Research Square

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Bedside Ultrasound Evaluation of Gastric Emptying for Optimizing Fasting Duration in Outpatients Undergoing Sedation: A Prospective Observational Study

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Abstract

Objective

This study aims to explore the gastric emptying patterns in sedated children undergoing outpatient procedures through bedside ultrasonography. The results are anticipated to provide a basis for formulating an evidence - based and optimized fasting protocol for this specific population.

Methods

A total of 205 children aged 0–6 years scheduled for outpatient examinations under sedation were included. Prior to sedation administration, the fasting status of each child was verified and then classified into two groups: an exposed group (in compliance with guidelines) and a non - exposed group (non - compliant). The gastric emptying status was quantitatively evaluated using bedside ultrasonography based on the Perlas three - grade grading system, which entailed measuring the cross - sectional area (CSA) of the gastric antrum and calculating the gastric fluid volume.

Results

A total of 199 children were incorporated into the analysis. The overall incidence of "full stomach" was 15.1% (95% CI: 10.4% – 19.8%). The incidence of "full stomach" in the non - exposure group (8.2%, 95% CI: 3.9% – 12.5%) was significantly lower than that in the exposure group (42.5%, 95% CI: 27.2% – 57.8%) ($P < 0.001$). The proportion of Perlas grade 2 in the exposure group was significantly higher than that in the non - exposure group (25% vs 6.3%, $P < 0.05$). In the exposure group, 23 cases had their sedation strategies adjusted after ultrasound assessment.

Conclusion

Bedside ultrasound facilitates the assessment of gastric emptying status in pediatric patients, which helps to reduce the risk of pulmonary aspiration and supports the optimization of preoperative fasting protocols.

Introduction

Procedural sedation is a medication - based approach aimed at inducing mild - to - moderate sedation. It effectively mitigates pain and anxiety during clinical procedures, while guaranteeing patient safety through the maintenance of vital physiological functions [1]. Procedural sedation has wide - ranging applications in clinical settings, including emergency departments and outpatient clinics, and it is specifically recommended for procedures that do not require general anesthesia [2][3].

Controversy persists regarding the fasting management prior to sedation in pediatric patients. The majority of institutions adhere to the "post-midnight fasting" standard put forward by the ASA grading[4] [5], whereas organizations like international committee for procedural sedation（ICAPS）have proposed optimized protocols [6].

Nevertheless, numerous studies have consistently indicated an extremely low incidence of adverse events during procedural sedation. Moreover, extensive research has revealed no significant correlation between the pre-procedural fasting duration and the occurrence of these complications [7][8]. Excessive fasting may also give rise to hypoglycemia, metabolic disturbances, and incidents that pose a threat to life safety [9].

Gastric ultrasound, a bedside tool employed to assess the volume and characteristics of gastric content for determining the gastric emptying status, has been proven to significantly reduce the incidence of reflux aspiration in the peri-operative settings [11], enhance the emergency response in acute medical scenarios [12], improve patient monitoring in intensive care units [13], and offer valuable perspectives for the management of special populations [14].

This study explores the role of gastric ultrasound as an objective quantitative instrument to guide and optimize fasting strategies for children in need of procedural sedation, with the aim of enhancing the accuracy of gastric content evaluation and the overall patient experience.

1 Data and Methods

1.1 General Data

This study recruited 205 pediatric patients (aged 0–6 years, with an American Society of Anesthesiologists classification of I-II) who required sedation for outpatient non-invasive examinations, such as magnetic resonance imaging, computed tomography, pulmonary function tests, or electroencephalography. Inclusion criteria stipulated the absence of contraindications to sedation and the provision of signed informed consent by the guardians. Patients were excluded if they were scheduled for invasive examinations or outpatient surgical procedures, had confirmed gastroesophageal reflux or other esophageal/gastric developmental anomalies, a history of gastroesophageal surgery, or any severe medical conditions that were incompatible with sedation.

1.2 Research Design and Measures

1.2.1 Methodology

Participants were stratified into two groups according to their adherence to the preoperative fasting guidelines of the Chinese Medical Association: an exposure group (full compliance) and a non - exposure group (non-compliance). The specified fasting durations were 2 hours for clear liquids, 4 hours for breast milk, 6 hours for infant formula, and 8 hours for solid foods.

After the fasting times were confirmed, all children underwent sedation. A single investigator, blinded to the fasting history, conducted gastric ultrasonography to guarantee objective assessment. If necessary, caregivers employed standardized calming interventions, such as solid lollipops, to alleviate agitation and promote successful imaging.

The gastric antrum was investigated using a Versana Active 1.5 portable ultrasound system. Transducer selection was customized according to the patients' somatic features: a high-frequency linear probe (5–10 MHz) was employed for achieving superior resolution in younger children, and a curved array probe (2–5 MHz) was utilized for ensuring adequate penetration in older children. The standard sonographic plane of the gastric antrum was identified based on its anatomical relationship with the left hepatic lobe and the abdominal aorta. Children were placed in either the supine or right lateral decubitus position to optimize the acoustic window for imaging.

The Perlas scoring scale [10] was utilized to conduct a qualitative assessment of the post - oral fasting gastric juice volume, with the following criteria: Grade 0: No fluid was observed in either position; Grade 1: Fluid was present only in the right lateral position; Grade 2: Fluid or solid material was detected in both positions.

Following image acquisition, the longitudinal diameter (CC) and anteroposterior diameter (AP) during gastric antral systole were measured. Three measurements were conducted, and subsequently, the mean value was computed. The gastric antral CSA was calculated by means of the formula: $CSA = (\pi \times AP \times CC) / 4$. The gastric volume per kilogram (GV/kg) was ascertained using a pediatric validation formula[16]: $GV/kg = [-7.8 + 0.035 \times \text{right lateral CSA } (mm^2) + 0.127 \times \text{age (months)}] / \text{body weight (kg)}$.

In the pediatric population, the fasting gastric capacity ranges from 1.2 to 1.5 ml/kg [16][18]. For sedated pediatric patients undergoing non-invasive examinations while maintaining spontaneous breathing, Perlas level 0 (gastric capacity ≤ 1.5 ml/kg) was defined as a 'fasted stomach', and Perlas level 2 (gastric contents > 1.5 ml/kg) was defined as a 'non - fasted stomach' [18].

1.2.2 Observation Indicators

The primary indicators encompass Perlas classification, fasting duration, and gastric contents (CSA, GV, GV/kg). Secondary indicators involve adverse events such as reflux, aspiration, hypotension, and hypoglycemia.

Pre-sedation records comprise fasting/liquid deprivation duration, food composition and intake volume, as well as demographic data (age, gender, weight, height, disease diagnosis, comorbidities, gastric capacity, Perlas classification, non - invasive outpatient examination type, and ASA classification).

Sedation records document the details of medications (name, dosage, administration method).

Nursing records monitor the patient's condition until discharge and record adverse events for analysis.

1.3 Sample Size and Statistical Analysis

It was hypothesized that approximately 3% to 5% of pediatric patients would be assessed as Perlas Level 2 [10]. To verify that around 3% of pediatric patients would reach Perlas Level 2 in the gastric antrum during outpatient sedation, 175 pediatric patients were required. Considering a clinical dropout rate of approximately 20%, a minimum of 200 pediatric patients were ultimately recruited.

Statistical analysis was performed using SPSS 28.0. Normally distributed data were presented as the mean±standard deviation ($\bar{x}\pm s$), while non-normally distributed data were expressed as the median and interquartile range (IQR). Nonparametric tests were employed to compare the anorexia, satiety, and exposure groups with the non-exposure group. The gastric antrum grading data were analyzed using the Kruskal-Wallis H test. Incidence rates were reported, and percentages were calculated with a 95% confidence interval. Differences were evaluated using Fisher's exact test or the chi - square test, depending on the sample size and expected frequencies.

2 Results

The study initially conducted a screening of 205 pediatric patients (Fig. 1). Two children were excluded as their guardians declined to sign the informed consent, and four met the exclusion criteria. Ultimately, 199 patients underwent gastric ultrasound evaluation and were incorporated into the analysis. The effective ultrasound examination rate was 97.1% (95% CI: 94.8%–99.4%).

2.1 General Information of the Children

A total of 199 children were incorporated into the study. Among them, 169 participants were allocated to the fasting group, consisting of 93 boys and 76 girls. The mean age was (21.15 ± 14.18) months, and the mean fasting duration was (8.70 ± 3.51) hours. This fasting period is consistent with historical guidelines recommending fasting times of 2 hours for clear liquids and 6 to 8 hours for solid foods; however, the actual fasting times observed in clinical practice frequently surpass these recommendations. Thirty children were in the fed group, including 18 males and 12 females, with a mean age of (13.60 ± 12.19) months and a mean fasting time of (5.60 ± 2.65) hours.

There was a statistically significant difference between the two groups in terms of CSA□GV□ GV/kg, age, weight, and fasting time ($P < 0.001$). No significant differences were detected in gender, body mass index (BMI), and ASA grading ($P > 0.05$). See Table 1.

Table 1
Data analysis of children with empty stomach versus full stomach (data presented as $\bar{x}\pm s$, n)

Gender: Male/Female	**empty stomach (n = 169,84.9%)**	**full stomach (n = 30,15.1%)**	***t***	***P***
	93/76	**18/12**	**0.255[a]**	**0.613**
Age(month)	21.15 ± 14.18	13.60 ± 12.19	-3.093[b]	0.002**
Weight(kg)	11.68 ± 3.58	9.56 ± 3.38	-3.022[b]	0.003**
Height(m)	0.81 ± 0.15	0.73 ± 0.14	-2.865[b]	0.004**
BMI	17.40 ± 2.21	17.71 ± 3.20	-0.012[b]	0.990
Birth type (premature/term)	17/152	5/25	0.559[a]	0.455[b]
Mode of birth (vaginal/cesarean)	73/96	12/18	0.106[a]	0.744
Check type (non-interventional/interventional)	80/89	12/18	0.552[a]	0.458
ASA(I/II)	163/6	30/0	0.220[a]	0.594[a]
Food type: liquid/solid	126/43	27/3	3.419[a]	0.064
Fasting period(h)	8.70 ± 3.51	5.60 ± 2.65	4.620[b]	< 0.001**
CSA(cm^2)	451.98 ± 135.41	882.79 ± 279.34	-7.575[b]	< 0.001**
GV(ml)	10.54 ± 5.77	24.83 ± 10.48	-6.682[b]	< 0.001**
GV/kg(ml/kg)	0.88 ± 0.36	2.73 ± 1.23	-8.694[b]	< 0.001**

a: Pearson chi-square test; Fisher test;b:Mann-Whitney U test**P<0.01

2.2 Distribution of CSA, GV, GV/kg, and GV/kg > 1.5 mL/kg under the Perlas Grading System

There were highly significant differences in CSA, GV, and GV/kg among the Perlas grading groups (P < < 0.01). Pair - wise comparisons indicated statistically significant differences between Grade 1 and Grade 2 when compared to Grade 0 (P < < 0.01). No statistically significant difference was detected between the Grade 1 and Grade 2 groups (P > > 0.05).

Among the 30 children with a gastric volume >greater than 1.5 mL/kg, 13 were classified as Grade 1 and 17 as Grade 2, which also demonstrated a statistically significant difference in the Perlas grading ($P << 0.001$). Pair - wise comparisons revealed statistically significant differences among all groups ($P << 0.01$).

According to the data presented in the study, the incidence rate of 'full stomach' among sedated children in outpatient settings was reported to be 15.1% (95% confidence interval: 10.4% − 19.8%). Refer to Table 2.

Table 2
Data analysis of CSA, GV, GV/kg, GV/kg > 1.5mL/kg under the Perlas classification (data are expressed as M (IQR)/n (%))

CSA(mm^2)	**Perlas 0 (n = 114)**	**Perlas 1 (n = 65)**	**Perlas 2 (n = 20)**	***t***	***P***
	380 (310–453)	**609* (557–609)**	**931# (690–1243)**	**134.111a**	**0.000**
GV(ml)	7.58 (4.54–10.48)	17.66*(557–609)	25.89#(690–1243)	119.891a	0.000
GV/kg(ml/kg)	0.73 (0.53–0.87)	1.36*(1.19–1.49)	2.87#(1.80-4.027)	149.323a	0.000
GV/kg > 1.5mL/kg	0 (0%)	13 (20%)*	17 (85%)*	97.850b	< 0.001

CSA: cross-sectional area of the antrum of the stomach, GV：gastric volume, GV/kg：Gastric volume-to-weight ratio

a: Kruskal-Wallis H test ,b: Pearson chi-square test;

CSA：GV：GV/kg：GV/kg > 1.5mL/kg Post hoc comparison with Bonferroni correction(α = 0.05/3 ≈ 0.017),

**P*<0.01, Compared with the perlas 0 level;#*P*> 0.05, Compared with the perlas 1 level.

2.3 Distribution of Gastric Ultrasound Findings and Fasting Requirements

The non - exposure group (n = 159) consisted of 97 cases with Grade 0, 52 with Grade 1, and 10 with Grade 2. The exposure group (n = 40) had 17 cases with Grade 0, 13 with Grade 1, and 10 with Grade 2.

The Perlas grading indicated statistically significant differences between the two groups (P < < 0.001), with the exposure group exhibiting a significantly higher proportion of Grade 2 cases (25% vs. 6.3%).

Although no significant difference was detected between the CSA and GV groups (P > > 0.05), the exposure group presented a significantly higher GV/kg ratio (*P* < < 0.05).

The incidence of 'full stomach' was significantly lower in the non - exposure group (8.2% [95% CI: 3.9% – 12.5%] vs. 42.5% [95% CI: 27.2% – 57.8%]) (P < 0.001). See Table 3.

Table 3
Distribution of gastric ultrasound and fasting requirements

	Meet fasting requirements (n, %)		***t***	***P***
	non-exposed group(n = 159,79.9%)	**exposure group(n = 40,20.1%)**		
Perlas0	97(61.0%)	17(42.5%)		
Perlas1	52(32.7%)	13(32.5%)		
Perlas2	10(6.3%)	10(25.0%)	13.044[a]	< 0.001**
CSA(cm^2)	498.45 ± 202.99	590.35 ± 290.55	-1.453[b]	0.146
GV(ml)	12.22 ± 7.75	14.60 ± 10.51	-0.925[b]	0.355
GV/kg(ml/kg)	1.06 ± 0.79	1.57 ± 1.09	-2.634[b]	0.008**
GV > 1.5ml/kg	13(8.2%)	17(42.5%)	29.410[a]	< 0.001**

CSA: cross-sectional area of the antrum of the stomach, GV：gastric volume, GV/kg：Gastric volume-to-weight ratio

a.Pearson chi-square test; b:Mann-Whitney U test

P* < 0.05,*P* < 0.01

Based on the fasting time, 40 cases (20.1%) were deemed unsuitable for sedation in accordance with the fasting guidelines, and the anesthesia strategy was adjusted for 23 cases following gastric ultrasound evaluation. No reflux aspiration events were observed among the 199 cases.

3 Discussion

The study demonstrated that 15.1% of sedated pediatric patients in outpatient settings presented signs of gastric fullness. In the non - exposure group, 8.2% of the children had a gastric fluid volume exceeding 1.5 ml/kg, which could potentially increase the risk of reflux aspiration. Although the majority of patients compliant with fasting protocols showed empty stomachs on gastric ultrasound, some cases still exhibited gastric fullness [7][11].

Research indicates that the consumption of clear liquids one hour prior to surgery may result in gastric fullness as detected by ultrasound, suggesting that fasting duration alone is inadequate for accurate assessment [17][18].

The findings validate the observation of Maala B et al., indicating that in pediatric patients undergoing procedural sedation, no pulmonary aspiration occurred despite a 48.1% non - adherence rate to fasting protocols. The duration of fasting exhibited no correlation with adverse events [19]. Our analysis disclosed substantial variations in the gastric fullness threshold, which was established at 1.5 ml/kg, and no reflux aspiration was detected. These results illustrate the viability of implementing a higher gastric fullness threshold (above 1.5 ml/kg) for outpatient sedated pediatric care.

In accordance with the recommendations put forward by Steven M. et al., strict fasting protocols ought to be selectively implemented for pediatric patients at a high risk of aspiration. This includes patients with an ASA class of III or higher, those suffering from gastrointestinal obstructions, individuals experiencing frequent vomiting episodes, infants under 12 months of age, and patients with obstructive sleep apnea or morbid obesity [20].

Gastric ultrasound, an advanced diagnostic instrument, is employed to evaluate the risk of aspiration and appraise the depth and characteristics of gastric lesions, such as tumors and ulcers. It offers detailed information that guides therapeutic processes and improves patient safety, especially in cases of 'full stomach' states. Research has indicated that gastric ultrasound can be integrated into the fasting - time standard assessment protocol for sedated pediatric outpatients, particularly when the fasting status is ambiguous, for high - risk patients, or in emergency scenarios [8][20].

The limitations of this study encompass its single - center design, the utilization of non - invasive ultrasound technology for the direct measurement of gastric contents, and the indirect calculation through the application of a specific GFV mathematical model [16] to assess gastric volume, a crucial factor in comprehending gastric conditions such as atrophic gastritis and gastric residue in very low birth weight infants. Moreover, caregivers' descriptions of children's feeding times and food types may be imprecise. All ultrasound images were evaluated by a single researcher, which may introduce potential evaluator bias.

4 Conclusion

Bedside ultrasound assessment of gastric emptying in sedated pediatric patients during outpatient visits facilitates effective risk stratification for reflux aspiration. This approach not only optimizes the fasting duration. Preoperative sedation with dexmedetomidine has been demonstrated to mitigate adverse effects, including prolonged crying and hypoglycemia, while substantially improving patient comfort and guaranteeing surgical safety.

Abbreviations

CSA
cross-sectional area
ASA
American Society of Anesthesiologists
ICAPS
International Committee for Procedural Sedation
CC
longitudinal diameter
AP
anteroposterior diameter
GV/kg
the gastric volume per kilogram
IQR
interquartile range
GV
gastric volume
BMI
body mass index

Declarations

Ethics approval and consent to participate

This research protocol has been approved by the Ethics Committee of Sichuan Provincial Maternal and Child Health Care Hospital (Approval No.: 20231025 - 256) and registered with the Clinical Trial Registry (Registration No.: ChiCTR2400085655). Prior to enrollment, written informed consent was obtained from the guardians of all child participants. And we ensure all experiments were performed in accordance with relevant guidelines and regulations (such as the Declaration of Helsinki).

Consent for publication

Not applicable.

Data availability

The data that support the findings of this study are available from the corresponding author, Benzhen Chen, upon reasonable request.

Competing interests

The authors declare no competing interests.

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Author contributions

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Figures



Figure 1

Legend not included with this version.