Gastric fluid measurement by blind aspiration in paediatric patients: a gastroscopic evaluation

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Purpose: Numerous investigators have estimated gastric fluid volume using blind aspiration through multi-orificed catheters, but none have confirmed the validity of this technique in infants and children. We sought to validate the accuracy of this technique in a fasted paediatric population by using gastroscopy. Data from several studies were then combined to generate a gastric fluid volume frequency distribution for healthy paediatric patients fasted for surgery.

Methods: This is a prospective study of 17 patients aged six months to 11 yr who underwent elective upper endoscopy at a paediatric teaching hospital. Gastric contents were aspirated blindly with a syringe and a 16 or 18F multi-orificed orogastric tube, and the volume of gastric contents removed in the supine and decubitus positions was measured. Residual gastric fluid was aspirated using an endoscope. Data from 611 infants and children enrolled in previously published studies utilizing the same blind aspiration technique were pooled and a gastric fluid volume frequency distribution was created.

Results: Blind aspiration removed 97 ± 8% of the total gastric fluid volume. In 661 children presenting for elective surgery, the gastric fluid volume was 0.40 ± 0.45 $ml \cdot kg^{-1}$. Median volume was 0.27 $ml \cdot kg^{-1}$, with the 95%ile at 1.25 $ml \cdot kg^{-1}$ and an upper limit of 4.1 $ml \cdot kg^{-1}$.

Conclusion: Blind aspiration of gastric contents accurately estimates gastric fluid volume for paediatric patients fasted for surgery. Population estimates for gastric fluid volume in otherwise healthy fasted paediatric patients are shown.

Objectif : Plusieurs investigateurs évaluent à l'aveugle le volume du liquide gastrique à l'aide de cathéters à orifice multiples, mais aucun n'a jamais prouvé la validité de cette technique chez les nourrissons et les enfants. Cette étude visait à valider l'exactitude de cette technique avec la gastroscopie chez des enfants gardés à jeun pour la chirurgie. Les données compilées de plusieurs études ont été réunies pour créer une pente de distribution de fréquence du volume de liquide gastrique chez des jeunes patients non tarés gardés à jeun pour la chirurgie.

Méthodes : Cette étude prospective, réalisée dans une hôpital pour enfants à vocation éducative, réunissait 17 jeunes patients de six mois à 11 ans programmés pour une endoscopie digestive supérieure. Avec le patient en position de décubitus, le liquide gastrique était aspiré à l'aveugle à l'aide d'une seringue aboutée à un tube naso-gastrique 16 ou 18F à orifices multiples et mesuré. Le liquide résiduel était par la suite aspiré par endoscopie. Les données de 611 nourrissons et enfants recueillies à partir d'études antérieures sur la même technique d'aspiration étaient compilées et une distribution de fréquence établie pour le volume de liquide gastrique.

Résultats : L'aspiration à l'aveugle a permis de retirer 97 ± 8% du volume gastrique total. Chez 661 enfants programmés pour une chirurgie élective, le volume du contenu gastrique était de 0,40 ± 0,45 $ml \cdot kg^{-1}$. La médiane du volume était de 0,27 $ml \cdot kg^{-1}$, avec un 95^e centile à 1,25 $ml \cdot kg^{-1}$ et une limite supérieure à 4,1 $ml \cdot kg^{-1}$.

Conclusion : L'aspiration à l'aveugle du contenu gastrique évalue avec exactitude le volume du liquide gastrique chez des enfants gardés à jeun pour la chirurgie. Après validation, cette technique permet d'évaluer le volume du contenu gastrique chez des enfants non tarés à jeun.

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BLIND aspiration of gastric contents has been used to estimate gastric fluid volume (GFV) in both children and adults. The mean GFV measured using this technique in infants and children fasted at least eight hours for solids and two hours for clear liquids ranges from 0.24–0.8 $ml \cdot kg^{-1}$.[1–6] Several investigators have questioned the accuracy of mean GFV estimates measured in this way. In a study of 42 adults, Ong *et al.* found poor correlation between GFV aspirated by syringe via a gastric tube and that determined by polyethylene glycol dilution.[7] The volume aspirated was often much less than the volume calculated (in one case 60 ml *vs* 355 ml, respectively). More recently, Adelhøj *et al.* reported that blind aspiration recovered, on average, only 54–87% of known quantities of glucose solution instilled into the stomachs of anaesthetized adults.[8] Taylor *et al.* reported that blind aspiration of GFV in 10 obese adults removed only 53% of the total contents when compared with endoscopic guided aspiration.[9] Søreide *et al.* reported a 78% recovery based on a similar fibreoptic gastroscopic technique.[10]

The blind aspiration GFV recovery in these studies may have been limited by the investigators' techniques using single catheter passes with supine patients. The aspiration technique used by Splinter *et al.*[2–4,11] and Schreiner *et al.*[5] included aspiration in three positions: supine and left and right lateral decubitus. The first objective of the present study was to validate the accuracy of this blind aspiration technique in infants and children. To do this GFV was measured by blind aspiration and the residual GFV was quantitated using definitive endoscopic-guided aspiration. The second objective was to combine the data from several previous studies which utilized the same blind aspiration technique [2–5,11] in order to generate a GFV frequency distribution for healthy children presenting for elective surgery.

Methods

The hospital institutional review boards approved the protocols for these studies. Parents of the infants and children who underwent gastrointestinal endoscopy gave written informed consent.

Seventeen patients, aged six months to 11 years, scheduled for upper endoscopy as part of an evaluation of gastro-oesophageal reflux-induced oesophagitis, were studied to assess the accuracy of this blind aspiration technique in measuring GFV. These infants and children were fasted at least eight hours for solids and two hours for clear liquids prior to their procedure. General anaesthesia was induced using 4–6 $mg \cdot kg^{-1}$ thiopentone or halothane, and the trachea was intubated following neuromuscular blockade with succinylcholine or vecuronium. Anaesthesia was maintained with O_2, N_2O, and a potent inhalational agent. Immediately after tracheal intubation, a 16 or 18F multi-orificed orogastric sump tube (Argyle, St. Louis, MO) was placed. With the patient supine, the orogastric tube position was confirmed by auscultation over the stomach and the gastric contents were aspirated with a syringe as the tube was withdrawn into the oesophagus. This procedure was repeated in the left and then right lateral decubitus positions and the aspirate volume obtained in each position was recorded. Prior to the scheduled diagnostic procedure, an experienced endoscopist (CAL) passed an Olympus GIF-XP20 endoscope (7.9 mm diameter) to visualize and aspirate all pockets of residual gastric fluid ($GFV_{residual}$) into a suction trap. The GFV obtained by blind aspiration (GFV_{blind}) was then compared with the total GFV (GFV_{total}) where $GFV_{total} = GFV_{blind} + GFV_{residual}$.

To obtain a GFV frequency distribution in healthy infants and children presenting for elective surgery, data from five recent studies using an identical blind aspiration technique (as confirmed by their principal authors)[2–5,11] were combined for a total of 611 patients. These studies compared GFV_{blind} in children fasted overnight with those in children allowed to drink clear liquids two to four hours before the induction of anaesthesia. In combining these data, only patients ages one to eleven years with recorded weights were included.

Statistical Analysis

Each patient's age, weight, duration of fast, GFV_{blind}, and $GFV_{residual}$ were recorded. All data are presented as mean ± standard deviation (SD). The mean and standard deviation of the recovery of GFV_{total} by blind aspiration as represented by the ratio GFV_{blind}/GFV_{total} were derived in percent and the integrity of the paired GVF_{blind} and $GFV_{residual}$ data was maintained. The 50%ile and 95%ile GFV_{blind} and associated interquantile range (IQR) for the pooled population of 611 patients were also determined.

Results

In the 17 infants and children studied endoscopically, the mean age was 5.9 ± 3.9 yr, weight 19.3 ± 13.9 kg, fasting interval 8.8 ± 4.2 hr, GFV_{blind} 17.9 ± 26.6 ml, $GFV_{residual}$ 0.9 ± 2.5 ml, and GFV_{total} 0.9 ± 1.0 $ml \cdot kg^{-1}$: 97 ± 8% of the GFV_{total} was removed using the three position blind aspiration technique. Of the GFV_{blind}, 80% was removed on the first orogastric tube pass in the supine position, 14% in the second pass left lateral position, and 6% in the final pass right lateral position

TABLE Summary of GFV with Positional Components of GFV_{blind}

Age(yr)	*Weight(kg)*	*supine(ml)*	*left(ml)*	*right(ml)*	GFV_{blind}*(ml)*	GFV_{resid}*(ml)*
0.66	6.7	1	0	1	2	0
1.25	7.9	4	0	0	4	0
0.5	8.8	0	1	3	4	0
1	9.6	9	0	2	11	0
2	9.8	11	2	2	15	0
2.5	12	0	5	0	5	0
2.25	13.2	15	0	0	15	0.5
4.5	14.3	8	0	0	8	0
4.25	17	7	0	0	7	0.5
4.75	17	3	15	2	20	10
9.5	20.8	8	0	2	10	0.2
7.2	21.5	12	0	0	12	0
7	24.5	2	0	0	2	0
11.75	24.5	8	0	0	8	0
8	26	89	19	6	114	0
11.2	28	29	0	0	29	3.5
10	66	36	1	1	38	0
Mean± SD		14.2 ± 21.6	2.5 ± 5.6	1.1 ± 1.6		
$GFV_{blind\%}$		80	14	6	100	

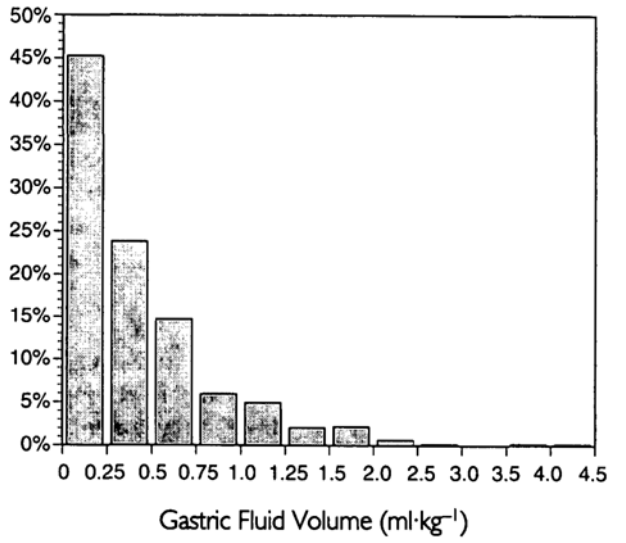

FIGURE Frequency Distribution of GFV_{blind} in Fasted Healthy Children

This histogram represents n=611. Data pooled from studies by Splinter *et al.*[2-4,11] and Schreiner *et al.*[5] which utilized a three position blind aspiration technique to estimate gastric fluid volume. Wide-bore (14–18Fr) multi-orificed catheters were used in all five studies. Only three children had GFV_{blind} >2.5 ml·kg^{-1}.

(Table). Only one of the 17 endoscopy patients had a significant residual gastric fluid aspirated by subsequent endoscopy: 10 ml (= 0.59 ml·kg^{-1} $GFV_{residual}$) after removal of 20 ml GFV_{blind}. This 6% incidence of significant $GFV_{residual}$ in our small sample has a 95% confidence interval (CI) of 5–23%.

The demographic data for the 611 healthy children in the combined studies include a mean age of 6.1 ± 2.6 yr (range 1–11 yr), weight of 22.9 ± 9.1 kg, and fasting interval of 8.6 ± 5.7 hr. The mean GFV_{blind} is 0.40 ± 0.45 ml·kg^{-1}. The median (50%ile) is 0.27 ml·kg^{-1} with an IQR of 0.43. The frequency distribution of GFV_{blind} in these fasted healthy children is presented in the figure. The upper limit of GFV_{blind} was 4.1 ml·kg^{-1}, with 95% having GFV_{blind} ≤1.25 ml·kg^{-1}.

Discussion

These data validate the utility of the three position blind aspiration technique and demonstrate that the measured GFV_{blind} is an accurate estimate of the GFV_{total} for paediatric patients fasted at least eight hours for solids and two hours for clear liquids. Blind aspiration removes 97 ± 8% of GFV_{total} as documented by endoscopy. Only the occasional paediatric patient has a $GFV_{residual}$ of >1 ml and the SD about the mean recovery was largely due to one patient who had 10 ml $GFV_{residual}$ for a recovery of 67%. This patient represents 6% of our endoscopy patients and the 95% CI of a similarly disparate data point ranges from 5–23% in our sample size. There are two likely explanations for the poor GFV recovery in this patient. The first invokes a malpositioned orogastric tube: with only the tip in the stomach, the investigator would "confirm" placement by auscultation, but not expose the GFV to the multiple orifices for complete evacuation. Another possibility is an incompetent pylorus which may have allowed retrograde flow of a duodenal fluid collection subsequent to blind aspiration.

Some studies which appear to invalidate blind gastric aspiration as a measure of GFV_{total} are problematic because they are based on calculated or otherwise unknown GFV_{total}. In the study by Ong *et al.*[7] polyethylene glycol was used to determine GFV_{total} by dilution, a method reportedly validated in the literature.[12,13] Yet Bloom *et al.* stated that none of their dilution indicators could be completely recovered under all experimental conditions in their canine Heidenhain gastric pouch model, thereby subjecting GFV_{total} calculations to some uncertainty.[12] Using polyethylene glycol instilled into the stomachs of 12 adult patients, Ivey *et al.* were only able to report the ratio of instillation concentration to final aspirate concentration as opposed to total recovery and estimation of GFV_{total}.[13] Ivey *et al.* attributed the lower concentration of indicator in the first aspiration measurement to polyethylene glycol adhesion to the gastric mucosa and to incomplete distribution of the relatively large marker molecule.[13] Thus, the fundamental problems with studies based on indicator dilution measurements for assessing GFV_{total} are the unreliable assumptions regarding the indicator: immediate and total dissolution in the gastric fluid, no adsorption to the mucosa (or to the sump tube), and no selective gastric absorption or exodus via the pylorus.

The Adelhøj study using recovery of a known quantity of glucose solution in 80 adult patients also fails to document GFV_{total} with certainty.[8] The reported inaccuracy of blind aspiration claimed in this study assumes complete initial evacuation of the stomach (one pass of a gastric tube with the patient in the supine position) and no further gastric secretion or emptying out the pylorus. Again, without the knowledge of the actual GFV_{total} at the time of blind gastric aspiration, one cannot claim true recovery of GFV and validate or invalidate the blind aspiration technique.

As in our study, Taylor *et al.* used endoscopy to definitively document $GFV_{residual}$ (and with this, GFV_{total}) and thereby assess the efficacy of blind gastric aspiration.[9] However, unlike our result of 97% effective removal of GFV_{total}, the Taylor study showed that only 53% of GFV_{total} was removed by blind aspiration. There are several possible explanations for the differences between our results and those of Taylor. First is the difference in patient populations: 10 obese (100 kg) adult patients *vs* 17 nonobese infants and children. Either the infant/child's gastric anatomy is subtly different from that of adults, or the relatively large 16 to 18F sump tube size we used in relation to the smaller paediatric stomach allowed us to aspirate GFV more effectively. Also different between the two studies was the technique of blind aspiration itself: we blindly aspirated the stomach three times (in the supine, left, and right lateral positions) whereas Taylor and colleagues positioned their adult patients in the left and right lateral decubitus positions but appear to have aspirated a 16F catheter only once and with the patient in the supine position.

The improved recovery of our method may solely result from patient positioning. In the adult endoscopic study by Søreide *et al.* the mean underestimation of the GFV_{total} was 6 ml = 22%. This suggests a mean recovery of 78% with a double, supine-position-only blind aspiration technique. This figure is identical to our recovery percentage of the GFV_{total} after the first aspiration pass with the patient in the supine position (80% GFV_{blind}·97% recovery = 78%). Had Soreide and colleagues repositioned their patients to both lateral decubitus positions prior to subsequent blind aspiration attempts, their overall recovery may have approached that of our study.

The GFV frequency distribution from the combined data shows that the vast majority of fasted, healthy children presenting for elective surgery have $GFV_{blind} \leq 1.25$ ml·kg^{-1}, with a median of 0.27 ml·kg^{-1} and a mean of 0.40 ml·kg^{-1}. The shape of the distribution curve shows that the data are not normally distributed. Using a 97% recovery estimate based on our endoscopy data, this translates to a corrected mean GFV_{total} of 0.41 ml·kg^{-1}. We attribute the larger mean GFV_{total} of 0.90 ml·kg^{-1} in our endoscopy patients (of similar age and weight to the cohort of 611 patients) to their presumed abnormal gastrointestinal function.

While data on GFV is interesting, its clinical importance with regard to the risk of vomiting and subsequent aspiration on induction cannot be specifically stated.[14] In a feline model a threshold GFV of 8–40 ml·kg^{-1} is needed to produce spontaneous regurgitation.[15] The only relevant human data on GFV and regurgitation risk comes from a small study of seven adult patients under general anaesthesia for elective gastric resection.[16] Although the main purpose of this study was to show that the lower oesophageal sphincter may be less competent in the presence of a transoesophageal gastric tube than without, the study also demonstrated that, in the absence of a tube, regurgitation could occur with an instilled GFV varying from approximately 200 to 2100 ml. One cannot generalize this data, however. Several aspects of the study are problematic: the small sample size, the unknown patient weight and, most importantly, the unknown actual GFV. Although the stomach was "emptied" with a cannula prior to instillation of a known quantity of saline, there is no documentation of possible residual fluid following initial evacuation. Furthermore, the position of

the instilling cannula is not noted. Could it accidentally have been placed at the lower oesophageal sphincter, giving rise to an "early" and falsely low volume to reflux? Finally, the pathology leading to the surgical procedure itself may have considerably altered gastric volume and compliance.

In summary, the three position blind aspiration technique using a 16–18Fr multi-orificed catheter removes 97 ± 8% of GFV_{total} in fasted infants and children. This study validates our method as a research tool for measuring GFV under the minimal preoperative eight hour fast for solids and two hour fast for clear liquids. A GFV_{blind} frequency distribution was constructed for fasted healthy children and showed a mean GFV_{blind} of 0.40 ± 0.45 $ml \cdot kg^{-1}$, with 95% of patients having ≤1.25 $ml \cdot kg^{-1}$. Studies relating GFV and regurgitation in the paediatric population need to be designed, and could utilize the blind aspiration technique described in this paper to assess GFV_{total} accurately.

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