tration of ephedrine as soon as any fall in maternal blood pressure is detected prevents further fall in blood pressure and markedly reduces the incidence of nausea alone or with vomiting. In addition, acid-base status in the infants of parturients so treated is normal and identical to that in the patients who did not experience a fall in blood pressure and hence did not receive ephedrine. This simple alteration in clinical practice seems to provide significant improvement in clinical care of mothers and babies.

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Assessment of Risk Factors Related to the Acid Aspiration Syndrome In Pediatric Patients—Gastric *p*H and Residual Volume

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Stress and emotional upset apparently increase gastric acid production.[1-2] Since the presurgical period is stressful for many children, we examined risk factors for the acid aspiration syndrome in a prospective randomized study. Factors investigated included anxiety, gastric volume and *p*H, inpatients *vs.* outpatients, and the number of previous anesthetic experiences. Our intent was to define a subgroup of patients at increased risk for acid aspiration.

Materials and Methods

This protocol was approved by the Subcommittee on Human Studies of our institution. Fifty-one ASA physical status I children ages 3–17 years were randomly chosen for this study. Group I (n = 16) consisted of children anesthetized for the first time; all were inpatients. Group II (n = 16) consisted of pediatric outpatients anesthetized for the first time. Group III (n = 19) consisted of children who had been hospitalized and anesthetized on multiple occasions; all of this group were plastic surgical patients at least one year post-acute burn injury. No patient had a known history of ulcer disease or was taking a medication that would interfere with gastric emptying.

The level of anxiety prior to induction was assessed by a physician not involved in the study. Each patient was scored as either anxious or comfortable. The term anxious meant that the child was obviously nervous and uncomfortable with the events about him. Comfortable meant that there were no overt signs of anxiety such as crying, agitation, clinging to the parent, or refusing to talk.

Children were not premedicated. Induction of anesthesia in children under age 7 consisted of 20 to 30 mg/kg methohexital (100 mg/ml) administered rectally by a physician in the presence of a parent. Older children were induced with intravenous thiopental; all patients were maintained with halothane, nitrous oxide, and oxygen.

After induction of general anesthesia gastric samples were obtained through a Salem Sump® catheter (Argyle)

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TABLE 1. Gastric Volume, *p*H and Level of Anxiety

	Gastric Volume* (ml/kg)		Gastric pH*	
	Anxious	Comfortable	Anxious	Comfortable
Group I (n = 16)	0.77 ± 0.3 (4)	0.86 ± 0.2 (12)†	1.61 ± 0.04	1.48 ± 0.07
Group II (n = 16)	0.58 ± 0.1 (7)	1.01 ± 0.5 (9)†	1.62 ± 0.09	1.35 ± 0.05
Group III (n = 19)	0.76 ± 0.2 (10)	0.75 ± 0.1 (9)†	1.57 ± 0.09	1.29 ± 0.07
Overall	0.70 ± 0.1 (21)	0.83 ± 0.2 (30)	1.60 ± 0.06	1.38 ± 0.05‡

* Mean ± SE.
† Chi-square > 0.1.
‡ $P < 0.005$.
Numbers in parentheses indicated number of patients.

by gentle aspiration with a large syringe. Manipulation of the catheter and multiple aspirations were attempted on each patient so as to obtain as complete gastric emptying as possible. The age, weight, estimate of preoperative anxiety, and the volume and *p*H of the gastric aspirate of each patient were recorded. The *p*H was measured on a Corning digital *p*H meter which was calibrated prior to each use. The *p*H values were converted to hydrogen ion (H^+) concentration prior to statistical analysis. Multiple unpaired Student's *t* test were applied to data on gastric volume and H^+ concentration. Significance of anxiety was assessed by chi-square analysis. All values are expressed as means ± standard error and were considered significant when $P < 0.05$.

RESULTS

Fifty of 51 pediatric patients between the ages of 3 and 17 years had a gastric *p*H of 2.5 or less; one had a *p*H of 2.6. There was no significant difference in age or weight between any two groups. The mean age was 10.2 years and the mode 8 years. There was no difference in the degree of anxiety among Groups I to III (table 1). There was no statistical difference in gastric volume or *p*H comparing inpatients to outpatients, or multi-anesthetized to single anesthetized patients (table 2). There was no difference in gastric volume comparing the anxious to the comfortable patient; however, comfortable patients had a significantly greater acid content (*p*H 1.38 ± 0.05 *vs.* 1.6 ± 0.06; $P < 0.005$) (table 1). The range of gastric volume was quite large, from 0.11 ml/kg to 4.72 ml/kg. The overall mean gastric residual for all patients was 0.78 ± 0.1 ml/kg with a *p*H of 1.45 ± 0.03.

TABLE 2. Gastric Volume and *p*H (mean ± SE)

	Gastric volume (ml/kg) (Mean ± SE)	Gastric *p*H (Mean ± SE)
Group I	0.84 ± 0.17	1.51 ± 0.06
Group II	0.82 ± 0.27	1.45 ± 0.06
Group III	0.69 ± 0.10	1.42 ± 0.07

DISCUSSION

Studies on anesthetized adult patients demonstrate that 46 to 75 per cent of patients will have a gastric *p*H of less than 2.5[3-6] Between 32 and 55 per cent of adult patients will have both a gastric residual of 20–40 ml and a *p*H of less than 2.5.[3-6] We found that 96 per cent of pediatric patients between the ages of 3 and 17 years had a gastric *p*H of less than 2.5. Salem *et al.*[1] examined 206 children but did not break down the patients according to inpatient, outpatient, or previous anesthetic experience. Their study found a mean gastric residual of 0.6 ml/kg and 93 per cent of children having a *p*H of 2.5 or less. Our data for all patients are in close agreement with that of Salem *et al*; 76 per cent of our patients had both a *p*H of less than 2.5 and a gastric residual volume of greater than 0.4 ml/kg (table 3).

Aspiration of acidic gastric contents is a life-threatening complication associated with anesthesia in both adults and children.[8-9] The critical *p*H appears to be less than 2.5 with a volume greater than 0.4 ml/kg.[10,11] There are no data regarding pediatric patients but there is no

TABLE 3. Distribution of Patients (per cent) with a Gastric *p*H of Less than 2.5 and a Gastric Residual Volume greater than 0.4 ml/kg

	*p*H < 2.5	Volume > 0.4 ml/kg	Both *p*H < 2.5 and Volume > 0.4 ml/kg
Group I—inpatients first anesthetized (n = 16)	100	75	75
Group II—outpatients first anesthetized (n = 16)	100	81	81
Group III—inpatients multi-anesthetized (n = 19)	89.5	79	74
Overall	96.1	78 $\chi^2 > 0.1$	76.5

reason to assume that children are different from adults. Although our study did not examine an adult population, our data indicate that if a pediatric patient vomits and aspirates he may be at greater risk than an adult for severe pulmonary damage since a higher percentage of pediatric patients appear to have a gastric *p*H less than 2.5 (96 per cent vs. 75 per cent) and a gastric residual volume greater than 0.4 ml/kg (76 per cent *vs.* 55 per cent).

We were unable to demonstrate a correlation between gastric *p*H or gastric residual volume and inpatient *vs.* outpatient status, or with first anesthetized *vs.* multi-anesthetized children (table 1). This finding is different from one adult study where gastric residual volumes were significantly greater in outpatients compared with inpatients.[13] The patient in our study with the largest residual volume (4.72 ml/kg) was an outpatient. When we compared anxious with comfortable patients there was no difference in gastric residual volume but there was a highly significant increase ($P < 0.005$) in gastric acid content in comfortable patients (*p*H 1.38 ± 0.05 *vs.* *p*H 1.6 ± 0.06). This latter finding was contrary to the hypothesis that anxiety increases gastric acid production. Whether this difference is of clinical significance is certainly open to question since both groups had a *p*H less than 2.5. We were surprised to find no difference in the gastric residuals of children admitted to the hospital overnight (Group I) or children who had been hospitalized and anesthetized many times (Group III), compared with first anesthetized outpatients (Group II). Even more interesting was the discovery that outwardly comfortable patients had a greater acid output than obviously anxious children.

We conclude that children may be at slightly greater risk than adult patients for acid aspiration syndrome because they have a greater gastric residual volume and nearly all have a gastric *p*H of less than 2.5. In addition, all unpremedicated pediatric patients, whether anesthetized for the first time or many times, whether inpatient or outpatient, or whether outwardly anxious or calm, appear to be equally at risk for the complications of acid aspiration since each group demonstrated nearly identical gastric acid content and volume. We were unable to define a particular group of pediatric patients who were uniquely susceptible to acid aspiration.

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