Observational study of the effect of preoperative consumption of different doses of carbohydrates before spinal surgery

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Research Article

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Abstract

Objective

To investigate the effects of two carbohydrate doses administered 2 hours prior to spinal surgery on the perioperative period of patients, aiming to add evidence to help optimize enhanced recovery after surgery (ERAS).

Methods

One hundred patients undergoing spinal surgery were divided into a 200 ml carbohydrate group (group A) and a 400 ml carbohydrate group (group B), with 50 patients in each group, according to the random number method. Patients in both groups consumed the carbohydrates (maltodextrin fructose drink) 2 hours before surgery. The gastric antral cross-sectional area (CSA) of the patients was recorded using gastric ultrasound at different time points. Gastric volume (GV), gastric emptying rate, and the proportion of patients with gastric emptying were calculated. Postoperative hunger, thirst, and anxiety scores were recorded on a visual analog scale (VAS). Postoperative nausea and vomiting (PONV) and length of stay (LOS) were recorded.

Results

The mean CSA and GV of both groups had returned to baseline at T4, with no significant difference from Tm ($P > 0.05$). Group B exhibited a lower gastric emptying rate than group A during period A1 ($P < 0.05$), while it was faster in group B during periods A2, A3, and A4 ($P < 0.05$). At T4, almost all patients had gastric emptying, the emptying rates of group A and group B being 92% and 88%, respectively. When comparing the blood glucose values before drinking (Tm) vs. after the operation (T5), there were no differences in either group ($P > 0.05$). The hunger and thirst scores of patients in group B were significantly lower than those in group A ($P < 0.05$). There was no significant difference in anxiety score, incidence of nausea and vomiting or length of stay ($P > 0.05$).

Conclusion

Oral carbohydrate drinks of 400 ml or 200 ml administered 2 hours prior to spinal surgery are safe for patients and can be incorporated into ERAS protocols to minimize postoperative complications and facilitate patient recovery. The larger 400 ml carbohydrate dose brings no increased risk of aspiration and effectively alleviates patient discomfort such as hunger and thirst.

Introduction

In recent years, spinal surgery has become more common due to various societal factors, such as evolving lifestyles, an aging global population, and rapid advancements in medical and economic domains[1, 2]. The high complexity and long duration of spinal surgery have resulted in a notable escalation in the prevalence of postoperative complications, lengthier hospital stays, and increased expenditures[3–5]. The implementation of enhanced recovery after surgery (ERAS) schemes in spinal surgery has led to significant reductions in postoperative complications, readmission rates, and hospitalization time while potentially enhancing patient outcomes and facilitating functional recovery[6, 7]. Further exploration is warranted to optimize the implementation of all aspects of ERAS for spinal surgery.

The efficacy of prolonged fasting has been questioned, leading to the recognition that traditional perioperative water-fasting guidelines are no longer applicable in clinical practice[8, 9]. In 1999, the American Society of Anesthesiology (ASA) revised its preoperative fasting guidelines, recommending a more lenient approach for elective surgical patients without feeding difficulties. It suggested that ingesting moderate amounts of fluids (excluding alcohol, milk, and fat-containing fluids) prior to surgery could help patient recovery[10]. Research under the ERAS paradigm proposes that the ingestion of a carbohydrate-rich clear drink 2 hours prior to anesthesia for most elective surgeries is safe [11–13]. Several studies have indicated that this practice not only poses no increased risk of reflux aspiration but also mitigates thirst, anxiety, surgical stress, postoperative gastrointestinal complications, and insulin resistance while expediting patient recovery after surgery [14, 15].

It is reasonable to optimize the ERAS protocol while ensuring that patients are not at risk of aspiration. Several studies have demonstrated that consuming 150 ml of clear liquids, including black tea, coffee, and carbonated beverages, up to 2 hours before surgery under general anesthesia is safe and reduces gastric fluid secretion [16]. Some ERAS protocols have introduced a preoperative oral carbohydrate regimen of carbohydrate fluids (less than 400 ml) 2 h before anesthesia. This approach has been shown to shorten hospital stay, increase insulin sensitivity, and not prolong gastric emptying compared with traditional fasting [17–19]. Oral carbohydrate fluids (200 ml) 2 h preoperatively have succeeded at reducing postoperative catabolic stress and the surgical inflammatory response [20–22]. However, the safety profile of these two ERAS regimens remains to be fully confirmed [23], necessitating further assessment of gastric emptying to ascertain the potential risk of reflux aspiration.

In recent years, the assessment modalities for gastric emptying have been categorized into two groups: invasive approaches, including the saline loading method [24], dye dilution method [25], and stress test method, which are seldom employed due to limited acceptance by patients; and noninvasive approaches, encompassing X-ray potential tomography [26], scintigraphic scanning techniques [27], and magnetic resonance testing [28]. Due to factors such as radiation exposure, high costs, and high test variability, the clinical use of these methods is also limited. In contrast, bedside gastric ultrasound is a noninvasive alternative that can provide good information on the type and volume of gastric contents. This technique boasts the advantages of simplicity, comfort, efficiency, reproducibility, and nonradioactivity, giving it great potential for assessing the risk of reflux aspiration in clinical practice [29].

Gastric ultrasound is increasingly employed in both outpatient and preoperative evaluations of gastric emptying [30, 31]. In this study, we propose the utilization of gastric ultrasound to assess gastric contents within two preoperative ERAS protocols for spinal surgery involving oral carbohydrate drinks. This study will provide a robust foundation for optimizing ERAS regimens specifically tailored to spinal surgery.

Materials and methods

1. Study subjects and groups

1.1 General information

The study was approved by the Ethics Committee of Shiyan Renmin Hospital in Hubei Province (No. syrm2023-016), and all participants signed an informed consent form for research ethics prior to their inclusion. A total of 100 patients meeting the specified inclusion and exclusion criteria were selected for spinal surgery under general anesthesia.

1.2 Inclusion Criteria

Patients aged 18–65 years, of ASA class I-III, scheduled for elective spinal surgery under general anesthesia with tracheal intubation

1.3 Exclusion Criteria

Upper gastrointestinal bleeding (within 1 month), BMI $\geq$ 28 kg/m^2, high risk of reflux aspiration (gastroesophageal shunt, hiatal hernia, Zenker's diverticulum, achalasia of cardia, gastrointestinal obstruction, etc.), history of previous gastric surgery, diabetes mellitus (gastroparesis), hemodynamic instability, preoperative medications affecting gastric motility, pregnancy, and psychiatric abnormalities.

1.4 Grouping situation

One hundred patients undergoing elective spinal surgery under general anesthesia were selected from our hospital between May and August 2023. The patients were randomly assigned to either group A or group B, each group consisting of 50 patients. Patients in group A consumed a carbohydrate drink of 200 ml 2 h before surgery on the day of the procedure, while those in group B consumed a carbohydrate drink of 400 ml at the same time.

2. Major instruments and materials

Ultrasound equipment: color Doppler ultrasound diagnostic instrument (LOGIQ e, GE Medical Systems Co., Ltd, China), convex array probe (2–5 MHz, GE Medical Systems Co., Ltd, China), and medical coupler (Foshan Pingchuang Medical Technology Co., Ltd., China).

Carbohydrate Drink: maltodextrin fructose drink, trade name: Suqian, Jiangsu Zhengda Fenghai Pharmaceutical Co., Ltd, specification: 200 mL/bottle, shelf life: 18 months, execution standard No.: Q/CTFH 0001S (Table 1).

Table 1
Carbohydrate composition

Iterms	Per 100mL
energy(kg)	212
protein(g)	0
fat(g)	0
carbohydrate(g)	12.5
sodium(mg)	50

3. Anesthesia

No premedication was administered, and the prescribed fasting protocol was followed. Upon entering the operating room, NIBP(Noninvasive blood pressure), ECG(Electrocardiograph), SpO2(Pulse blood oxygen saturation), temperature and PetCO2(End-tidal carbon dioxide partial pressure) were monitored. Peripheral venous access was established and Ringer's lactate solution (10ml/kg) was administered intravenously. All patients were treated with 100% oxygen for 3min before induction, and then propofol 2.5mg/kg, cisatracurium 0.3mg/kg, sufentanil 0.05ug/kg and flurbiprofen axetil 50mg were given. 3 minutes later, tracheal intubation was performed with a video laryngoscope, and mechanical ventilation was initiated following confirmation of the tracheal tube placement. The ventilation parameters are adjusted to maintain PetCO2 levels between 35 and 50 mmHg. Anesthesia was maintained by inhalational 1.5%-2% sevofurane, intermittent infusion of cisatracurium, continuous infusion of 0.025-0.100 ug/(kg· min)remifentanil. At the conclusion of the procedure, extubation was performed upon restoration of spontaneous respiration and regaining consciousness.

4. Inspection method

4.1 Preoperative carbohydrates

Patients came to the hospital the day before surgery, when they were given necessary preoperative education if they met the criteria. The importance of drinking a carbohydrate drink before surgery was explained. They signed the informed consent, which required them to refrain from drinking water after 22:00 p.m. that night. At precisely 6:00 a.m. on the day of surgery, the two groups of patients were directed to orally consume 200 ml or 400 ml of the carbohydrate drink within a five-minute period.

4.2 Measuring method

4.2.1Gastric antral cross-sectional area measurement

The patients were instructed to assume a right lateral decubitus position to minimize the interference of intestinal air. Fasting was required before measuring the cut surface of the gastric antrum.The longest diameter, anteroposterior (AP), and the largest longitudinal diameter, craniocaudal (CC), were measured from the serosal layer to the serosal layer. The average of three measurements was calculated as the final measurement for each patient. Following carbohydrate consumption, the gastric sinus was scanned again to record the AP and CC values. Measurements were taken every 30 minutes until CSA returned to its "empty antral" state. That is, when the CSA was less than or equal to the antral cross-sectional area before drinking, gastric emptying was indicated. The predrinking (during fasting), immediate postdrinking (0 min), 30 min, 60 min, 90 min, 120 min, and end of the procedure time points were noted as Tm, T0, T1, T2, T3, T4, and T5, respectively. The cross-sectional area of the gastric antral (CSA) was determined from AP and CC: CSA = $\pi \times AP \times CC/4$ [32] (Fig. 1).

4.2.2 Calculation of gastric emptying index and aspiration risk assessment.

Gastric volume (GV) was calculated from the CSA: GV (ml) = 27.0 + 14.6 × CSA (cm2) − 1.28 × age (years) [33]. If the measured GV exceeds 1.5 mL/kg, it indicates a high risk of reflux aspiration, requiring surgical delay and continued assessment of the gastric antral every 30 minutes until GV falls below 1.5 mL/kg. When it has, anesthesia induction can begin. When the GV value ranged from 0.8 mL/kg to 1.5 mL/kg, the patient was deemed to have a low risk of reflux and aspiration; when the measurement was below 0.8 mL/kg, it indicated a very low risk [34].

4.2.3 Rate of gastric emptying in different time intervals

In this study, the gastric emptying rate (mL/h) was assessed by measuring changes in GV during specific time intervals. The first interval was denoted as A1: the time from immediately after drinking (T0) to 30 min after drinking (T1); A2 was the time between 30 minutes (T1) and 60 minutes (T2); and so forth for A3 and A4.

4.2.4 Ratio of gastric emptying at T4

The gastric antrum status of the patients was evaluated 120 minutes after preoperative oral administration of carbohydrates (T4 moment). The percentage of patients with an emptied gastric antrum (i.e., CSA at the T4 ≤ Tm) at this time point was calculated as a proportion of the total population, defined as the proportion of individuals whose stomachs had emptied at the T4 moment.

4.2.5 Glucose measurement

The patients' fingertip blood glucose levels were measured prior to their consumption of drink (Tm) and immediately following the procedure (T5).

4.2.6 Recording of thirst, hunger and anxiety levels

Preoperative oral administration of carbohydrates has been shown to alleviate postoperative discomfort, including anxiety, depression, hunger, nausea, pain, thirst, fatigue and weakness, in patients [35]. In this study, we employed the visual analog scoring (VAS) method to compare the postoperative hunger scores, thirst scores and anxiety scores between the two patient groups. This scale was a 10-cm-long Vernier scale ranging from 0–10, where 0 represents normal levels with no hunger, thirst or anxiety and 10 indicates intolerable levels of hunger, thirst or anxiety. Patients indicated their conditions on the Vernier scale corresponding to their level of hunger, thirst and anxiety; higher scores indicated more severe levels.

5. Statistical methods

(Sample size calculation: The estimation of sample size using PASS software indicated a minimum requirement of 41 cases in each group, resulting in a total sample size of 82 cases. Considering an anticipated loss-to-follow-up rate of 10%, a minimum of 50 patients per group was deemed necessary).

The data were processed using SPSS 21.0 statistical software. Measurement data (± s) were analyzed with Student's t test, while measurement data at different time points were subjected to ANOVA with repeated measurements. Count data (%) were analyzed using the chi-square test. A statistically significant difference was accepted at $P < 0.05$.

Results

1. General information

The general data of patients, including sex, height, weight, body mass index (BMI), and duration of surgery (min), were similar between groups ($P > 0.05$) (Table 2).

Table 2
Comparison of the demographic data and Operation duration between two groups (n = 50, $\bar{x} \pm s$)

Group	Sex(Male/Female)	Height (cm, ± s)	Weight (kg, ± s)	BMI (kg/m2, ± s)	time of operation(min)
Group A	22/28	164.77 ± 7.28	63.87 ± 6.33	23.53 ± 1.81	100.42 ± 23.65
Group B	18/32	167.26 ± 6.87	66.42 ± 7.58	24.19 ± 2.15	96.32 ± 21.78
c2/t	0.667	1.759	1.827	1.668	0.902
P	0.414	0.082	0.071	0.098	0.369

2. Comparison of gastric antral cross-sectional areas between the two groups of patients

The mean CSA at Tm and T4 were similar between the two groups (P > 0.05). At each time from T0 to T3, group B had a significantly larger mean CSA than group A (P < 0.05). At T4, both groups showed a restoration of mean CSA to baseline levels, both being similar to their respective Tm values (P > 0.05), indicating complete emptying of carbohydrates from the stomachs in both groups at T4 (Tables 3; Figs. 2).

Table 3
Comparison of CSA between the two groups at each time point (n = 50, cm^2, $\bar{x} \pm s$)

Group	Tm(Before drinking)	T0(0min)	T1(30min)	T2(60min)	T3(90min)	T4(120min)
Group A	3.40 ± 1.59	16.86 ± 1.89	11.41 ± 1.57	5.62 ± 1.18	4.05 ± 0.96	3.36 ± 1.03
Group B	3.59 ± 1.07	33.01 ± 3.86*	20.97 ± 2.22*	12.29 ± 1.51*	5.63 ± 0.81*	3.64 ± 1.00
P	0.388	0.000	0.000	0.000	0.000	0.161
Note: Compared with group A, *P < 0.05						

3. Comparison of gastric volume between the two groups of patients

The GV values were also compared between the two groups by time period(The GV values were also compared between the two groups across different time periods.), revealing a consistent correlation between changes in GV and CSA. At each time from T0 to T3, group B had a significantly larger mean GV than group A ($P < 0.05$).At T4, the GV shrank returned to baseline levels in both of the groups, both being similar to their respective Tm values ($P > 0.05$), indicating complete emptying of gastric contents in both groups at T4(Tables 4; Figs. 3).

Table 4
Comparison of GV between the two groups at each time point (n = 50, ml, $\bar{x} \pm s$)

Group	Tm(Before drinking)	T0(0min)	T1(30min)	T2(60min)	T3(90min)	T4(120min)
Group A	17.13 ± 15.62	334.50 ± 24.87	132.88 ± 24.18	48.63 ± 19.41	25.26 ± 14.57	16.38 ± 14.95
Group B	19.51 ± 15.87	375.61 ± 19.48*	271.84 ± 30.05*	145.19 ± 22.16*	47.95 ± 16.00*	19.54 ± 16.27
P	0.451	0.000	0.000	0.000	0.000	0.313
Note: Compared with group A, *P < 0.05						

4. Comparison of gastric emptying rate between the two groups in each time period

During time period A1, group B had a lower gastric emptying rate than group A. Later (A2, A3, and A4), the gastric emptying rate of group B surpassed that of group A (*P*< 0.05) (Table 5; Fig. 4).

Table 5
Comparison of gastric emptying rate between the two groups in different time periods (n = 50, ml/h)

Group	A1(0-30min)	A2(30-60min)	A3(60-90min)	A4(90-120min)
Group A	401.67(364.58, 449.54)	172.57(145.93, 193.89)	52.71(29.20, 61.39)	16.35(2.92, 31.10)
Group B	198.75(165.79, 256.46)	262.22(217.18, 301.20)	186.88(175.13, 207.54)	56.94(30.66, 79.86)
Z	8.266	6.598	8.618	5.937
P	0.000	0.000	0.000	0.000

5. Comparison of the proportion of patients with gastric antrum emptying between the two groups

At T2 (60 minutes), group A initiated complete gastric emptying, achieving a 92% emptying rate by T4 (120 minutes). Members of group B completed gastric emptying as early as T3 (90 minutes), resulting in an 88% emptying rate at T4. Although the gastric emptying rates of group A were consistently higher than those of group B at T2, T3, and T4, none of these differences reached statistical significance (*P*> 0.05) (Table 6).

Table 6
Comparison of gastric emptying rate between the two groups (n = 50)

Group	Tm (Before drinking)	T0(0min)	T1(30min)	T2(60min)	T3(90min)	T4(120min)
Group A	0	0	0	8%	24%	92%
Group B	0	0	0	0	10%	88%
c2	-	-	-	2.344	3.473	0.444
P	-	-	-	0.126	0.062	0.505

6. Assessment of the risk of reflux aspiration in patients with unemptied T4 moments

At T4 in group A, 4 patients had incomplete liquid emptying (with GVs of 0.39 mL/kg, 0.84 mL/kg, 0.57 mL/kg, and 0.23 mL/kg). In group B, there were 6 patients with incomplete liquid emptying (with GVs of 0.67 mL/kg, 0.50 mL/kg, 0.33 mL/kg, 0.25 mL/kg, 0.44 mL/kg and 0.25 mL/kg).All GV values were below the threshold of < 0.8 mL/kg, indicating an extremely low risk for reflux aspiration in these patients. Thus, routine preoperative induction of anesthesia could be safely performed.

7. Comparison of postoperative blood glucose values between the two groups of patients

Comparison between groups: Blood glucose was similar between groups at Tm (before drinking) and at T5 (after surgery) ($P > 0.05$). Comparison within groups: Both group A and group B exhibited significantly higher blood glucose values at T5 (after surgery) than at Tm ($P < 0.05$) (Table 7).

Table 7
Comparison of gastric antral cross-sectional areas between the two groups at each time point (n = 50, mmol/ml,

$\bar{x} \pm s$)

Group	Tm(Before drinking)	T5(After operation)	P
Group A	5.69 ± 1.22	7.95 ± 2.07*	0.000
Group B	5.62 ± 1.47	7.48 ± 1.77*	0.000
P	0.796	0.220	-
Note: Compared with Tm, *P < 0.05			

8. Comparison of postoperative conditions between the two groups of patients

The hunger scores and thirst scores of patients in group B were lower than those in group A ($P < 0.05$). The anxiety scores of patients in group B were slightly higher than those in group A ($P > 0.05$). The incidence of nausea and vomiting in patients in group B was higher than that in group A, although the difference did not reach statistical significance ($P > 0.05$). Additionally, patients in group B had a slightly shorter hospitalization than those in group A, but this difference was also not statistically significant ($P > 0.05$) (Table 8).

Table 8
Comparison of discomfort VAS, nausea and vomiting and inpatient days between the two groups (n = 50, $\bar{x} \pm s$)

Group	Hunger score(cm)	Thirst score(cm)	Anxiety score(cm)	nausea and vomiting(N)	length of stay(Day)
Group A	3.76 ± 1.95	4.58 ± 1.53	3.54 ± 1.42	13(13/50)	14.40 ± 3.49
Group B	2.18 ± 1.37*	3.04 ± 1.87*	3.84 ± 1.27	17(17/50)	13.44 ± 2.69
c2/t	4.686	4.507	1.116	0.762	1.541
P	0.000	0.000	0.267	0.383	0.127

Note: Compared with group A, *P < 0.05

Discussion

In this study, gastric ultrasound was employed to quantitatively and qualitatively evaluate gastric contents in two cohorts of spinal surgery patients who were administered varying doses of oral carbohydrates. Gastric emptying was observed, and a comparative analysis was conducted between the two patient groups on the protocol with respect to blood glucose levels, thirst and hunger sensations, anxiety levels, and length of stay. In this study, 100 patients undergoing spinal surgery were enrolled, and the experimental findings demonstrated that both group A and group B achieved fasting sinus levels within 120 minutes after consuming a carbohydrate beverage (i.e., prior to surgery), with no significant difference in emptying rate ($P > 0.05$). The risk of reflux aspiration was deemed low enough to permit routine anesthesia induction. When we compared postoperative hunger, thirst, anxiety, postoperative nausea and vomiting (PONV), and hospitalization duration between group A and group B, Group B was superior in postoperative hunger and thirst. The data obtained from this study can serve as a valuable foundation for optimizing the Enhanced Recovery After Surgery (ERAS) protocol.

The preferred method for assessing gastric emptying by many researchers is gastric ultrasound [36, 37]. Gastric ultrasound scans the changes in the cross-sectional area of the gastric antrum at various time points to determine gastric emptying [38]. In this study, the CSA after 120 minutes of carbohydrate intake (T4) was 3.36 ± 1.03 cm^2 in group A and 3.64 ± 1.00 cm^2 in group B, both of which closely resembled the CSA during fasting (Tm moment), indicating that oral administration of less than 400 ml of carbohydrate 2 h before surgery is safe. Previous studies have demonstrated that patients undergoing surgery under general anesthesia who consumed 400 ml of carbohydrates 2 h preoperatively and underwent gastric ultrasound examination at 120 min did not show an increased risk of aspiration[11, 18], which aligns with our findings. In a previous investigation involving cesarean section patients [36], the median CSA in right lateral recumbency during fasting was 4.35 cm^2 (IQR 3.4–5.6), which was not different from the median CSA in right lateral recumbency at 120 min, 4.55 cm^2 (IQR 3.8–6.5) ($P > 0.05$). Considering that pregnant individuals may be more susceptible to aspiration due to alterations in gastric physiology caused by an enlarged uterus and hormonal changes [39], these results further support our findings. In a study conducted by Jeong et al. [40], the gastric emptying of patients who underwent midnight fasting was compared to those who received preoperative oral carbohydrates. The ultrasonographic CSA at 120 minutes after oral carbohydrate intake was found to be 7.97 ± 3.62 cm^2, similar to the CSA of patients who fasted at midnight during the same period. Furthermore, our findings align with previous studies in terms of the risk of regurgitation aspiration. Notably, this study observed larger CSA at 120 minutes after oral intake than other studies, suggesting a potential predisposing factor for delayed gastric emptying in elderly patients [41]. However, this aspect was not investigated within our study; therefore, further preoperative risk assessment should be conducted regarding drinking regimens in elderly patients.

Previous studies have demonstrated a linear correlation between GV and the cross-sectional area of the gastric sinus, enabling us to accurately calculate GV using cross-CSA, for a more precise assessment of aspiration risk [42]. In our study, both group A and group B exhibited a return to fasting state GV at 120 min, with similar speeds ($P > 0.05$). When we evaluated the aspiration risk in patients who had not emptied their stomachs, we found that the GV was less than 0.8 ml/kg, indicating a very low risk. These findings suggest that after oral administration of 400 ml and 200 ml carbohydrate solutions, the patients' GV essentially returned to predrinking levels within two hours. Another experimental study comparing maltodextrin with another carbohydrate solution in healthy adults demonstrated safe reduction of GV to fasting baseline levels for 2 hours, which suggests that anesthesia induction can be performed safely with a low risk of reflux and aspiration 2 h after oral carbohydrate intake [43]. Another study demonstrated that the GV measured in the immediate preoperative period was comparable between the 2-hour preoperative oral carbohydrate group and the fasting group, with no significant difference [44]. This further supports the feasibility of administering oral carbohydrates 2 hours before surgery. Song et al. investigated gastric emptying in children who consumed carbohydrates preoperatively and found no significant difference in GV between them and patients who fasted for 8 hours prior to surgery [37]. In a study utilizing gamma-photography, complete emptying of the stomach occurred at 90 minutes after consuming a drink containing 12.0% carbohydrates, administered 4 hours before surgery. The present study revealed that at 90 minutes postconsumption, both groups A and B had higher GV than the baseline fasting levels ($P < 0.05$), indicating an inappropriate state for anesthesia induction. These discrepancies may be attributed to differences in research equipment, formulation of the carbohydrate fluid, and the populations themselves [45]. Shin et al. [46] discovered a statistically significant difference in gastric capacity measured at 120 minutes between the first and second stages of total knee arthroplasty (TKA) in elderly patients, the latter stage showing greater capacity. This difference may be attributed to the presence of postoperative stress-induced inflammatory factors after the initial TKA, as well as chronic postoperative pain, which affects gastric emptying prior to the TKA. Considering that our study focused on a single operation and that spinal surgery-related stress and pain have less impact on gastric emptying than a second-stage surgery shortly after the similar first stage of TKA, our findings suggest that successful gastric emptying can be achieved at 120 minutes following preoperative consumption of 400 ml and 200 ml carbohydrates, indicating the safety and reliability of commencing surgery at this time point.

The rate of gastric emptying at each stage was determined based on the GV, and gastric emptying did not occur at a constant rate in either group. Interestingly, in group A, gastric emptying reached its top speed between the initiation of oral intake and 30 minutes, whereas in group B the peak rate was between 30 and 60 minutes after oral intake. These findings suggest that carbohydrate emptying does not solely follow a pattern of initial rapid and subsequent slow rates. Nygren et al. [45] conducted a comparative study on the rate of gastric emptying for water and carbohydrates, revealing that within the first 60 minutes after consuming 400 ml of liquid, water emptied from the stomach at a faster rate than carbohydrates; however, both groups reached similar levels of emptying after 90 minutes. This phenomenon can be attributed to various factors related to the nature of the liquid, including dosage and state. It has also been suggested that peak gastric emptying occurs within 30 minutes following oral intake of liquids, followed by a decrease in rate. This observation can be explained by the rapid passage through the gastric curvature facilitated by physiological structures upon initial entry into the stomach [47]. In this study, the rate of gastric emptying in group A was significantly higher than that in group B in the first 30 min after oral administration of carbohydrates, while from 30–120 min, gastric emptying in group B was faster ($P < 0.05$), indicating that a carbohydrate volume of 400 ml outperformed a volume of 200 ml in terms of the overall gastric emptying rate. Wong et al. [48] assessed the impact on gastric emptying when patients were orally administered either 300 ml or 50 ml of water and found that the former not only did not delay gastric emptying but also resulted in a significantly shorter half-time for gastric emptying compared to the latter. The rate of gastric emptying is influenced by both the quantity of food intake and the energy content of liquids, a larger volume and higher energy of liquids exerting a greater impact on the work rate of the duodenum and the speed of gastric emptying compared to smaller volumes of liquids [49, 50].

Achieving optimal gastric emptying while meeting energy requirements is a crucial aspect of ERAS, and the rate of gastric emptying is influenced by the preoperative number of individuals with delayed gastric emptying. The gastric emptying number ratio reflects the final preoperative gastric emptying number of patients. In this study, patients in groups A and B exhibited gastric emptying rates of 92% and 88%, respectively. Importantly, nonemptying patients did not demonstrate a high risk of reflux aspiration, highlighting the efficacy of preoperative carbohydrate utilization in ERAS. Garg et al. [51] discussed gastric emptying in children after 8 ml/kg of pure fruit juice and 8 h of fasting before the operation. Significant gastric emptying was observed 120 min after taking pure fruit juice, to an even more complete level than that after 8 h of fasting. This suggested that carbohydrates can promote gastric emptying, 71.8% of their patients achieving complete gastric emptying. Although some patients did not achieve complete emptying, their associated risks remained below the threshold. Carbohydrates do not significantly affect gastric emptying, and the change in total liquid volume consumed (less than 400 ml) does not have significantly affect the gastric emptying rate. This effect may be attributed to the faster emptying rate observed with larger liquid doses, as mentioned earlier. Therefore, considering the absence of significant differences in gastric emptying rates between the two groups, a 400 ml carbohydrate drink (as in group B) would provide enough energy and ensure safe anesthesia induction.

Prolonged preoperative water fasting may result in dehydration, hypoglycemia, and reduced insulin sensitivity in patients. The intake of preoperative carbohydrates has been shown to decrease the occurrence of complications [52, 53]. It is crucial to control perioperative blood glucose levels, as traditional water fasting can lead to postoperative hypoglycemia, causing symptoms such as malaise and syncope that can impede patient recovery. Furthermore, both fasting and surgical stress responses can promote muscle catabolism and trigger the release of stress hormones, leading to insulin resistance and hyperglycemia [54, 55]. This was also observed by Rajan et al. [56]: patients who did not receive carbohydrates exhibited higher intraoperative glucose values than those who received carbohydrates two hours before surgery. Elevated glucose is detrimental to wound healing and increases the risk of wound infection, particularly in major surgeries [57]. Preoperative oral carbohydrate intake aims to minimize fluctuations in blood glucose levels, enhance postoperative hypoglycemia management, and reduce glycemic variability and insulin resistance, potentially shortening hospital stays [55, 58, 59]. However, it has been suggested that the association between preoperative carbohydrate loading and insulin resistance may only be significant if high doses of carbohydrates are administered [60], or they may have no effect at all [61]. In this study, we compared fasting and postsurgery blood glucose concentrations between groups at the same time points. The observed changes were not statistically significant, indicating minimal differences in the impact of orally administered carbohydrates with varying doses on patients' blood glucose levels. The blood glucose concentration after surgery was significantly higher than the fasting level in both groups, but it remained within the safe range. Therefore, preoperative carbohydrate loading effectively stabilizes postoperative blood glucose levels and reduces the incidence of postoperative hypoglycemia, thus promoting recovery. Diabetic patients were excluded from this study due to their special dietary requirements and the potential presence of gastroparesis [62]. Further studies are needed to investigate whether diabetic patients can benefit from preoperative carbohydrate intake.

In recent years, many scholars have reached a consensus that preoperative carbohydrate intake can ease patients' subjective discomfort and reduce the incidence of thirst, hunger, anxiety, and fatigue compared to fasting [63, 64]. In this study, we observed postoperative complications in both groups after administering varying doses of carbohydrates to patients undergoing spinal surgery. In the comparison of hunger and thirst scores in this study, we found that group A had less discomfort caused by hunger and thirst than group B, though the two groups had no significant difference in anxiety scores. Previous studies have suggested that preoperative administration of carbohydrates reduces anxiety scores [65] due to their ability to raise the serotonin concentration within the body [66]. In addition to the properties of the liquid, anxiety may also be influenced by individual differences within the population, surgical procedure type and duration, and factors such as preoperative drug administration. In this study, the two groups had similar anxiety scores, but consuming carbohydrates 2 hours before surgery significantly reduced patient anxiety when compared to traditional water fasting. Importantly, we did not conduct a controlled experiment with patients on traditional water fasting this time but only compared patients who consumed different doses of carbohydrates 2 hours before surgery because many studies have demonstrated the advantages of shortening the water fast in reducing postoperative complications. Preoperative carbohydrate intake has reduced the incidence of nausea and vomiting after several elective surgeries [67, 68], which may be explained by the improvement of gastric emptying and the reduction of stress response. For the particular surgical position of spine surgery, this may increase the risk of postoperative nausea and vomiting. In our study, there was no significant difference in the incidence of nausea and vomiting between the 400 ml and 200 ml groups, and both groups showed a lower incidence than seen under traditional water fasting. Additionally, preoperative consumption of carbohydrates has been associated with shorter hospital stays, which strongly correlate with patients' subjective well-being and may advance the time to discharge when the patient's postoperative recovery improves, such as through a reduction in insulin resistance and surgical stress and stabilization of glucose metabolism and gastrointestinal function [69, 70]. Before major invasive surgery, such as orthopedic surgery, intake of carbohydrates also reduces postoperative protein loss and enhances muscle strength and weight recovery [71]. Consistent with these findings, our results demonstrated no significant difference in hospitalization duration between the two groups, indicating that both interventions can be incorporated into an ERAS protocol, promoting functional recovery and shortening hospital stays. Carbohydrate loading in both groups improved the incidence of postoperative complications and alleviated discomfort, ultimately facilitating patients' postoperative recovery. These outcomes provide a solid foundation for implementing the ERAS program. Our findings suggest that 400 ml of carbohydrates can be a better way to reduce the patients' postoperative thirst and hunger, and it performed better at promoting postoperative recovery.

Conclusion

In conclusion, the oral administration of 400 ml and 200 ml carbohydrate beverages administered 2 hours prior to spinal surgery is deemed safe for patients and can be incorporated into ERAS protocols to minimize postoperative complications and facilitate patient recovery. Notably, the higher dose of 400 ml better alleviated postoperative thirst and hunger without increasing the risk of aspiration. Therefore, we recommend a preoperative carbohydrate loading dose of 400 ml for patients undergoing spinal surgery.

Declarations

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Authors’ contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by [Chengru Qiu], [Ao Li], [Jia Li], [Jie Chang], [Siqi Ma], [Xi Zhang]. The first draft of the manuscript was written by [Chengru Qiu] and [Xi Zhang] and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

All data generated or analysed during this study are included in this published article [and its supplementary information files]. Ethics approval and consent to participate. This study was approved by the Ethics Committees of Shiyan Renmin Hospital in Hubei Province (No. syrm2023-016).

Ethics approval and consent to participate

This study was approved by the Ethics Committees of Shiyan Renmin Hospital in Hubei Province (No. syrm2023-016). All methods were carried out in full accordance with the Declaration of Helsinki. Informed consent was obtained from all subjects and/or their legal guardian(s).

Consent for publication

Not applicable.

Declaration of interest statement

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

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Figures

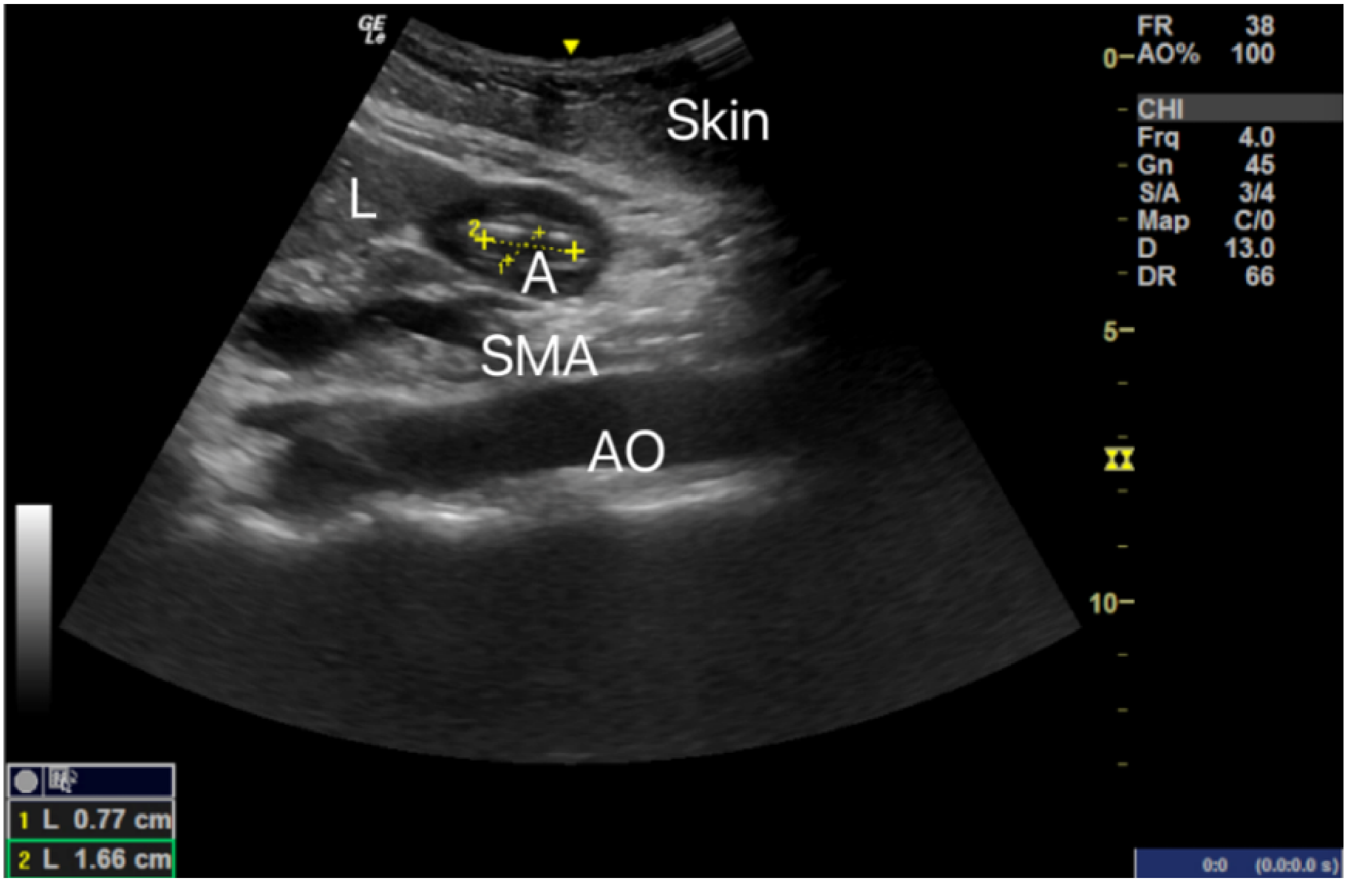

Figure 1

Image of the gastric antrum during fasting

(A: gastric antrum; L: liver; SMV: superior mesenteric vein; AO: abdominal aorta

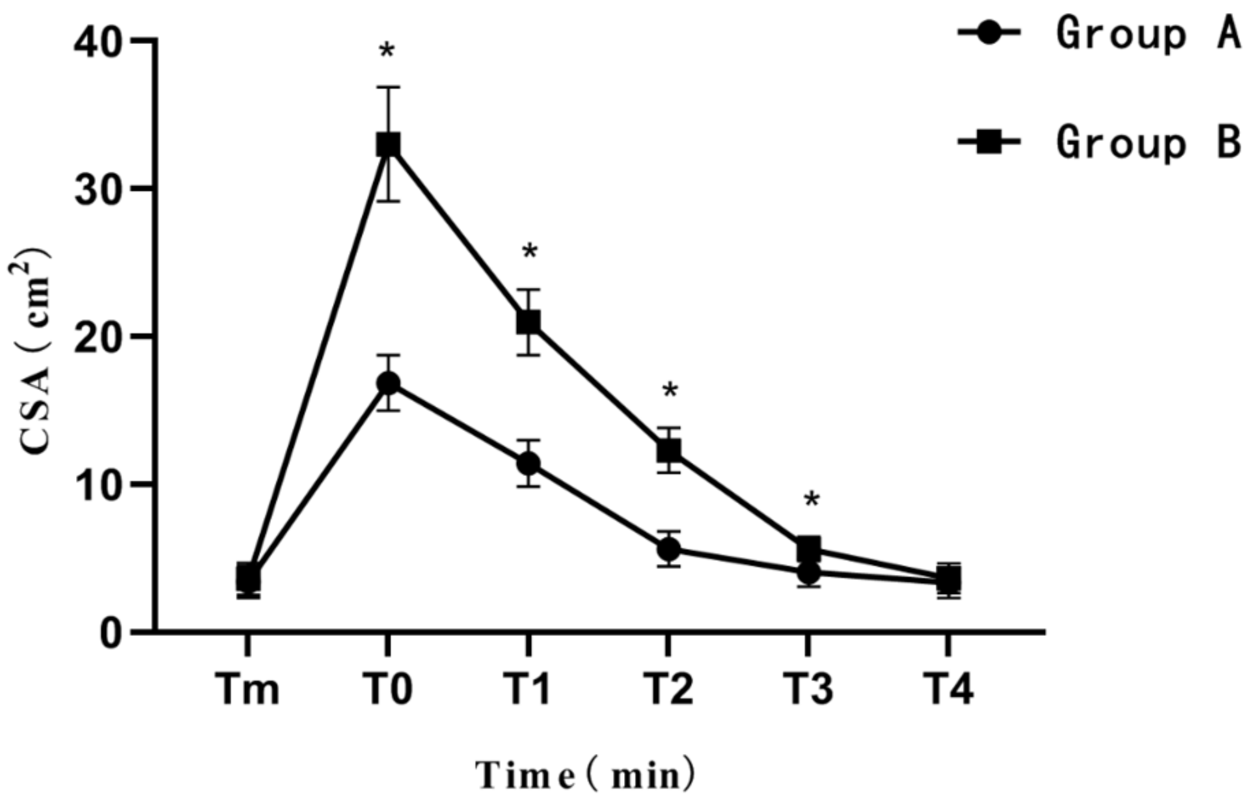

Figure 2

Trends in CSA at various time points in both groups (Note: Compared with group A ,*P < 0.05)

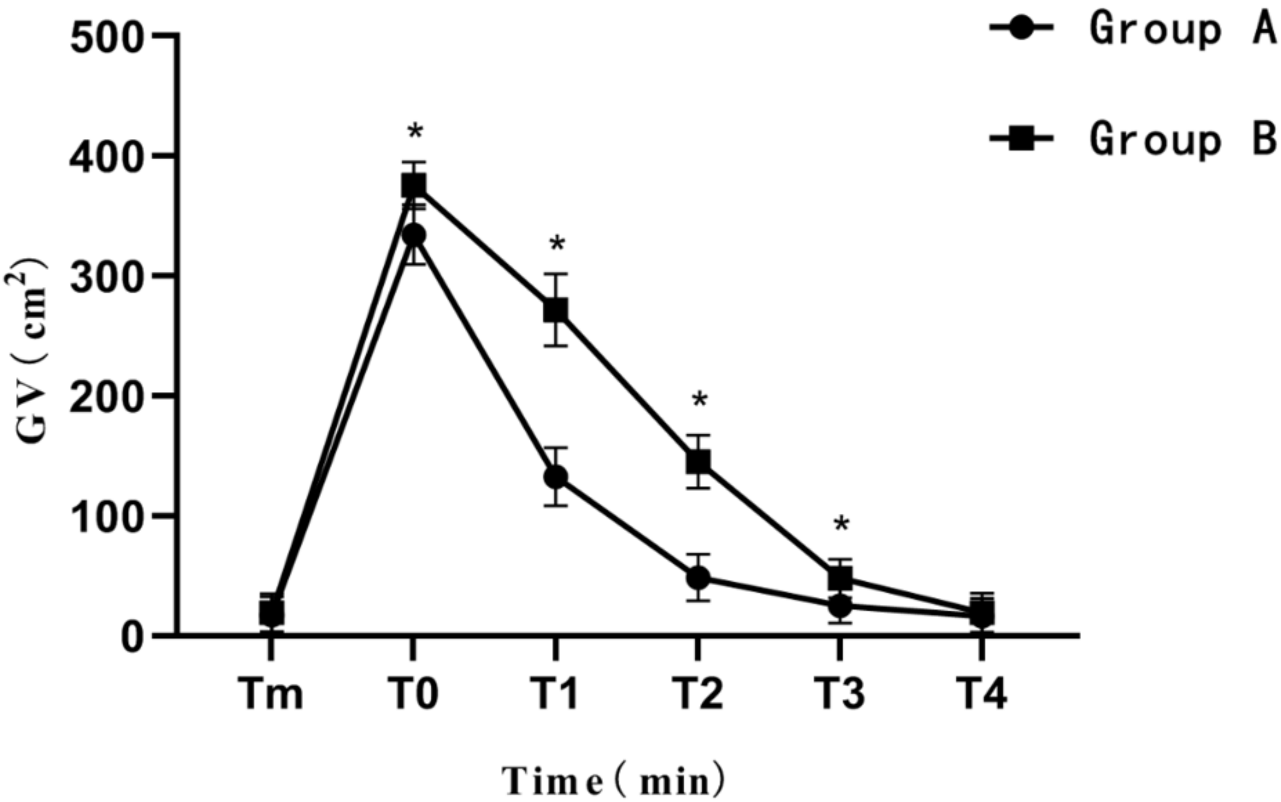

Figure 3

Trends in GV changes at various time points in both groups (Note: Compared with Group A *P < 0.05)

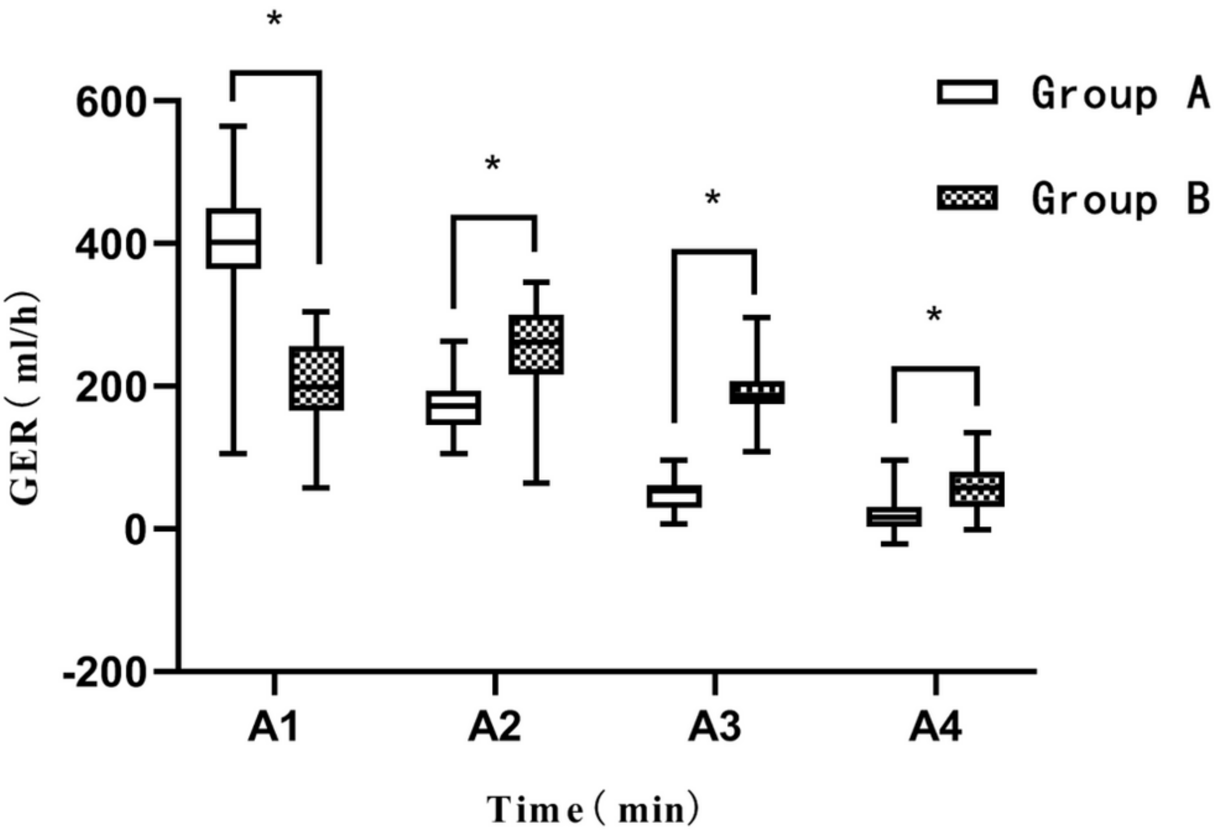

Figure 4

Comparison of gastric emptying rate by time period between the two groups (Note: Compared with group A **P* < 0.05)

Supplementary Files

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