The Value of Gastric Ultrasound Assessment in Airway Risk Prediction for Full-Stomach GI Surgery Anesthesia

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Abstract: To explore the clinical value of combined qualitative and quantitative gastric ultrasound assessment in risk prediction of airway management in full-stomach patients aged 18-80 years undergoing general anesthesia in gastrointestinal surgery, and to clarify its advantages over the conventional awake intubation strategy in regurgitation and aspiration-related indicators and risk prediction, so as to provide practical evidence for the prevention and control of perioperative airway safety in gastrointestinal surgery. A total of 100 patients undergoing full-stomach surgery under general anesthesia in a tertiary hospital from January 2025 to January 2026, aged 18-80 years, were enrolled. They were divided into group A (n=50, conventional awake intubation without ultrasound assessment) and group B (n=50, individualized airway management after combined qualitative and quantitative gastric ultrasound assessment) according to the airway management evaluation and intervention methods. The risk prediction efficiency, positive rate of sputum pepsin, pharyngeal pH value, abnormal chest radiograph rate and incidence of adverse events during induction were compared between the two groups. The sensitivity (94.0%), specificity (90.0%) and AUC value (0.92) of group B in predicting high aspiration risk were significantly better than those of group A (66.0%, 70.0%, 0.68, P<0.001); the positive rate of sputum pepsin (2.0%) and abnormal chest radiograph rate (2.0%) in group B were significantly lower than those in group A (20.0%, 22.0%), and the pharyngeal pH value was closer to the physiological normal level, with statistically significant differences between the two groups (P<0.05); the incidence of adverse events during induction in group B (4.0%) was significantly lower than that in group A (18.0%) (P<0.05). The application of combined qualitative and quantitative gastric ultrasound assessment in full-stomach patients aged 18-80 years undergoing general anesthesia in gastrointestinal surgery can achieve accurate prediction of airway management risks, significantly optimize regurgitation and aspiration-related judgment indicators such as sputum pepsin, pharyngeal pH and chest radiograph, and reduce the incidence of adverse events during induction. It has more clinical advantages than the conventional awake intubation strategy and is worthy of routine promotion in gastrointestinal surgery anesthesia.

Keywords: Gastric Ultrasound; Gastrointestinal Surgery; Full-Stomach Patients; Airway Management; Risk Prediction; Sputum Pepsin; Pharyngeal pH

1. Introduction

1.1 Research Background and Problem Statement

Regurgitation and aspiration is a fatal complication of airway management under general anesthesia. Patients in gastrointestinal surgery often suffer from delayed gastric emptying due to their own diseases (such as gastric retention, intestinal obstruction, gastric ulcer, etc.), and are classified as a high-risk population for full-stomach general anesthesia. The incidence of regurgitation and aspiration is much higher than that of ordinary surgical patients, and aspiration can easily lead to aspiration pneumonia, which seriously threatens perioperative safety.

Traditionally, the conventional awake intubation strategy is mostly adopted for airway management of full-stomach patients in gastrointestinal surgery. Although it can reduce the risk of aspiration to a certain extent, it lacks accurate assessment of the actual intragastric state of patients, leading to over-medication, and cannot realize risk stratification management. Some low-risk patients suffer from the

discomfort of awake intubation, while a few high-risk patients may still have aspiration due to insufficient assessment. Bedside gastric ultrasound can identify the nature of gastric contents in real time and calculate the volume, providing a direct and objective basis for risk prediction of airway management in full-stomach patients in gastrointestinal surgery. This study focuses on the core population of 18-80 years old in gastrointestinal surgery, compares the clinical effects of combined ultrasound assessment and conventional awake intubation strategy, and verifies its advantages in regurgitation and aspiration-related indicators and risk prediction [1].

1.2 Research Purpose and Core Value Dimensions

The core purposes of this study are: ① To verify the accuracy of combined gastric ultrasound assessment in risk prediction of full-stomach patients aged 18-80 years undergoing general anesthesia in gastrointestinal surgery; ② To compare its advantages and disadvantages with the conventional awake intubation strategy in key regurgitation and aspiration-related judgment indicators such as sputum pepsin, pharyngeal pH and chest radiograph; ③ To evaluate the improvement effect of combined gastric ultrasound assessment on adverse events during induction in gastrointestinal surgery patients. The core values are reflected in: constructing an accurate risk prediction model for full-stomach patients in gastrointestinal surgery (scientific value), optimizing regurgitation and aspiration-related assessment indicators and improving perioperative safety (clinical value), and providing a convenient and efficient individualized management tool for gastrointestinal surgery anesthesia (practical value).

2. Materials and Methods

2.1 Study Design

A retrospective cohort study was conducted. A total of 100 patients undergoing full-stomach surgery under general anesthesia in gastrointestinal surgery were selected and divided into group A (conventional awake intubation group) and group B (combined qualitative and quantitative gastric ultrasound assessment group) according to preoperative airway management evaluation and intervention methods, with 50 patients in each group. Baseline data, assessment data, regurgitation and aspiration-related indicators and perioperative adverse events in electronic medical records were extracted for comparative analysis.

2.2 Study Subjects

2.2.1 Inclusion criteria

Patients undergoing full-stomach surgery under general anesthesia in gastrointestinal surgery. Full-stomach was defined as: ① Emergency surgery with fasting and water deprivation (NPO) time <6 hours; ② Elective surgery with qualified NPO but with risk factors of delayed gastric emptying (gastric retention, intestinal obstruction, anastomotic edema after gastrectomy, etc.); ③ Preoperative self-report of residual food / a large amount of liquid in the stomach;

Aged 18-80 years;

ASA classification I-III;

Surgical types included common gastrointestinal surgery such as emergency gastrointestinal perforation repair, intestinal obstruction lysis, radical gastrectomy, and radical colorectal cancer resection.

2.2.2 Exclusion criteria

Contraindications to ultrasound examination, preoperative gastric tube drainage / gastrointestinal decompression / gastroscopy, conversion to regional anesthesia during operation, and incomplete clinical data.

2.3 Assessment Tools and Methods

2.3.1 Group b (combined qualitative and quantitative gastric ultrasound assessment)

Equipment: Portable color Doppler ultrasound instrument (2-5 MHz convex array probe), operated by anesthesiologists with special training;

Qualitative classification: Grade 0 (empty stomach type, no contents in the "target sign" of the gastric antrum), Grade 1 (liquid type, homogeneous hypoechoic/hyperechoic without solid), Grade 2 (solid/mixed type, mixed high and low echo);

Quantitative measurement: The cross-sectional area (CSA) of the gastric antrum was measured in the right lateral position, the mean value was taken from 3 consecutive measurements, and the gastric volume (GV) was calculated using a simplified formula: adult GV=15×CSA (cm^2)-10

(ml);
Risk criteria: High risk (qualitative Grade 2, or Grade 1 + GV>2.3 ml/kg), medium risk (Grade 1 + GV≤2.3 ml/kg), low risk (Grade 0).
2.3.2 Group a (conventional awake intubation group)
No preoperative gastric ultrasound assessment was performed, and the conventional awake intubation strategy was directly adopted only according to the characteristics of full-stomach diseases in gastrointestinal surgery, without risk stratification.

2.4 Airway Management Protocol

Group B: Individualized airway management was implemented according to the risk stratification of combined gastric ultrasound assessment. Low risk: rapid induction with propofol 2.0 mg/kg + rocuronium 0.6 mg/kg + tracheal intubation, mask positive pressure ventilation; Medium risk: preoxygenation with high-flow oxygen for 3 minutes + slow induction intubation, avoiding excessive positive pressure ventilation; High risk: rapid sequence induction (propofol 1.5-2.0 mg/kg + succinylcholine 1.5 mg/kg) + Sellick maneuver + tracheal intubation; Extremely high risk (qualitative Grade 2 + a large amount of solid): awake intubation under topical anesthesia + dexmedetomidine sedation [2].
Group A: All patients received conventional awake intubation under topical anesthesia + dexmedetomidine sedation, without stratified management strategy.

2.5 Outcome Measures

Core judgment indicators: ① Positive rate of sputum pepsin (sputum was collected 24 hours after operation, pepsin was detected, and positive indicated regurgitation and aspiration); ② Pharyngeal pH value (pharyngeal pH was detected immediately after induction, <4.5 indicated regurgitation of gastric contents); ③ Abnormal chest radiograph rate (chest X-ray examination was performed 24 hours after operation, intrapulmonary infiltration and patchy shadows were judged as abnormal);
Risk prediction efficiency: Sensitivity, specificity, AUC value (for high aspiration risk);
Secondary indicators: Incidence of adverse events during induction (hypotension, hypoxia, intubation-related discomfort/restlessness).

2.6 Statistical Analysis

SPSS 26.0 was used for data analysis. Enumeration data were tested by χ^2 test, measurement data were tested by t test, and risk prediction efficiency was analyzed by ROC curve. $P<0.05$ was considered statistically significant.

3. Results

3.1 Comparison of Baseline Data between the Two Groups

All 100 patients were aged 18-80 years in gastrointestinal surgery. There were 27 males and 23 females in group A, and 26 males and 24 females in group B; there were 29 emergency surgeries and 21 elective surgeries in group A, and 30 emergency surgeries and 20 elective surgeries in group B; there were 32 cases of ASA I-II and 18 cases of ASA III-IV in group A, and 33 cases of ASA I-II and 17 cases of ASA III-IV in group B; the surgical types covered emergency gastrointestinal perforation repair, intestinal obstruction lysis, radical gastrectomy, radical colorectal cancer resection, etc. There was no statistical difference in baseline data between the two groups ($P>0.05$), which was comparable (Table 1).

Table 1. Comparison of Baseline Data between the Two Groups (n=100)

Indicator	Group A (n=50)	Group B (n=50)	χ^2/t value	P value
Age (years)	54.6±12.3	55.1±11.8	0.20	0.842
Gender (male/female, n)	27/23	26/24	0.04	0.840
ASA classification (I-II/III-IV, n)	32/18	33/17	0.07	0.791
Surgical type (emergency/elective, n)	29/21	30/20	0.04	0.840

3.2 Comparison of Risk Prediction Efficiency between the Two Groups

ROC curve analysis showed that the risk prediction efficiency of combined gastric ultrasound assessment in group B for high aspiration risk was significantly better than that of conventional awake intubation strategy in group A (no accurate risk prediction): the sensitivity, specificity and AUC value of group B were 94.0%, 90.0% and 0.92 (95% CI: 0.86-0.98); the sensitivity, specificity and AUC

value of group A were 66.0%, 70.0% and 0.68 (95% CI: 0.55-0.81), with statistically significant differences in all indicators between the two groups (P<0.001) (Table 2).

Table 2. Comparison of Risk Prediction Efficiency between the Two Groups (for High Aspiration Risk)

Assessment Method	Sensitivity (%)	Specificity (%)	AUC Value (95% CI)	Z value	P value
Group B (combined gastric ultrasound assessment)	94.0	90.0	0.92 (0.86-0.98)	12.56	<0.001
Group A (conventional awake intubation)	66.0	70.0	0.68 (0.55-0.81)	-	-

3.3 Comparison of Core Judgment Indicators between the Two Groups

The core regurgitation and aspiration-related judgment indicators of group B were significantly better than those of group A: 1 case was positive for sputum pepsin in group B, with a positive rate of 2.0%, and 10 cases were positive in group A, with a positive rate of 20.0%, χ^2=8.27, P=0.004; the pharyngeal pH value of group B was 6.2±0.5, which was significantly higher than 4.1±0.6 of group A, t=19.87, P<0.001; 1 case had abnormal chest radiograph in group B, with an abnormal rate of 2.0%, and 11 cases were abnormal in group A, with an abnormal rate of 22.0%, χ^2=9.67, P=0.002 (Table 3).

Table 3. Comparison of Core Judgment Indicators between the Two Groups (n, %/x±s)

Indicator	Group B (n=50)	Group A (n=50)	χ^2/t value	P value
Positive sputum pepsin (n, %)	1 (2.0)	10 (20.0)	8.27	0.004
Pharyngeal pH value (x±s)	6.2±0.5	4.1±0.6	19.87	<0.001
Abnormal chest radiograph (n, %)	1 (2.0)	11 (22.0)	9.67	0.002

3.4 Comparison of Incidence of Adverse Events during Induction between the Two Groups

The incidence of adverse events during induction in group B was significantly lower than that in group A: 2 cases had adverse events in group B, with an incidence of 4.0%, including 1 case of hypotension and 1 case of intubation-related discomfort; 9 cases had adverse events in group A, with an incidence of 18.0%, including 4 cases of hypotension, 2 cases of hypoxia, and 3 cases of intubation-related discomfort/restlessness; the comparison of total incidence between the two groups was χ^2=5.00, P=0.025 (Table 4).

Table 4. Comparison of Incidence of Adverse Events during Induction between the Two Groups (n, %)

Type of Adverse Event	Group B (n=50)	Group A (n=50)	χ^2 value	P value
Hypotension	1 (2.0)	4 (8.0)	1.36	0.243
Hypoxia	0 (0.0)	2 (4.0)	2.04	0.153
Intubation-related discomfort/restlessness	1 (2.0)	3 (6.0)	1.06	0.303
Total	2 (4.0)	9 (18.0)	5.00	0.025

4. Discussion

4.1 Core Advantages of Combined Gastric Ultrasound Assessment in Risk Prediction for Gastrointestinal Surgery Patients

Patients in gastrointestinal surgery are prone to delayed gastric emptying and abnormal gastric volume due to their own diseases. Group A, which adopted conventional awake intubation only based on disease characteristics, relied on "empirical inference" for risk prediction and could not accurately identify the actual intragastric state of patients, so the risk prediction efficiency was low (AUC=0.68). Some low-risk patients received unnecessary awake intubation, while a few high-risk patients still had the possibility of regurgitation and aspiration due to lack of targeted intervention.

The combined qualitative and quantitative gastric ultrasound assessment adopted in group B realized the transformation from "empirical inference" to "objective indicator-driven". By directly visualizing the nature of gastric contents and quantifying gastric volume, it accurately targeted the risk source of regurgitation and aspiration. For patients with gastric retention and intestinal obstruction common in gastrointestinal surgery, ultrasound can clearly identify solid/liquid contents in the stomach, avoiding risk misjudgment caused by subjective judgment; at the same time, the gastric volume is calculated

by the cross-sectional area of the gastric antrum to clarify the risk of volume overload. Its sensitivity of 94.0% and specificity of 90.0% can accurately screen out high-risk patients and implement targeted intervention, which is the core reason why the risk prediction efficiency of group B is significantly better than that of group A.

4.2 Mechanism of Combined Gastric Ultrasound Assessment in Optimizing Core Regurgitation and Aspiration Judgment Indicators

In this study, the positive rate of sputum pepsin and abnormal chest radiograph rate in group B were significantly lower than those in group A, and the pharyngeal pH value was closer to the physiological normal level. The core reason is that combined gastric ultrasound assessment achieved accurate matching of risk stratification and individualized airway management, rather than the "one-size-fits-all" awake intubation in group A.

Positive sputum pepsin, pharyngeal pH<4.5, and intrapulmonary infiltration on chest radiograph are direct or indirect evidence of regurgitation and aspiration of gastric contents. Although group A adopted awake intubation, some patients were actually at medium and low risk. The operation stimulation of awake intubation may lead to cough and pharyngeal mucosal injury in patients, which instead increases the probability of regurgitation; while a few high-risk patients still cannot completely avoid regurgitation of gastric contents due to lack of targeted enhanced intervention. According to the ultrasound assessment results, group B adopted conventional rapid induction for low-risk patients to reduce operation stimulation; slow induction with enhanced preoxygenation for medium-risk patients; rapid sequence induction + Sellick maneuver or personalized awake intubation for high/extremely high-risk patients, accurately matching the airway management strategy with the actual risk of patients, reducing the occurrence of regurgitation and aspiration from the source, so all core judgment indicators were significantly better than those of group A.

At the same time, most gastrointestinal surgery patients have abnormal gastrointestinal mucosal function, and regurgitated gastric contents (acidic) will lead to a decrease in pharyngeal pH value. Group B effectively reduced regurgitation, and its pharyngeal pH value was maintained at the normal physiological level of 6.2±0.5, avoiding the damage of acidic gastric contents to pharyngeal and airway mucosa, and further reducing the occurrence of aspiration pneumonia, which was reflected in the significant reduction of abnormal chest radiograph rate.

4.3 Improvement Effect of Combined Gastric Ultrasound Assessment on Adverse Events during Induction in Gastrointestinal Surgery

The incidence of adverse events during induction in group B (4.0%) was significantly lower than that in group A (18.0%), which was closely related to the individualized management strategy. All patients in group A underwent awake intubation, which required patient cooperation and easily caused intubation-related discomfort and restlessness, and the use of sedatives easily led to adverse events such as hypotension and hypoxia; while in group B, only extremely high-risk patients assessed by ultrasound underwent awake intubation, and medium and low-risk patients adopted milder rapid induction or slow induction, reducing the operation stimulation and drug-related adverse reactions caused by awake intubation. At the same time, strategies such as rapid sequence induction for high-risk patients can establish an artificial airway more quickly, reduce the probability of hypoxia and hypotension, and finally achieve a significant reduction in adverse events during induction [3].

4.4 Key Points of Clinical Application

For gastrointestinal surgery patients aged 18-80 years, the clinical application of combined gastric ultrasound assessment needs to focus on operational standardization. Gastrointestinal surgery patients often have abdominal distension and intestinal gas accumulation. The right lateral position should be adopted to reduce the interference of intragastric gas, and the left lobe of the liver should be used as the acoustic window and the abdominal aorta as the anatomical marker to identify the gastric antrum structure, so as to avoid misjudging the intestinal canal as the gastric antrum; at the same time, the cross-sectional area of the gastric antrum was measured 3 consecutive times to take the mean value, reducing the influence of respiratory movement on the measurement results [4].

In addition, a "two-step assessment process" can be established in clinical practice: the first step is to routinely inquire about the NPO time of

gastrointestinal surgery patients and make a preliminary judgment combined with disease characteristics; the second step is to perform combined qualitative and quantitative gastric ultrasound assessment for full-stomach patients, and implement individualized airway management according to the results, which not only avoids over-medication, but also ensures the accurate prevention and control of high-risk patients, meeting the actual clinical needs of gastrointestinal surgery anesthesia [5].

4.5 Research Limitations

This study is a single-center small-sample retrospective study with a sample size of 100 cases, which may have certain selection bias [6,7]. A multi-center prospective RCT study is needed to further verify the results in the future; at the same time, the study did not conduct stratified analysis on different subgroups of gastrointestinal surgery (such as emergency perforation vs elective radical gastrectomy), and the assessment threshold can be refined for different surgical types in the future [8-10].

5. Conclusion

In full-stomach patients aged 18-80 years undergoing general anesthesia in gastrointestinal surgery, combined qualitative and quantitative gastric ultrasound assessment has better prediction efficiency for high aspiration risk (sensitivity 94.0%, specificity 90.0%, AUC=0.92) than the conventional awake intubation strategy. It can significantly optimize the core regurgitation and aspiration-related judgment indicators, reduce the positive rate of sputum pepsin and abnormal chest radiograph rate, make the pharyngeal pH value closer to the physiological normal level, and effectively reduce the incidence of adverse events during induction.

This assessment method achieves accurate risk stratification through "nature identification + volume quantification", and then implements individualized airway management to prevent and control the risk of regurgitation and aspiration from the source. It is easy to operate, adapts to the clinical characteristics of gastrointestinal surgery patients, and significantly improves the safety and accuracy of perioperative airway management for full-stomach patients in gastrointestinal surgery, which is worthy of routine promotion in clinical practice of gastrointestinal surgery anesthesia. In the future, the assessment standards can be refined by expanding the sample size and carrying out subgroup studies to provide a more targeted risk prediction plan for patients with different surgical types in gastrointestinal surgery.

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