</td>
<td>1.7 (1.3–6.0)</td>
<td>15 (44)*</td>
</tr>
<tr>
<td>2B. Drink and biscuits</td>
<td>0.46 (0.06)**</td>
<td>3 (9)</td>
<td>1.8 (1.4–5.5)</td>
<td>15 (47)*</td>
</tr>
</tbody>
</table>
TABLE III. Data from controls and children given premedication by mouth. Significant differences from controls: *P < 0.05; **P < 0.01; ***P < 0.001

<table>
<thead>
<tr>
<th>Group</th>
<th>Volume of aspirate (ml kg(^{-1}))</th>
<th>&quot;Dry&quot; patients No. (%)</th>
<th>pH of aspirate Median (Range)</th>
<th>Aspirates with pH &lt; 2.5 and vol. &gt; 0.4 ml kg(^{-1}) No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Control</td>
<td>0.25 (0.04)</td>
<td>16 (29)</td>
<td>1.9 (1.1-2.5)</td>
<td>12 (22)</td>
</tr>
<tr>
<td>3. Trimeprazine syrup</td>
<td>0.19 (0.04)</td>
<td>17 (35)</td>
<td>2.2 (1.8-7.8)***</td>
<td>3 (6)*</td>
</tr>
<tr>
<td>4. Temazepam elixir</td>
<td>1.10 (0.11)**</td>
<td>1 (3)**</td>
<td>2.2 (1.6-6.5)***</td>
<td>21 (54)**</td>
</tr>
<tr>
<td>5. Temazepam capsules</td>
<td>0.32 (0.07)</td>
<td>3 (19)</td>
<td>1.8 (1.5-2.8)</td>
<td>6 (38)</td>
</tr>
</tbody>
</table>

Aspirate was significantly increased in children given a drink (P < 0.05) or a drink and biscuits (P < 0.01) within 4 h of operation. Although the increase in volume tended to be greater in patients given biscuits compared with those given a drink alone, this difference was not significant.

In each group there were a number of patients from whom no aspirate could be obtained. The frequency of these "dry" patients tended to be greater in the control group than in patients fasted for less than 4 h, and when data from the latter groups were combined this difference was shown to be significant (P < 0.05). No significant differences were found between the pH values of the gastric content in the unpremedicated groups. pH was less than 2.5 in 93% of the patients from whom an aspirate was obtained.

In both groups fasted for less than 4 h, there was a statistically significant increase in the number of aspirates with a pH of less than 2.5 and volume greater than 0.4 ml kg\(^{-1}\). They were considered at risk of developing pulmonary aspiration syndrome (P < 0.05).

Premedicated patients

Table III compares data from the premedicated groups and the unpremedicated controls. Premedication with trimeprazine syrup tended to decrease the volume of aspirate and increase the number of "dry" patients, although this difference was not significant. In contrast, there was a large and statistically significant increase in the volume of aspirate (P < 0.001) and fewer dry patients (P < 0.01) after premedication with temazepam elixir—a feature noted in the patients given temazepam capsules. pH was significantly increased in patients premedicated with trimeprazine syrup (P < 0.001) and temazepam elixir (P < 0.001), but not in patients given temazepam capsules.

Applying the criteria of pH and volume, the risk of developing pulmonary aspiration syndrome was significantly reduced by premedication with trimeprazine syrup (P < 0.05), increased by premedication with temazepam elixir (P < 0.01) and unchanged by premedication with temazepam capsules.

DISCUSSION

Measurements of the pH and volume of gastric aspirate have been used to identify patients at risk of developing pulmonary damage in the event of pulmonary aspiration. The criteria used, namely, a pH less than 2.5 and a volume greater than 0.4 ml kg\(^{-1}\), were derived from experiments on rabbits and rhesus monkeys which clearly cannot be reproduced in humans. Although there must be some doubt as to whether these criteria can be strictly applied to our patients, they have been used extensively in previous studies in children (see below), and there appears to be general agreement that the effect of aspirated volume is pH dependent (Morgan, 1984).

Our finding that the volume aspirated was greater in children fasted for less than 4 h would seem to be in agreement with the notion of a 2–4 h gastric emptying time (Bannister and Sattilaro, 1962; Green, 1978). The normal variation in gastric emptying time is largely attributable to differences in the physical and chemical properties of the food ingested (Heading, 1980). Thus liquids pass more rapidly from the stomach than solids, and a meal rich in carbohydrates will be evacuated more rapidly than one rich in proteins or fats. The rate of gastric emptying is also affected by the pH...
P.H AND VOLUME OF GASTRIC CONTENTS

and osmolality of the meal. Although there was a
tendency for higher volumes in patients given a
drink and biscuits compared with those given a
drink alone, the difference between the two fed
groups was less than might have been anticipated.
One reason for this may have been the decision to
give orange squash to our patients rather than
water. Dilute orange squash, which has a pH of
approximately 3.2 and an osmolality of
269 mmol kg\(^{-1}\), could have delayed gastric
emptying in both groups. Whilst the choice of the
test drink was largely dictated by custom, it was
thought that many children would refuse to drink
water.

The results of the present study apparently
conflict with the findings of Miller, Wishart and
Nimmo (1983). These authors found no difference
in the volume of the gastric aspirate at induction
of anaesthesia in 22 adult patients fasted overnight,
compared with 23 patients fed on the morning of
surgery. They concluded that a fast of 2–3 h was
adequate to ensure the minimum gastric volume
after a light breakfast. Although gastric stasis is
said to be common in neonates (Kliegman and
Fanaroff, 1983) we have been unable to find any
evidence that the rate of gastric emptying in older
children differs from that in adults. A more likely
explanation for the discrepancy is that many of the
fed patients in the adult study were fasted for
longer than anticipated. Despite the fact that
breakfast was permitted 2–3 h before surgery, 10
patients fasted for longer than 4 h, and the mean
fasting time for the group as a whole was 3.8 h.

Our results confirm those of earlier studies
which showed that the pH of gastric contents is
less than 2.5 in the great majority of anaesthetized
children (Salem et al., 1976; Goudsouzian et al.,
1981; Yildiz et al., 1984; Manchikanti et al.,
1985). The volumes of aspirate obtained from our
control group (tables II and III) were somewhat
less than those obtained in previous studies. This
may be the result of methodological differences
such as the use of premedicants in most of the
previous studies, and the use in some of Salem
sump tubes to aspirate the stomach. Whilst no
method using a gastric tube can guarantee to
empty the stomach completely, it may be that
vented sump tubes are more efficient than the
single-lumen Ryles tubes used in our study. However,
when comparing the results from
groups within the present study, the use of a
standard method to obtain samples should
minimize the importance of any constant error.

Although all the patients in the control group
had fasted for a minimum of 4 h (table I), 17
patients received a drink and 18 patients received
a drink and two biscuits 4–6 h before anaesthesia.
However, no significant difference in the pH or
volume of the aspirate or the number at risk of
aspiration was found between these patients and
the remaining 20 patients of the control group
who had fasted for longer than 6 h.

Trimeprazine is a mild phenothiazine sedative
with antihistaminic and anticholinergic properties
(Vickers, Schnieden and Wood-Smith, 1984).
The latter may account for the increase in pH and
the trend towards a decrease in volume in those
patients premedicated with trimeprazine syrup
(table III). Indeed, similar results have been
obtained in children premedicated with atropine
and glycopyrrolate (Salem et al., 1976). Tema-
zepam, on the other hand, is a short acting
benzodiazepine which should be devoid of any
direct gastrointestinal actions (Gilman, Goodman
and Gilman, 1980). For this reason we supposed
that the observed increase in the volume of the
stomach contents after temazepam elixir might
have been caused by one or more constituents of
the vehicle. This hypothesis would appear to be
supported by our results with temazepam capsules
(table III).

Water insoluble temazepam is prepared as an
elixir with approximately 9% ethanol, 45% sorbitol
and 50% glycerol, all of which can
produce significant gastrointestinal effects. Etha-
nol is a very effective stimulant of gastric acid
secretion, possibly acting directly on the gastric
mucosa, but also by releasing gastrin from cells in
the antral region of the stomach (Gilman,
Goodman and Gilman, 1980). Sorbitol and
glycerol are osmotically active in the concentra-
tions given (Reynolds, 1982), and there is evidence
that glycerol produces gastric irritation (Staples,
Misher and Wardell, 1967). The increase in pH
seen in patients given temazepam elixir, but not in
those given temazepam capsules, is attributed to
the dilution of gastric acid by mucus secretion and
fluid drawn into the stomach by osmosis.

Under the conditions of the present study there
was an increase in the volume of aspirate and the
number of patients at risk of developing pul-
monary aspiration syndrome when small amounts
of food or drink were given within 4 h of
operation. Thus the practice of fasting patients for
at least 4 h before anaesthesia would appear to be
justified. However, aspiration of gastric contents
may also cause injury, even death, if the airway is blocked by large particles of food. In the present study identifiable food residue was found in the gastric aspirates of three patients given biscuits within 4–6 h, and in 13 patients given biscuits within 4 h, of operation. No solid particles were found in the aspirates of patients denied food for longer than 6 h, supporting the view that large meals should be prohibited within 6 h of operation.

The study also demonstrated that oral premedicants and their vehicles may have significant effects on the stomach. Trimeprazine syrup, an oral premedicant used commonly, was found to increase pH and decrease the risk of developing pulmonary aspiration syndrome. Temazepam in the form of a low-alcohol elixir, but not as capsules, was found to increase the volume of aspirate and the risk of lung damage in the event of pulmonary aspiration.

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REFERENCES