COMPARISON OF THE PROPHYLACTIC USE OF MAGNESIUM TRISILICATE MIXTURE B.P.C., SODIUM CITRATE MIXTURE OR CIMETIDINE IN OBSTETRICS

M. FRANK, M. EVANS, P. FLYNN AND C. AUN

SUMMARY

The effects of magnesium trisilicate mixture B.P.C., sodium citrate mixture or cimetidine on gastric pH and aspirated gastric volumes were compared in 78 obstetric patients during elective (a), or emergency (b) surgery. Magnesium trisilicate mixture B.P.C. was associated with the most alkaline values of gastric pH (mean (a) 7.9, (b) 7.3; range 2.9–9.1). Sodium citrate 0.3 mol litre⁻¹ mixture resulted in the narrowest range of pH values of gastric contents (mean (a) 5.4, (b) 5.9; range 3.9–7.7). The ranges of aspirated gastric volumes were wide with both antacid regimens (magnesium trisilicate 12–172 ml, sodium citrate 9–290 ml). Cimetidine increased gastric pH to greater than 2.5 in 82% of patients (mean (a) 6.2, (b) 5.0; range 1.6–7.3), and was associated with significantly smaller volumes of aspirated gastric contents (range 0.5–44 ml). When gastric pH and volume were considered together, the groups of patients who received cimetidine were found to be closest to the defined "safe limits", of pH > 2.5 and volume < 25 ml.

Aspiration pneumonitis in obstetric patients was described initially by Hall (1940). Preventive measures, recommended first by Mendelson (1946), included emptying of the stomach and neutralization of the remaining contents before the induction of anaesthesia.

Since that date there has been a tendency to focus attention on increasing the pH of the gastric contents, while less consideration has been given to their volume. Thus it has become established practice in the United Kingdom to use magnesium trisilicate B.P.C. to neutralize gastric contents (Taylor and Pryse-Davies, 1966; Crawford, 1971). However, as yet there has been no decrease in maternal mortality associated with aspiration of gastric contents (Tomkinson et al., 1979, 1982). In the 1973–75 report (Tomkinson et al., 1979), eight of the nine patients who died received the recommended dose of antacids, and the report concluded that "Antacid therapy as presently practised... requires re-examination".

Possible causes for the lack of efficacy of antacids include inefficient mixing of the magnesium trisilicate with the gastric contents, and the effect on the lungs following aspiration of the antacid itself (Gibbs et al., 1979). Sodium citrate was found to mix more effectively with gastric contents (Holdsworth et al., 1980) and to cause only transient and mild pulmonary changes when inhaled (Gibbs, Hempling and Wynne, 1979). Recently, interest in H₂-receptor antagonists has grown and variable results have been obtained following different regimens using cimetidine in obstetric patients (Husemeyer and Davenport, 1980; Pickering, Palahniuk and Cumming, 1980; Hodgkinson et al., 1982; Johnston et al., 1982; Ostheimer et al., 1982).

This study was undertaken to compare gastric pH and volume following the administration of magnesium trisilicate mixture B.P.C., sodium citrate mixture and cimetidine in elective and emergency obstetric patients.

PATIENTS AND METHODS

Seventy-eight obstetric patients (ASA 1 and 2) at term were studied. Forty-six patients underwent elective surgery and 32 required an emergency operation. They were allocated randomly to three groups according to the planned medication. Informed consent was obtained from each patient.

Elective anaesthesia

Group A. Patients received 15 ml of magnesium trisilicate mixture B.P.C. before transfer to the operating theatre, and a further 15 ml before the induction of anaesthesia.

Group B. Patients received sodium citrate mixture using the same regimen as group A.

Group C. Patients received cimetidine 400 mg orally the night before operation and a further...
200 mg i.m. 90 min before the induction of anaesthesia.

**Emergency anaesthesia**

Patients in labour who subsequently required anaesthesia for emergency surgery were in one of the following groups:

- **Group A.** Patients were given 15 ml of magnesium trisilicate mixture B.P.C. every 2 h throughout labour, and again before the induction of anaesthesia.

- **Group B.** Patients received sodium citrate mixture using the same regimen as group A.

- **Group C.** Patients were given a loading dose of cimetidine 400 mg orally followed by 200 mg orally every 2 h for a maximum of seven doses. They drank water 15 ml with each administration.

The technique of analgesia used during labour was noted for each patient, including the drugs administered and the times of their administration.

General anaesthesia was used in all patients. A Crawford's wedge was used for lateral uterine displacement, the patient was preoxygenated for 3–5 min and cricoid pressure applied. Methohexi
tone 80–100 mg and suxamethonium 75–100 mg were administered i.v. and tracheal intubation performed. Anaesthesia was maintained with 50% nitrous oxide and 0.2–0.5% halothane in oxygen until the delivery of the infant. Then 67% nitrous oxide in oxygen, supplemented with fentanyl 0.05–0.2 mg was used.

Immediately after the induction of anaesthesia, a wide-bore orogastric tube was passed and aliquots of 5–10 ml of gastric contents were aspirated, timed and labelled. When a large volume of gastric contents was encountered, the remainder was collected in samples of 20 ml or more. Therefore the number of samples collected from each patient varied according to the final volume aspirated. When no further aspiration was possible, the tube was withdrawn and reintroduced two more time in an attempt to aspirate further residual contents.

The pH of each collected sample of gastric contents was measured with a Radiometer 27 pH meter to test the range of pH in each patient as a possible measure of inefficient mixing of antacid with gastric contents. The total volume of aspirated contents for each patient was measured.

**Fig. 1. Ranges of gastric pH in the individual patients during anaesthesia.** — Elective; . . . = emergency.
PROPHYLAXIS AGAINST ASPIRATION PNEUMONITIS

TABLE I. Median pH of the aspirated gastric contents in patients undergoing elective obstetric surgery. *P < 0.05; **P < 0.01 (Kruskal–Wallis test)

<table>
<thead>
<tr>
<th>Medication</th>
<th>n</th>
<th>Minimum pH</th>
<th>Mean pH</th>
<th>Maximum pH</th>
<th>Range (mean pH)</th>
<th>pH &lt; 2.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnesium trisilicate</td>
<td>12</td>
<td>7.7*</td>
<td>7.9</td>
<td>8.1**</td>
<td>5.2–9.1</td>
<td>0</td>
</tr>
<tr>
<td>Sodium citrate</td>
<td>15</td>
<td>5.4</td>
<td>5.4</td>
<td>5.8</td>
<td>3.9–7.7</td>
<td>0</td>
</tr>
<tr>
<td>Cimetidine</td>
<td>15</td>
<td>5.6</td>
<td>6.2</td>
<td>6.7</td>
<td>1.6–7.3</td>
<td>3</td>
</tr>
</tbody>
</table>

Neonatal Apgar scores at 1 and 5 min were recorded.

RESULTS

pH of gastric contents

The minimum and maximum pH values of aspirated gastric contents for each patient are plotted in figure 1. One patient in group A who received magnesium trisilicate before elective surgery showed a range of gastric pH from 2.1 to 8.0 (5.9) while the pH range found in the remaining patients in this group was 3.1 or less. There was considerable variation in gastric pH between patients and many produced alkaline gastric contents (11 of 23 patients had gastric pH greater than 8.0). In group B, the maximum pH range in any patient was 1.6 and the variation of gastric pH between patients receiving sodium citrate was less than in group A. In two patients in group C, gastric pH ranged from 3.2 to 7.6 and 2.6 to 7.2, respectively. However, these samples were contaminated, in one patient with duodenal contents and in the other with saliva as the tube was withdrawn. The remaining patients who received cimetidine showed an individual range of pH of 1.5 or less in their aspirated gastric contents. The variation between patients in this group was greater than in group B and comparable to that in group A, although the spectrum spread over a lower pH. The variation in pH in the measured gastric contents for each patient was not related to the order of collection of the samples nor of their timing, but reflected the degree of pH heterogeneity in the stomach within a narrow time interval.

The medians of the minimum, maximum and mean gastric pH values for patients undergoing elective procedures in each group are shown in table I, and for patients undergoing emergency surgery, in table II.

Examination of individual results (fig. 1) showed that, in group A, there was a greater scatter of pH values, from 2.1 to 9.4. One patient in group A produced some samples with a pH less than the regarded critical value of 2.5. Group B showed the least scatter of pH values (3.15–8.0). In group C, three patients who underwent elective surgery and one undergoing emergency operation produced gastric contents with a pH at or less than 2.5, while the remainder (82%) were above this figure. Actual pH values for all patients in this group ranged from 1.5 to 7.6.

Volumes of aspirated gastric contents

In the patients scheduled for elective surgery the

TABLE II. Median pH of aspirated gastric contents in patients undergoing emergency obstetric surgery

<table>
<thead>
<tr>
<th>Medication</th>
<th>n</th>
<th>Minimum pH</th>
<th>Mean pH</th>
<th>Maximum pH</th>
<th>Range (mean pH)</th>
<th>pH &lt; 2.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnesium trisilicate</td>
<td>11</td>
<td>6.8</td>
<td>7.3</td>
<td>7.4</td>
<td>2.9–8.9</td>
<td>0</td>
</tr>
<tr>
<td>Sodium citrate</td>
<td>10</td>
<td>5.8</td>
<td>5.9</td>
<td>6.0</td>
<td>4.7–6.2</td>
<td>0</td>
</tr>
<tr>
<td>Cimetidine</td>
<td>9</td>
<td>4.9</td>
<td>5.0</td>
<td>5.1</td>
<td>3.4–7.1</td>
<td>0</td>
</tr>
</tbody>
</table>
Table III. Aspirated gastric volumes in obstetric patients undergoing anaesthesia for obstetric surgery. * P < 0.001; ** P < 0.01 (Kruskal–Wallis test)

<table>
<thead>
<tr>
<th></th>
<th>Elective</th>
<th></th>
<th>Emergency</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Range (ml)</td>
<td>Median (ml)</td>
<td>&gt; 25 ml</td>
</tr>
<tr>
<td>Magnesium</td>
<td>12</td>
<td>13–99</td>
<td>47</td>
<td>9</td>
</tr>
<tr>
<td>trisilicate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sodium</td>
<td>15</td>
<td>9–125</td>
<td>49</td>
<td>13</td>
</tr>
<tr>
<td>citrate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cimetidine</td>
<td>16</td>
<td>0.5–39</td>
<td>10*</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Median volumes for patients in group A, 47 ml, and group B, 49 ml, differed significantly from that of patients in group C, 10.0 ml (P < 0.001, Kruskal–Wallis test) (table III). Most patients in groups A and B had gastric aspirates greater than the suggested safe maximum value of 25 ml, but only one patient in group C exceeded this value. However, the aspirate of this patient was contaminated with bile and it is possible that the tube had passed into the duodenum (fig. 2).

In patients undergoing emergency surgery (table III) the median values for group A, 42 ml and group B, 46 ml, differed significantly from group C, 24 ml (P < 0.01, Kruskal–Wallis test). The range of aspirated volumes showed a marked individual variation in groups A and B, while in group C all patients had gastric aspirates less than 50 ml, and more than 50% were below 25 ml (fig. 2).

The relationships between gastric pH and aspirated gastric volume were plotted for all patients.

![Figure 2](https://academic.oup.com/bja/article-abstract/56/4/355/256479)

**FIG. 2.** Distribution of aspirated gastric volume in obstetric patients following the administration of magnesium trisilicate mixture B.P.C. (black columns), sodium citrate mixture (cross-hatched columns) or cimetidine (open columns).
There was a tendency towards more alkaline contents and a wider range of aspirated volumes in group A patients. The high volumes but more consistent gastric pH values found in group B patients are also evident. The largest number of coordinate volume/pH values lying within and close to the hypothetical "safe" area, denoting gastric pH greater than 2.5 and a volume less than 25 ml were obtained in patients in group C. Three patients in this group who underwent elective surgery produced gastric contents of pH below 2.5, but had aspirated gastric volumes of 4, 9 and 22 ml. One patient from group C who underwent emergency surgery produced 44 ml of gastric juice of pH 2.6.

When the relationship between analgesia during labour, aspirated volume and pH of gastric contents, and the duration of labour was examined, it was found that those patients who received pethidine (18 out of 32) showed a significant correlation ($P < 0.05$) between duration of labour and the volume of gastric contents aspirated.

Neonatal Apgar scores at 1 and 5 min following elective or emergency Caesarean section were similar in the three groups.

DISCUSSION

In the present study, the effects of magnesium trisilicate mixture B.P.C., sodium citrate mixture 0.3 mol litre$^{-1}$ or cimetidine on gastric pH and aspirated volume were compared. The administration of magnesium trisilicate mixture B.P.C. resulted in more alkaline gastric contents although the high pH values may be undesirable. In at least one patient who received magnesium trisilicate the range of pH of aspirated samples (2.1–8.0) suggested the possibility of inadequate mixing of antacid with gastric juice, resulting in pockets of unduly acid gastric contents. The most consistent results in relation to neutralization of gastric contents were obtained in the group of patients who received sodium citrate mixture, and this was noted in both the elective and emergency situations. There was also a more limited range of pH variation between samples obtained in each patient. No attempts were made to mix the antacids with the gastric residue by rotation or side-to-side movement of the patient as described by Holdsworth and co-workers (1980), and the results of this study suggest that this may not be necessary when sodium citrate is used. Both magnesium
trisilicate- and sodium citrate-treated patients produced a wide range of gastric volume, and the effectiveness of a single dose of sodium citrate 0.3 mol litre⁻¹ in increasing gastric pH when given to parturients a short time before anaesthesia (Lahiri, Thomas and Hodgson, 1973; Gibbs, Spohr and Schmidt, 1982; Stoops, Ravindran and Viegas, 1983) indicates that this may be preferable to multiple doses throughout labour.

The preoperative administration of cimetidine increased the pH of the gastric contents in patients who underwent elective or emergency procedures to greater than 2.5 in 82% of cases. The three elective and one emergency patient whose gastric pH values were at or below 2.5 following cimetidine suggest that this group, when compared with the other two groups, is less reliable when neutralization of gastric contents is considered in isolation. However, evidence suggests that the correction of gastric pH alone does not protect against aspiration pneumonitis. Experimental work (Gibbs et al., 1979) and clinical experience (Bond, Stoelting and Gupta, 1979) have shown that severe pulmonary damage may be caused by the aspiration of a particulate antacid, and maternal deaths have been reported following the aspiration of neutral gastric contents (Whittington, Robinson and Thompson, 1979), and after the recommended administration of magnesium trisilicate mixture B.P.C. (Tomkinson et al., 1979). In addition, animal studies have shown that the volume of acid gastric juice aspirated into the lungs determines the extent of the resulting pulmonary damage and its clinical outcome. Extrapolation to the human suggests that the aspiration of less than 25 ml is likely to cause little lasting damage (Roberts and Shirley, 1974). Therefore, attention should be given to the volume and nature of gastric contents as well as to their acidity.

According to the accepted approximation to a "safe" situation in which gastric volume is less than 25 ml and pH more than 2.5, in this study the cimetidine-treated patients were least at risk when compared with the other two groups. Those patients prepared for elective surgery who received cimetidine 400 mg by mouth the night before, and 200 mg i.m. 90 min before surgery all produced gastric volumes less than 25 ml except for one patient whose aspirate included duodenal contents. The median volume of 10.0 ml compares closely to the 10.5 ml found in the study by Johnston and colleagues (1982a) although, in their study, the range of aspirated gastric contents was 0–75 ml. A possible explanation for this difference may be that the i.m. injection of the cimetidine was more effective than the oral administration used by Johnston and co-workers. Weber and Hirshman (1979) demonstrated consistent increases in the pH of gastric contents (range 6.4–8.1) following a regimen of cimetidine 300 mg by mouth at night and 300 mg i.m. 90 min before surgery, in contrast to a regimen in which cimetidine was given orally on both occasions (pH range 2.2–7.5). A similar plasma concentration pattern has been found whether the same dose of cimetidine was injected i.v. or i.m., while concentrations during the 1st hour after the oral administration of cimetidine were one-third to one-half of those obtained when the drug was administered parenterally (Walkenstein et al., 1978).

The patients in our study who received cimetidine by mouth during labour and required anaesthesia for emergency surgery also produced low gastric aspirates (all less than 50 ml) compared with patients who received antacids. The cimetidine tablets were taken with 15 ml of water. Thus, the volume of fluid ingested was similar to that received by patients given an antacid. Johnston and co-workers (1982b) noted decreases in the average volumes of gastric contents in emergency obstetric patients treated with cimetidine, although a considerably greater range of aspirated gastric volumes was found in their series. The oral administration of cimetidine during labour, although associated with lower gastric volumes and, therefore, possibly, a lower risk of regurgitation, cannot be considered invariably reliable. The decreased effectiveness of the oral route of administration when gastric emptying is delayed may be responsible.

In this study those patients who received pethidine for analgesia showed a significant relationship between duration of labour and volume of gastric contents. The delaying effect of narcotic analgesics on gastric emptying during labour has been demonstrated previously (Nimmo, Wilson and Prescott, 1975; Wilson, 1978).

In conclusion, sodium citrate mixture most consistently neutralized the pH of the gastric contents but it was often associated with large volumes. Cimetidine was found to decrease the volume of gastric contents in elective obstetric patients when given orally the night before and by i.m. injection 90 min before anaesthesia. In the emergency situation, the decrease in gastric volume produced by oral cimetidine may decrease the risk of regurgitation. However, a preanaesthetic dose of sodium
citrate mixture in the emergency situation would be a precautionary measure. In those patients who have endured prolonged labour and narcotic analgesics, emptying of the stomach by mechanical or pharmacological means before anaesthesia might be considered an additional safety factor.

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COMPARAISON DES RESULTATS DE L'UTILISATION PROPHYLACTIQUE D'UN MELANGE DE TRISILICATE DE MAGNESIUM BPC, D'UN MELANGE DE CITRATE DE SODIUM OU DE LA CIMETIDINE AU COURS DU TRAVAIL

RESUME

Nous avons comparé les effets d'un mélange de trisilicate de magnésium BPC, d'un mélange de citrate de sodium et ceux de la cimétidine sur le pH gastrique et les volumes gastriques aspirés chez 78 patientes obstétriques opérées à froid (a) ou en urgence (b). C'est avec le mélange de trisilicate de magnésium BPC qu'ont été obtenues les valeurs les plus élevées de pH gastrique (moyenne pour (a) = 7,9 ; pour (b) = 7,3 ; éventail de 2,9-9,1). Le mélange de citrate de sodium a permis d'obtenir les valeurs les plus groupées de pH gastrique (moyenne (a) = 5,4 ; (b) = 5,9 ; éventail de 3,9-7,7). Les écarts dans les volumes gastriques aspirés étaient importants avec les deux solutions tampons (trisilicate de magnésium 12-172 ml, citrate de sodium 9-290 ml). La cimétidine élevait le pH gastrique au-dessus de 2,5 chez 82% des patientes (moyenne (a) = 6,2 ; (b) = 5,0 ; éventail de 1,6-7,3) et était associée à des volumes de liquide gastrique aspiré nettement plus faible (éventail de 0,5-44 ml). Si l'on considère l'association de pH gastrique et du volume aspiré, ce sont les patientes qui avaient reçu de la cimétidine qui étaient les plus proches de ce que l'on considère comme les "limites de sécurité" c'est-à-dire pH > 2,5 et volume < 25 ml.
ZUSAMMENFASSUNG

Die Auswirkungen der drei obigen Drogen auf gastrisches pH und auf abgesaugte gastrische Volumenmengen wurden bei 78 Frauen in Geburtswehen während elektiver (a) oder Noteingriffen (b) miteinander verglichen. Magnesiumtrisilikatmischung B.P.C. war verbunden mit den alkalischsten Werten für gastrisches pH (Mittel a) 5,4, b) 7,3; Bereich 2,9–9,1). Natriumzitratmischung von 0,3 mol Liter⁻¹ führte zum engsten Bereich von gastrischen pH-Werten (Mittel a) 5,4, b) 5,9; Bereich 3,9–7,7). Die Bereiche abgesaugter gastrischer Volumenmengen waren groß mit beiden Antazidbehandlungen (Magnesiumtrisilikat 12–172 ml, Natriumzitat 9–290 ml). Cimetidin erhöhte das gastrische pH bei 82% der Patientinnen auf über 2,5 (Mittel a) 6,2 b) 5,0; Bereich 1,6–7,3), und war verbunden mit deutlich geringeren gastrischen Volumenmengen (Bereich 0,5–44 ml). pH und Volumenmengen zusammengenommen zeigten, daß die Cimetidin-Patienten am nächsten bei den als sicher definierten Grenzen von pH > 2,5 und einer Volumenmenge von <25 ml lagen.

COMPARACION DEL USO PROFILACTICO DE UNA MEZCLA B.P.C. DE TRISILICATO DE MAGNESIO, DE UNA MEZCLA DE CITRATO DE SODIO O DE CIMETIDINA DURANTE EL PARTO

SUMARIO

Se llevaron a cabo comparaciones entre los efectos de una mezcla B.P.C. de trisilicato de magnesio, una mezcla de citrato de sodio o de cimetidina sobre el pH gástrico y los volúmenes gástricos aspirados en 78 pacientes de obstetricia durante cirugía electiva (a) o de emergencia (b). La mezcla B.P.C. de trisilicato de magnesio se encontró asociada con los valores alcalinos más altos del pH gástrico (promedio (a) 7,9, (b) 7,3; gama 2,9–9,1). La mezcla de citrato de sodio en 0,3 mol litro⁻¹ resultó en la más estrecha gama de valores pH del contenido gástrico (promedio (a) 5,4, (b) 5,9; gama 3,9–7,7). Las series de volúmenes gástricos aspirados eran extensas con ambos regímenes antiácidos (trisilicato de magnesio: 12–172 ml; citrato de sodio: 9–290 ml). La cimetidina hizo aumentar el pH gástrico hasta más de 2,5 en un 82% de los pacientes (promedio (a) 6,2; (b) 5,0; gama 1,6–7,3) y se encontró asociada con volúmenes de contenido gástrico aspirado mucho más reducidos (gama 0,5–44 ml). Cuando se consideraron el pH gástrico y el volumen gástrico en conjunto, los grupos de pacientes que recibieron la cimetidina se encontraban más cerca de los “límites seguros” definidos de pH > 2,5 y de volumen < 25 ml.