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Original Article

Oral carbohydrate intake before selective laparoscopic liver resection reduces insulin resistance and enhances recovery

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Abstract: Objective: To investigate the effects of preoperative oral carbohydrate administration on insulin resistance and recovery quality in patients undergoing selective laparoscopic liver resection. Methods: Data from 110 patients were retrospectively analyzed, and divided into a control group (n=55) and a research group (n=55). The control group received 800 mL of distilled water at 20:00 the evening before surgery, and 400 mL 2.5 hours before surgery. The research group received the same volume of carbohydrates at the same time points. Differences in blood glucose, insulin levels, insulin resistance (HOMA-IR), recovery quality (QoR-15), inflammatory and immune cell markers, and liver function were compared. Spearman correlation and logistic regression analyses were performed to explore the relationship between carbohydrate intake and recovery. Results: The research group had significantly lower incidence and severity of nausea and vomiting compared to the control group (χ^2=0.037, χ^2=0.030, both P<0.05). Postoperative recovery times, including post-anesthesia care, first rectal exhaust, and first feeding, were shorter in the research group (t=0.034, 0.021, 2.832, all P<0.05). Insulin levels and HOMA-IR were lower on postoperative days 1 and 3 in the research group (both P<0.05). QoR-15 scores were higher in the research group (F=100.100, P<0.001), showing an increasing trend over time (F=22.130, P<0.001). On day 3, inflammatory and liver function markers were lower in the research group, while immune cell markers were elevated (all P<0.05). Preoperative carbohydrate intake correlated with improved insulin sensitivity and recovery quality (P<0.05). Conclusion: Preoperative oral carbohydrate administration reduces insulin resistance, enhances recovery, and improves postoperative rehabilitation quality in patients undergoing elective laparoscopic liver resection.

Keywords: Preoperative carbohydrates, laparoscopic hepatectomy, insulin resistance, quality of recovery

Introduction

Laparoscopic liver resection offers the benefits of minimal trauma, a clear surgical field, fewer complications, and enhanced patient recovery, making it a preferred method for treating liver and gallbladder diseases [1]. However, it is important to recognize that laparoscopic liver resection still induces unavoidable surgical trauma. Such trauma triggers a complex stress response mechanism, activating the hypothalamic-pituitary-adrenal (HPA) axis and promoting the release of stress hormones like cortisol. This activation disrupts the body's metabolic balance, leading to a catabolic state [2].

Insulin resistance (IR) is a core manifestation of this stress-induced metabolic disorder. It is a protective response that prioritizes maintaining adequate blood glucose levels to ensure energy supply to critical organs such as the brain and heart. However, when insulin efficiency in promoting glucose uptake by peripheral tissues like muscles and fat decreases, IR develops. In response, the pancreas oversecretes insulin to maintain glucose homeostasis [3]. While this adaptation is initially beneficial, prolonged IR can impair immune system function, increasing the risk of postoperative infections such as bacteremia [4], and hindering recovery. Moreover, severe IR is a significant cause of postoperative complications and increased mortality [5].

Recent studies highlight the role of preoperative fasting in exacerbating IR. Prolonged fast-

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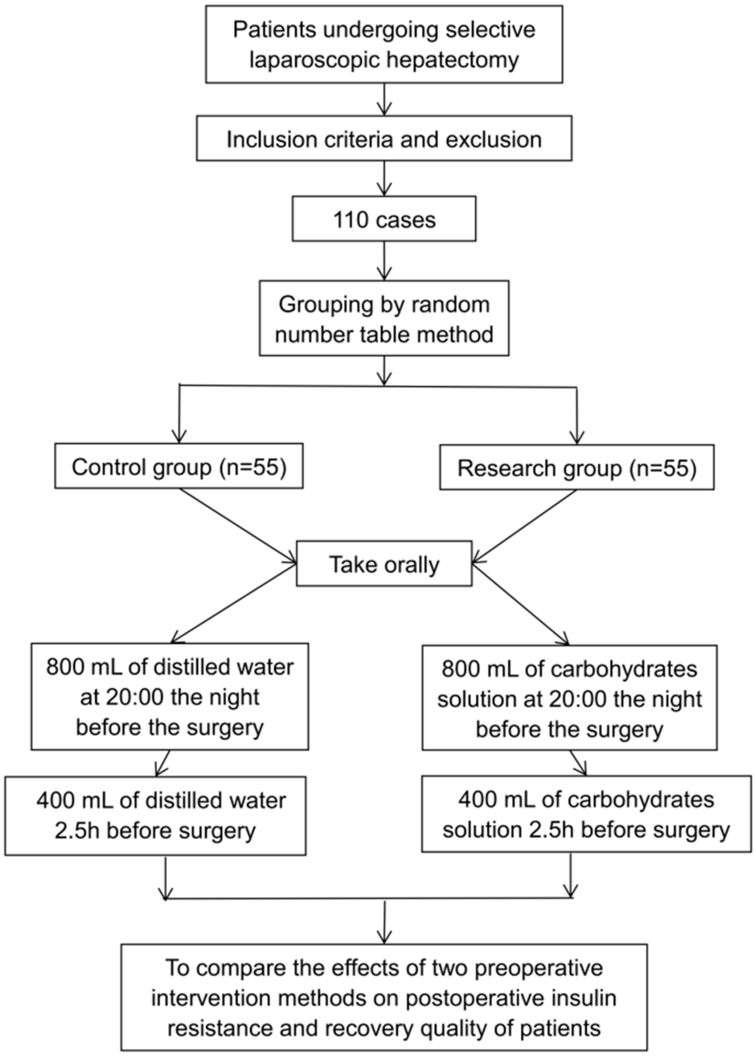

Figure 1. The flow chart of this study.

ing disrupts glucose metabolism, worsening IR. As a result, shortening preoperative fasting and allowing carbohydrate consumption within two hours before surgery has emerged as a new strategy in enhanced recovery after surgery (ERAS). This approach optimizes preoperative metabolic conditions, reducing the adverse impact of surgical stress on insulin sensitivity [6]. The use of preoperative carbohydrates is increasingly adopted in various surgical settings [7].

Notably, despite a growing body of research, there is a gap in the literature regarding the application of oral carbohydrates before elective laparoscopic liver resection. Given the unique metabolic challenges and surgical stress associated with this procedure, this topic deserves exploration. This study aims to investigate the effect of preoperative oral carbohydrate intake on IR and recovery in patients undergoing elective laparoscopic liver resection, ultimately providing evidence-based support for enhancing postoperative recovery by possibly altering preoperative care strategies.

Materials and methods

Case selection

The flow chart of this study is shown in **Figure 1**. Data from 110 patients who underwent selective laparoscopic hepatectomy at the Affiliated Hospital of North Sichuan Medical College between February 2019 and January 2023 were retrospectively analyzed. Based on different preoperative interventions, the patients were divided into a control group and a research group, with 55 patients in each group. In the control group, patients were orally administered 800 mL of distilled water at 20:00 the night before surgery, and 400 mL of distilled water 2.5 hours prior to surgery. In the research group, patients were orally administered 800 mL and 400 mL of carbohydrate solution at the same respective time points.

Inclusion criteria: (1) Patients over 18 years old. (2) Patients undergoing laparoscopic liver tumor resection [8]. (3) Patients classified as American Society of Anesthesiologists grade I-II [9]. (4) Patients with Child-Pugh grade A-B [10].

Exclusion criteria: (1) Patients with serious heart, lung, or renal dysfunction. (2) Patients with unstable angina. (3) Patients with preoperative complications affecting the objective evaluation of postoperative recovery. (4) Patients with mental or psychological. (5) Disorders. Patients with a history of alcohol or drug dependence. (6) Patients lacking complete clinical data necessary for the study.

This study was approved by the Medical Ethics Committee of the Affiliated Hospital of North Sichuan Medical College.

Intervention method

Both groups underwent selective laparoscopic hepatectomy by the same surgical and anesthesiology team.

Control group: At 20:00 the night before surgery, patients were orally given 800 mL of distilled water, consumed gradually over 2 hours. Fasting began at midnight. An additional 400 mL of distilled water was administered 2.5 hours before surgery (gradually sipped and consumed within 0.5 hours). Drinking was strictly prohibited within 2 hours prior to surgery.

Research group: At 20:00 the night before surgery, patients were orally given 800 mL of a carbohydrate solution (Jiangsu Xihong Biomedicine Co., Ltd., Approval No. TY20210024, containing 12.6 g of carbohydrate per 100 mL). The solution was consumed gradually over 2 hours, with fasting beginning at midnight. Another 400 mL of the carbohydrate solution was administered 2.5 hours before surgery (gradually sipped and consumed within 0.5 hours). Patients were strictly prohibited from drinking anything within 2 hours prior to surgery.

In both groups, prior to anesthesia induction, gastric ultrasound was performed to assess gastric contents for safety. Conventional general anesthesia induction followed, after establishing invasive radial artery blood pressure monitoring under local anesthesia. If residual gastric contents were deemed excessive by ultrasound, rapid-sequence induction was used to avoid reflux and aspiration.

Data collection and outcome measurement

<u>Primary indicators</u>

IR related indicators: Fasting blood glucose levels, insulin concentration, and the homeostasis model assessment of IR (HOMA-IR) were measured preoperatively, on postoperative day 1, and on day 3 after surgery.

Measurement methods: Peripheral venous blood samples (5 mL) were collected in the morning after fasting. Blood glucose concentration was measured using an automatic biochemical analyzer. Serum insulin concentration was determined using the BIOBASE automatic chemiluminescence immunoanalyzer (model: BKI1100/BKI2200). HOMA-IR was calculated using the formula: HOMA-IR = [Fasting glucose concentration (mmol/L) × Fasting insulin concentration (mU/L)]/22.5 [11].

Postoperative recovery quality: The 15-item quality of recovery (QoR-15) [12] was used to assess early postoperative recovery on days 1, 3, and 7.

Measurement method: The questionnaire consists of 15 items, each rated on a scale of 0-10, with 0 representing the absence of the condition and 10 representing its constant presence. For negative items, the scoring is reversed. Higher scores indicate better recovery quality.

<u>Secondary indicators</u>

General information: These included sex, age, Child-Pugh grade, and the maximum tumor diameter.

Operative indicators: These included operation time, extubation time, hilar occlusion time, post-anesthesia care unit (PACU) time, perioperative bleeding, blood transfusion volume, first rectal exhaust time, first feeding time, heart rate at skin incision, heart rate at extubation, systolic pressure at skin incision, and systolic pressure at extubation.

Occurrence and severity of nausea and vomiting: The occurrence and severity of postoperative nausea and vomiting were recorded and assessed based on the WHO grading system [13]: Grade I: No vomiting; Grade II: Mild nausea and abdominal discomfort, no vomiting; Grade III: Noticeable nausea and vomiting without content expulsion; Grade IV: Severe vomiting with expulsion of stomach contents, requiring medication for control.

Changes in heart rate and blood pressure: Heart rate and blood pressure changes during the perioperative period (skin incision and extubation) were recorded.

Fasting blood samples: Fasting venous blood samples (5 mL) were collected from patients in both groups preoperatively and on postoperative day 3.

Inflammation indicators: The levels of high-sensitivity C-reactive protein (hs-CRP) were measured by immunoturbidimetry using the BS-800 automatic biochemical analyzer (Mindray Medical). Interleukin-6 (IL-6), tumor necrosis factor-alpha (TNF-α), and soluble interleukin-2 receptor (sIL-2R) levels were determined by enzyme-linked immunosorbent assay (ELISA) with kits from Shanghai Yihui Biotechnology Co., Ltd. Detection was carried out using the BIOBASE-EL10A microplate reader.

Immune cell indicators: Anti-CD4 and anti-CD8 monoclonal antibodies were added to blood samples for fluorescence staining. The levels of CD4+ cells and the CD4+/CD8+ ratio were measured by flow cytometry using the CytoFLEXLX flow cytometer (Beckman Coulter, USA). Immunoglobulin G (IgG) and Immunoglobulin A (IgA) levels were measured by immunonephelometry using the BS-800 analyzer.

Liver function indicators: Liver function was assessed by measuring alanine aminotransferase (ALT), aspartate aminotransferase (AST), total bilirubin, and total bile acids using an automatic biochemical analyzer according to the provided reagent instructions.

Statistical methods

Data analysis was performed using SPSS 18.0 software. Measured data were expressed as mean ± standard deviation. Comparisons between groups were conducted using the t-test, and repeated measures analysis of variance was applied to compare data at different time points.

Counted data were presented as frequencies and percentages, with the chi-square test used for comparisons. Spearman correlation analysis was conducted to assess the relationship between oral carbohydrate intake, IR, and QoR-15 scores. Multivariable logistic regression analysis was used to explore the effect of oral carbohydrate intake on recovery quality and identify independent risk factors or protective factors affecting postoperative recovery. The significance level was set at $\alpha=0.05$.

Results

Comparison of basic data and operation-related indexes

The two groups were comparable in terms of sex, Child-Pugh classification, age, maximum tumor diameter, perioperative bleeding, blood transfusion volume, operation time, extubation time, hilar occlusion time, heart rate at skin incision, heart rate at extubation, systolic pressure at skin incision, and systolic pressure at extubation (all $P>0.05$). However, the research group had a significantly lower incidence of nausea and vomiting compared to the control group ($\chi^2=0.037$), and the severity of nausea and vomiting was milder in the research group ($\chi^2=0.030$), both $P<0.05$. The post-anesthesia care unit time, first anal exhaust time, and first feeding time were shorter in the research group (t=0.034, 0.021, 2.832) (all $P<0.05$). The basic data and operative indicators are shown in **Figure 2**.

Comparison of IR related indicators

Before surgery, there were no significant differences in blood glucose, insulin, and HOMA-IR between the two groups (all $P>0.05$). Postoperatively, insulin levels and HOMA-IR in the control group increased on both day 1 and day 3, whereas the increase in the research group was less pronounced (all $P<0.05$). On postoperative days 1 and 3, the insulin levels and HOMA-IR in the research group were significantly lower than those in the control group (both $P<0.05$). The comparison of IR-related indicators before and after surgery is shown in **Figure 3**.

Comparison of QoR-15 score

The QoR-15 score in the research group was significantly higher than that of the control group ($F=100.100$, $P<0.001$). Both groups showed an increase in QoR-15 scores over time ($F=22.130$, $P<0.001$). The interaction between group and time was significant $F=5.383$, $P=0.005$). The QoR-15 scores are shown in **Figure 4**.

Comparison of inflammatory indexes

There were no significant differences in hs-CRP, IL-6, TNF-α, and sIL-2R levels between the two groups before surgery (all $P>0.05$). Three days after surgery, the levels of these inflammatory markers were higher than preoperatively in both groups, but the research group showed lower levels than the control group (all $P<0.05$) (**Table 1**).

Comparison of immune cell indexes

Flow cytometry analysis of the proportions of $CD4^+$ and $CD8^+$ cells in both groups before and

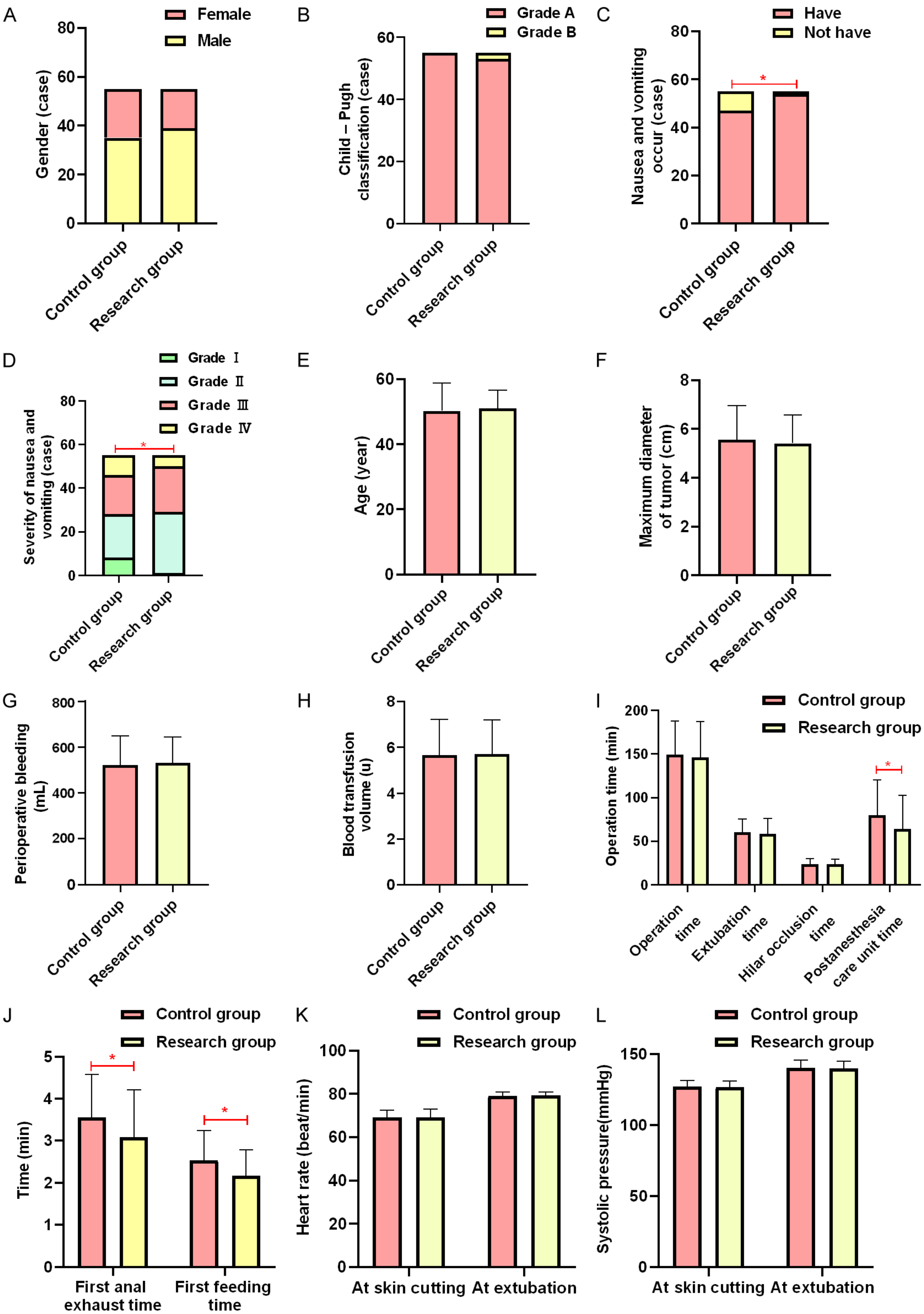

Figure 2. Comparison of basic data and operation-related indexes. *Note*: 55 patients were included in the control group and research group, respectively. The * represented data comparison between the two groups, P<0.05. A: Sex; B: Child - Pugh classification; C: Occurrence of nausea and vomiting; D: Severity of nausea and vomiting; E: Age; F: Maximum diameter of tumor; G: Perioperative bleeding; H: Blood transfusion volume; I: Operation time, Extuba-

tion time, Hilar occlusion time and Post anesthesia care unit time; J: First anal exhaust time and First feeding time; K: Heart rate at skin cutting and Heart rate at extubation; L: Systolic pressure at skin cutting and Systolic pressure at extubation.

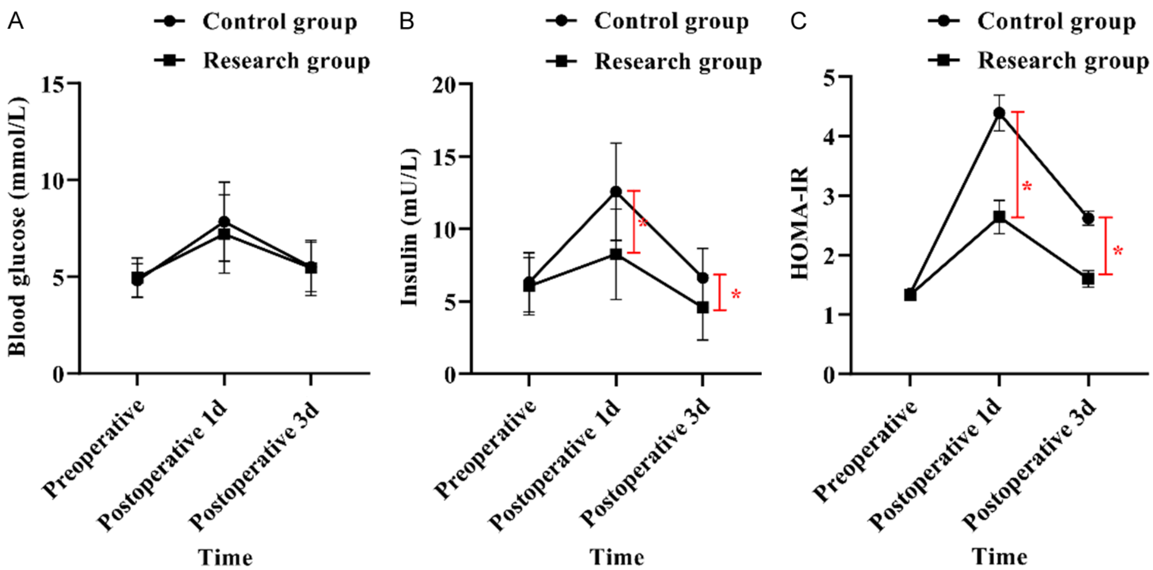

Figure 3. Comparison of insulin resistance-related indicators. *Note*: 55 patients were included in the control group and research group, respectively. The * represented data comparison between the two groups, P<0.05. A: Blood glucose levels; B: Insulin levels; C: Homeostasis model assessment of insulin resistance (HOMA-IR) levels.

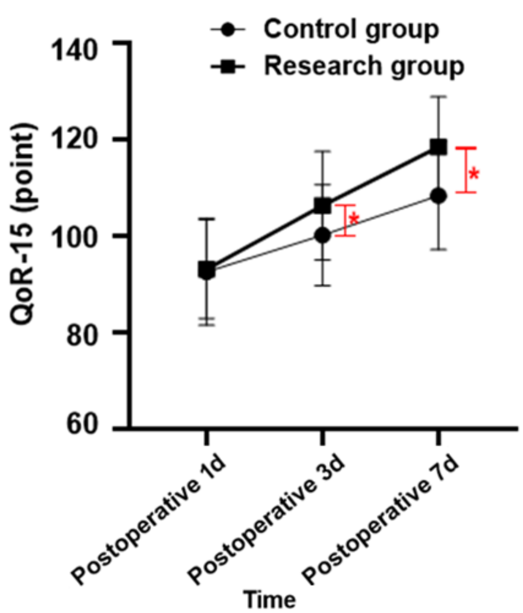

Figure 4. Comparison of 15-item quality of recovery (QoR-15) score. *Note*: 55 patients were included in the control group and research group, respectively. The * represented data comparison between the two groups, P<0.05.

after surgery is shown in **Figure 5**. Before surgery, there were no significant differences in CD4+ cells, CD4+/CD8+ ratio, IgG, and IgA levels between the two groups (all P>0.05). Three days postoperatively, the levels of CD4+ cells, the CD4+/CD8+ ratio, IgG, and IgA increased in both groups, with the research group showing higher levels (all P<0.05) (**Table 2**).

Comparison of liver function indexes

There were no significant differences in ALT, AST, total bilirubin, or total bile acids between the two groups before surgery (all P>0.05). Three days after surgery, these liver function markers were higher than preoperatively in both groups, but the research group had lower levels than the control group (all P<0.05) (**Table 3**).

Correlation between preoperative oral carbohydrate intake and postoperative IR and QoR-15 score

Preoperative oral carbohydrate intake was negatively correlated with insulin (r=0.436) and positively correlated with HOMA-IR (r=0.872) on the 3rd postoperative day, and positively correlated with the QoR-15 score on the 7th postoperative day (all P<0.05) (**Table 4**).

Table 1. Comparison of inflammatory indexes

Inflammatory indicator	Time	Control group (n=55)	Research group (n=55)	t	P
hs-CRP (mg/L)	Preoperative	3.80±0.62	3.75±0.53	0.455	0.650
	Postoperative 3 d	18.51±2.03*	13.02±1.23*	17.150	<0.001
IL-6 (pg/mL)	Preoperative	5.22±1.12	5.15±1.04	0.340	0.735
	Postoperative 3 d	23.03±2.21*	17.52±1.67*	14.750	<0.001
TNF-α (pg/mL)	Preoperative	10.53±1.63	10.34±1.50	0.636	0.526
	Postoperative 3 d	32.05±3.23*	26.08±2.48*	10.870	<0.001
sIL-2R (U/mL)	Preoperative	345.75±28.03	348.01±30.22	0.407	0.685
	Postoperative 3 d	520.15±42.16*	470.26±38.41*	6.487	<0.001

hs-CRP: High-sensitivity C-reactive protein; IL-6: interleukin-6; TNF-α: tumor necrosis factor-alpha; sIL-2R: soluble interleukin-2 receptor. Compared with those before surgery, **P*<0.05.

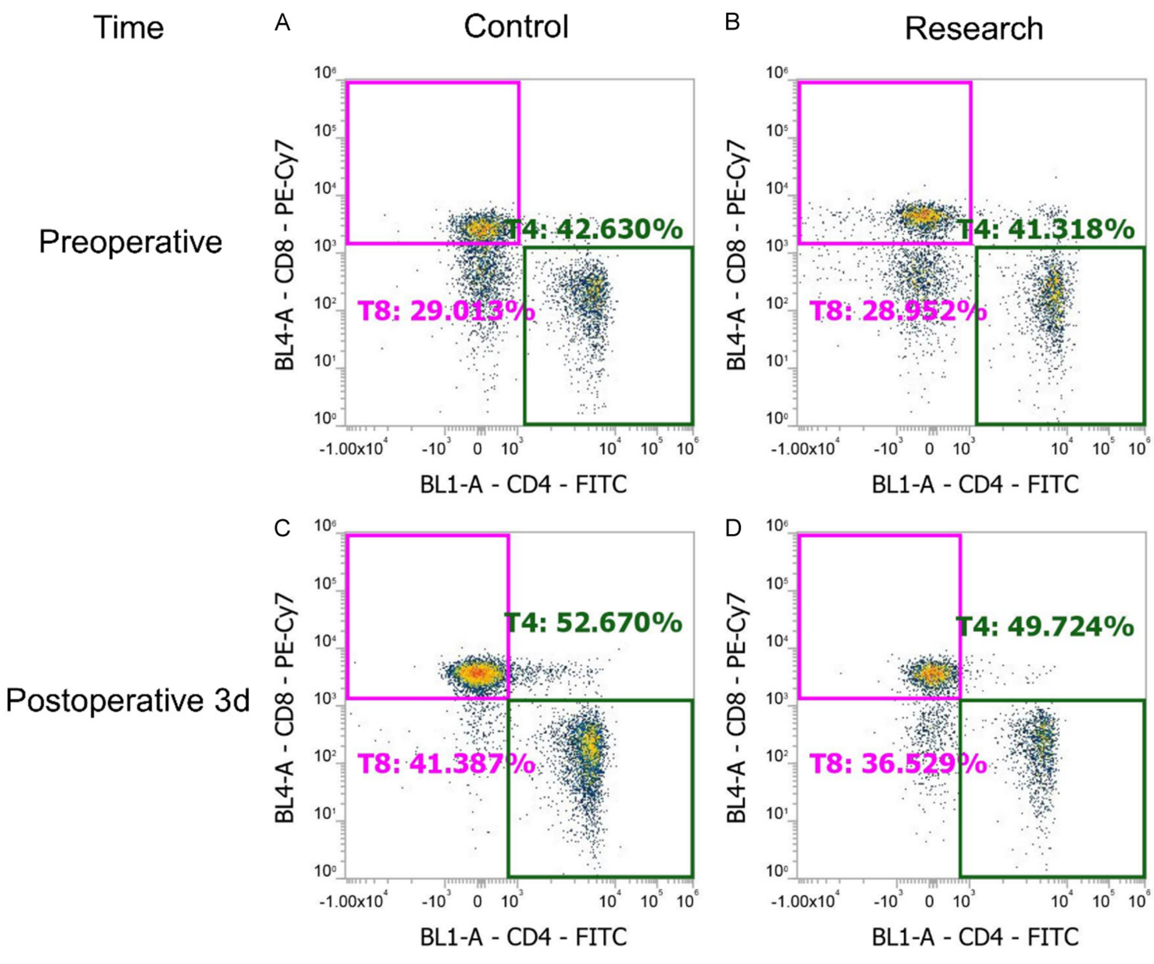

Figure 5. Flow cytometry plots of the proportions of T4 ($CD4^+$) and T8 ($CD8^+$) cells in the control group and the research group before and after surgery. A: Preoperative control group; B: Preoperative research group; C: Postoperative control group; D: Postoperative research group.

Effect of preoperative oral carbohydrate intake on recovery quality

Using baseline data and oral carbohydrate intake (yes =0, no =1) as independent variables, and postoperative recovery quality (good recovery =0, poor recovery =1) as the dependent variable, logistic regression analysis was performed (assignment table in **Table 5**). The results indicated that age and oral carbohydrate intake were independent factors influencing poor postoperative recovery quality in

Table 2. Comparison of immune cell indexes

Immune cell index	Time	Control group (n=55)	Research group (n=55)	t	P
CD4+ (/μL)	Preoperative	790.56±45.13	795.17±48.25	0.518	0.606
	Postoperative 3 d	680.58±35.27*	730.28±40.17*	6.895	<0.001
CD4+/CD8+	Preoperative	1.48±0.08	1.49±0.10	0.579	0.564
	Postoperative 3 d	1.25±0.07*	1.32±0.08*	4.884	<0.001
IgG (g/L)	Preoperative	9.82±0.70	9.95±0.80	0.907	0.366
	Postoperative 3 d	8.83±0.60*	9.25±0.70*	3.378	0.001
IgA (g/L)	Preoperative	1.95±0.15	1.98±0.18	0.950	0.344
	Postoperative 3 d	1.75±0.12*	1.82±0.14*	2.815	0.006

CD4+: aspartate aminotransferase; CD8+: Cluster of Differentiation 8 positive; IgG: immunoglobulin G; IgA: immunoglobulin A. Compared with those before surgery, *P<0.05.

Table 3. Comparison of liver function indexes

Liver function index	Time	Control group (n=55)	Research group (n=55)	t	P
ALT (U/L)	Preoperative	26.33±3.24	25.83±3.15	0.821	0.414
	Postoperative 3 d	42.82±5.27*	32.26±4.14*	11.690	<0.001
AST (U/L)	Preoperative	31.26±4.16	30.73±4.28	0.659	0.512
	Postoperative 3 d	47.28±6.28*	37.26±5.39*	8.979	<0.001
Total Bilirubin (μmol/L)	Preoperative	12.50±2.12	12.35±2.08	0.375	0.709
	Postoperative 3 d	16.24±4.36*	14.36±2.28*	2.834	0.005
Total Bile Acids (μmol/L)	Preoperative	8.25±1.11	8.04±1.02	1.033	0.304
	Postoperative 3 d	11.25±1.15*	10.02±1.28*	5.301	<0.001

ALT: alanine aminotransferase; AST: aspartate aminotransferase. Compared with those before surgery, *P<0.05.

Table 4. Correlation between preoperative oral carbohydrate and postoperative insulin resistance index and QoR-15 score

		Blood glucose	Insulin	HOMA-IR	QoR-15 score
Oral carbohydrates	r	0.113	0.436	0.872	-0.504
	P	0.24	<0.001	<0.001	<0.001

patients undergoing elective laparoscopic liver resection (both P<0.05) (**Table 6**).

Discussion

Conventional surgery typically requires patients to refrain from drinking for at least 6 hours and fast for no less than 10 hours before the procedure. While this approach helps reduce the risk of misjudgment by the surgical team, it can significantly affect the patient's body, leading to issues such as anxiety, thirst, hypoglycemia, increased stress response, and hyperglycemia, all of which may increase the risk of postoperative complications. Studies have shown that preoperative carbohydrate administration does not increase the rate of intraoperative physician error or patient aspiration [14]. Carbohydrates are a cost-effective, easy-to-administer source of nutrients and fiber, offering significant clinical benefits [15]. Preoperative carbohydrate intake shifts patients from a fasting to an eating state, replenishing lost energy and fluids. This significantly improves body temperature, reduces the likelihood of intraoperative and postoperative shivering, and enhances perioperative metabolism, ultimately aiding in postoperative recovery [16]. Currently, carbohydrate interventions are most commonly used in gastric cancer and colorectal surgeries, where they promote gastrointestinal recovery, shorten patient treatment times, and improve patient outcome [17, 18]. Based on these findings, this study explored the use of carbohydrates in selective laparoscopic liver resection, aiming to provide guidance for accelerating recovery in such patients.

This study found that the time for the first rectal gas release and the first feeding in the research group were significantly shorter, indicating that

Table 5. Assignment expression

Constant	Assignment
Gender	Male =1, female =0
Age	Actual value
Maximum diameter of tumor	Measured value
Child-Pugh classification	Grade A =0, Grade B =1
Oral carbohydrates	No =1, yes =0
Nausea and vomiting occur	Have =1, Not have =0
Severity of nausea and vomiting	Grade I =1, Grade II =2, Grade III =3, Grade IV =4
Peroperative bleeding	Measured value
Blood transfusion volume	Measured value
Operation time	Measured value
Extubation time	Measured value
Hilar occlusion time	Measured value
Post anesthesia care unit time	Measured value
First anal exhaust time	Measured value
First feeding time	Measured value
Heart rate at skin cutting	Measured value
Heart rate at extubation	Measured value
Systolic pressure at skin cutting	Measured value
Systolic pressure at extubation	Measured value

carbohydrate administration can promote the recovery of gastrointestinal function. We speculate that intraoperative anesthesia, surgical trauma, and liver stimulation are primary causes of gastrointestinal dysfunction [19]. Gastrointestinal dysfunction can reduce peristalsis and inhibit the normal function of the gastrointestinal tract [20]. Preoperative carbohydrate intervention provides nutritional support to the intestines, stimulating gastrointestinal activity, which aids in restoring function shortening the time for the first rectal exhaust, and facilitating early postoperative feeding.

Effect on Nausea, Vomiting, and IRA

Additionally, the study observed a reduction in the incidence and severity of nausea and vomiting in the research group. On the first and third days after surgery, insulin levels and HOMA-IR were significantly lower in the research group compared to the control group. This suggests that preoperative carbohydrate administration can significantly reduce IR, aligning with findings from other studies. Possible mechanisms include the following: First, carbohydrates can improve IR by acting on key enzymes (PKB and PI3K) in the insulin signaling pathway [21]. Fasting and withholding fluids before surgery may induce IR during the procedure, which can negatively affect the body and impair patient prognosis. Second, carbohydrate intervention provides energy supplementation, significantly improves IR, reduces stress response, lowers the incidence and severity of postoperative nausea and vomiting, and improves patient outcome. These results are consistent with previous studies [22].

The QoR-15 score in the research group was significantly higher than in the control group. Repeated measures ANOVA showed significant intergroup effects, time effects, and interaction effects, indicating that carbohydrate administration improved postoperative recovery quality. QoR-15 is a key indicator for assessing early recovery and health status after general anesthesia [23]. Previous studies [24] have shown that factors such as sex, age, body mass index, and operation time can influence QoR-15 scores. Other research [25] has linked QoR-15 to patient awareness of disease knowledge, disease duration, anesthesia time, complications, and early ambulation. Recovery after general anesthesia is complex, influenced by factors such as sex, age, anesthesia and surgical methods, disease type, and postoperative complications [26]. Poor recovery quality can prolong monitoring in the treatment room, increase medical resource consumption, and

Table 6. Multivariable Logistic regression analysis of factors affecting the recovery quality after oral carbohydrate before surgery

Constant	B	SE	Wals	*P*	OR	95% CI
Gender	0.500	0.629	0.633	0.426	1.649	0.481-5.659
Age	0.080	0.039	4.138	0.042	1.083	1.003-1.169
Maximum diameter of tumor	-0.143	0.258	0.308	0.579	0.867	0.523-1.436
Child–Pugh classification	-1.315	1.858	0.501	0.479	0.268	0.007-10.247
Oral carbohydrates	1.426	0.629	5.147	0.023	4.164	1.214-14.277
Nausea and vomiting occur	20.034	12130.489	0.000	0.999	502100000.000	0.000
Severity of nausea and vomiting (Grade I)			0.123	0.989		
Severity of nausea and vomiting (Grade II)	-20.028	12327.756	0.000	0.999	0.000	0.000
Severity of nausea and vomiting (Grade III)	-20.188	12327.756	0.000	0.999	0.000	0.000
Maximum diameter of tumor	-19.910	12327.756	0.000	0.999	0.000	0.000
Peroperative bleeding	-0.003	0.002	1.116	0.291	0.998	0.993-1.002
Blood transfusion volume	-0.115	0.181	0.399	0.528	0.892	0.625-1.272
Operation time	-0.002	0.007	0.046	0.830	0.999	0.985-1.012
Extubation time	0.001	0.015	0.001	0.970	1.001	0.971-1.031
Hilar occlusion time	0.065	0.053	1.495	0.221	1.067	0.961-1.185
Post anesthesia care unit time	0.006	0.008	0.571	0.450	1.006	0.991-1.021
First anal exhaust time	-0.297	0.246	1.456	0.228	0.743	0.458-1.204
First feeding time	0.249	0.439	0.320	0.571	1.282	0.542-3.032
Heart rate at skin cutting	-0.115	0.089	1.651	0.199	0.892	0.749-1.062
Heart rate at extubation	-0.004	0.201	0.000	0.986	0.996	0.672-1.477
Systolic pressure at skin cutting	-0.023	0.060	0.148	0.701	0.977	0.868-1.100
Systolic pressure at extubation	-0.011	0.056	0.039	0.843	0.989	0.887-1.103

reduce patients' quality of life. There were no significant differences in QoR-15 scores between the groups on postoperative day 1, but significant increases were observed on days 3 and 7. This suggests that while carbohydrate intervention did not have an immediate impact on recovery on the first day, significant improvements were seen by the third and seventh days. This could be due to initial postoperative pain and slower recovery of certain indicators, with recovery accelerating over time.

Postoperative levels of hs-CRP, IL-6, TNF-α, and sIL-2R were lower in the research group, indicating that preoperative carbohydrate intake can mitigate the inflammatory response. This effect may be attributed to reduced stress and improved metabolic regulation.

Higher levels of CD4+ cells, the CD4+/CD8+ ratio, IgG, and IgA in the research group suggested enhanced immune function recovery. Carbohydrates likely provide energy to immune cells, supporting their function during recovery.

The research group showed lower increases in ALT, AST, total bilirubin, and total bile acids post-surgery, indicating better liver function restoration. This could be due to the metabolic support carbohydrates provide to the liver during the perioperative period.

Correlation between preoperative carbohydrate intake and postoperative IR and QoR-15

Preoperative carbohydrate intake was negatively correlated with insulin levels and HOMA-IR on the third postoperative day, indicating its effectiveness in reducing IR. This is likely due to carbohydrates' influence on insulin transduction pathways and energy supplementation [27]. Additionally, a positive correlation was observed between carbohydrate intake and the QoR-15 score on postoperative day 7, suggesting improved long-term recovery quality. Logistic regression analysis confirmed that carbohydrate intake was an independent factor associated with better recovery quality, highlighting its critical role in enhancing postoperative outcomes. These findings emphasize the importance of preoperative carbohydrate administration in optimizing metabolic processes and promoting recovery [28].

This study has several limitations. First, it was a single-center retrospective study, which limits the generalizability of the findings, as the patient population may not represent the broader population. Second, the sample size was relatively small, which may not have provided sufficient statistical power to detect subtle but meaningful differences, increasing the risk of type II errors. Third, selection bias may have influenced the data, as uncontrolled factors such as differences in patient selection criteria or data recording methods could have affected the results. Future research should involve large-scale, multi-center prospective studies with more diverse patient populations and careful randomization to minimize bias. Moreover, incorporating comprehensive outcome measures, such as long-term quality-of-life assessments and cost-effectiveness analyses, would enhance the reliability of the findings and provide a more complete understanding of preoperative carbohydrate intervention's role in laparoscopic liver resection.

In conclusion, preoperative oral carbohydrate intake reduces postoperative IR and facilitates recovery. It lowers the incidence of nausea and vomiting, shortens key recovery times, and enhances immune and liver function recovery. This promotes overall postoperative health and recovery.

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Disclosure of conflict of interest

None.

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