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Comparison of goal-directed fluid therapy guided by superior vena cava collapsibility index versus central venous pressure in laparoscopic hepatectomy

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Abstract: Objective To compare the effects of superior vena cava collapsibility index (SVC-CI) guided goal-directed fluid therapy (GDFT) and central venous pressure (CVP) guided GDFT on bleeding and early postoperative recovery during laparoscopic hepatectomy. **Methods** Seventy patients who underwent laparoscopic hepatectomy in Gaochun Hospital Affiliated to Jiangsu University from March 2023 to March 2024 were included. The patients were randomly divided into a group C and a group S using a random number table method. Group S received intraoperative liquid therapy guided by SVC-CI>36% as the target, group C used CVP <5 cmH$_2$O as the target to guide intraoperative liquid therapy. The effects of two treatment options on intraoperative blood loss, fluid input and output, use of vasoactive drugs, arterial blood gas indicators, renal function, post anesthesia care unit (PACU) stay, time to ambulation, time to first anal exhaust and hospital stay in patients. **Results** There was no significant difference in intraoperative blood loss between patients in group S and group C [(366.65±24.69) mL *vs* (358.45±33.26) mL, t=1.072, P=0.288], except for 24 hours after surgery, no statistically significant difference was found in serum creatinine and urea nitrogen levels between the two groups (P>0.05). Compared with group C, the intraoperative amount of compound sodium chloride infusion in group S was lower, while the intraoperative amount of hydroxyethyl starch infusion and intraoperative urine volume were higher (P<0.05); the mean arterial pressure at and after hepatectomy in group S were higher, and the heart rate after hepatectomy was lower (P<0.05); intraoperative dosage of norepinephrine and nitroglycerin were lower[(164.46± 34.54)μg *vs* (355.68±28.36)μg, t=23.276, P<0.01; (126.43±27.48)μg *vs* (412.38±16.40)μg, t=48.728, P<0.01]; arterial lactate level at the end of the operation was lower[(0.97±0.13)mmol/L *vs* (1.28±0.12)mmol/L, P<0.05], postoperative PACU stay was shorter, and time to ambulation was earlier (P<0.05). There was no significant difference in postoperative time to ambulation and hospital stay between the two groups (P>0.05). Conclusion In laparoscopic hepatectomy, SVC-CI guided GDFT optimizes intraoperative volume management, improves tissue perfusion, shortens early postoperative recovery time, and offers a more precise fluid therapy strategy for laparoscopic hepatectomy.

Keywords: Laparoscopic hepatectomy; Superior vena cava collapsibility index; Central venous pressure; Goal-directed fluid therapy; Capacity management; Tissue perfusion; Postoperative recovery

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Laparoscopic liver resection has become the most common treatment for liver space-occupying lesions due to its advantages of minimal trauma and rapid recovery. However, due to the rich blood supply of the liver, bleeding remains the biggest issue in laparoscopic liver resection [1]. Some reports suggest that maintaining low central venous pressure (CVP) during laparoscopic liver resection can minimize bleeding [2]. Therefore, the current technique of goal-directed fluid therapy (GDFT) guided by low CVP is an important means to reduce bleeding during liver resection. However, as CVP is a static parameter, it has low sensitivity in assessing volume status and can be affected by various factors such as vasoactive drugs, mechanical ventilation, and intra-abdominal pressure, limiting its clinical application.

The superior vena cava collapsibility index (SVC-CI) refers to the percentage of the change in the diameter of the superior vena cava (SVC) during mechanical ventilation-induced periodic collapses. The change in SVC diameter during mechanical ventilation is more pronounced when the volume is insufficient, and it is not affected by pneumoperitoneum or abdominal surgery, offering higher sensitivity and accuracy in volume assessment. However, SVC-CI requires measurement through transesophageal echocardiography (TEE), which limits its use. TEE is a real-time, continuous, direct, and visualized minimally invasive monitoring technique for cardiac structure and function, widely used in high-risk surgeries to assess cardiovascular status and fluid load. It can also quickly identify gas embolism and reduce risks [3]. This study measures SVC-CI through TEE to explore its guiding role in volume therapy during laparoscopic liver resection and its effect on early postoperative recovery, providing reference for volume therapy in laparoscopic liver resection patients.

1 Data and Methods

1.1 Study Subjects

This study was approved by the Ethics Committee of Nanjing Gaochun People's Hospital (Ethics Approval No.: 2023-091-01). A total of 70 patients who were scheduled for elective laparoscopic liver resection at the Nanjing Gaochun People's Hospital from March 2023 to March 2024 were selected.

Inclusion criteria: (1) Preoperative diagnosis of liver tumor; (2) Age between 30 and 75 years; (3) Body Mass Index (BMI) <30 kg/m²; (4) American Society of Anesthesiologists (ASA) classification I–II.

Exclusion criteria: (1) Patients with heart, lung, liver, or kidney dysfunction; (2) Patients with cardiac structural or ventricular diameter abnormalities; (3) Patients with bleeding tendency or coagulation disorders; (4) Patients who had received preoperative radiotherapy, chemotherapy, immunosuppressants, or blood transfusions; (5) Patients with esophageal varices or other absolute contraindications for TEE.

Removal criteria: (1) Subjects withdraw informed consent; (2) Discontinuation of GDFT during the study; (3) Conversion to open surgery; (4) Sudden severe complications during the perioperative period (air embolism, circulatory failure, etc.); (5) Loss to follow-up.

1.2 Sample Size Calculation and Grouping

PASS 21 software was used to estimate the sample size. Intraoperative blood loss was taken as the primary endpoint to evaluate the sample size. According to previous literature and pre-experimental results, the group C had an intraoperative blood loss of (350±70) mL, and the group S had an intraoperative blood loss of (300±60) mL. The two-sided α was set at 0.05, and the power was 80%. After calculation, each group required 28 samples, for a total of 56 samples in both groups. Considering a possible 20% dropout rate, 70 patients were planned to be recruited, with 35 patients in each group.

Among the 70 patients, 4 patients were excluded, and 66 patients were randomly assigned to the observation group (group S, GDFT guided by SVC-CI, n=33) or the control group (group C, GDFT guided by CVP, n=33) using a random number table. A total of 7 patients withdrew from the study due to conversion to open surgery (n=3) and loss to follow-up (n=4). Therefore, 59 patients, consisting of 29 subjects from the group S and 30 patients from the group C, completed the study and were included in the final analysis. See **Figure 1**. There were no statistically significant differences in age, body mass index, gender, ASA classification, liver resection site, hypertension, and diabetes between the two groups (P>0.05). See **Table 1**.

1.3 Anesthesia Method

After the patient enters the room, electrocardiographic monitoring was initiated, and a background infusion of compound sodium chloride 2-3 mL/(kg·h) was administered. Radial artery puncture was performed to monitor invasive arterial pressure, and a dual-lumen catheter was inserted into the right internal jugular vein to measure CVP.

Anesthesia induction: Intravenous injection of midazolam 0.05 mg/kg, sufentanil 0.5 μg/kg, etomidate 0.3 mg/kg, rocuronium 0.8 mg/kg was administered. After the patient loses consciousness and muscle relaxation was satisfactory, endotracheal intubation was performed, followed by mechanical ventilation. The tidal volume was set to 8–10 mL/kg, oxygen flow rate to 2 L/min, inspired oxygen concentration (FiO_2) to 60%, respiratory rate to 10–14 breaths/min, and end-tidal carbon dioxide ($PetCO_2$) to 35–45 mmHg. A warming blanket was used to maintain normal body temperature. Brain electrical activity monitoring was performed for all patients to maintain an appropriate depth of anesthesia. Maintenance drugs included propofol 4–6 mg/(kg·h) and remifentanil 0.2 μg/(kg·min). Rocuronium 0.2 mg/kg was added as needed. Ondansetron 4 mg was used to prevent postoperative nausea and vomiting. At the end of the surgery, propofol and remifentanil infusion were discontinued, and the patient was transferred to the post-anesthesia care unit (PACU) for recovery. Both groups of patients received intravenous patient-controlled analgesia, with a formulation of sufentanil 2 μg/kg and saline up to 100 mL, with a background infusion rate of 2 mL/h, lockout time of 10 minutes, and a self-administered dose of 2 mL.

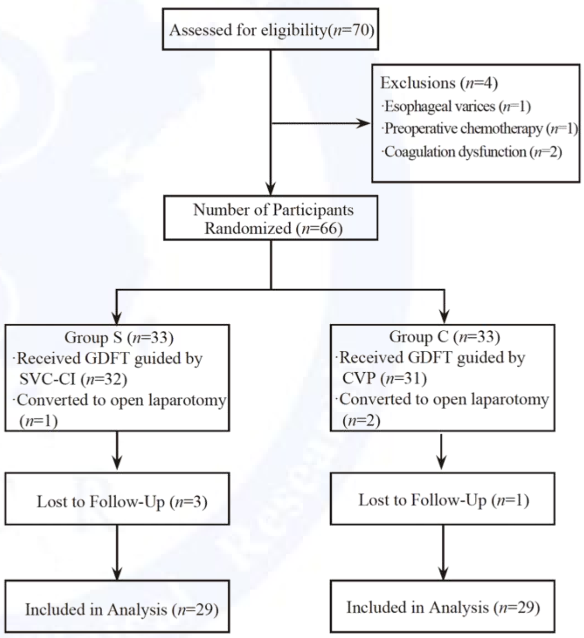

Fig.1 Inclusion of subjects

Tab.1 Comparison of general data between two groups

Indicators	Group S (n=29)	Group C (n=30)	χ^2/t value	P value
Age(years, $\bar{x}\pm s$)	52.13±11.24	49.35±12.76	0.887	0.379
Weight (kg, $\bar{x}\pm s$)	59.33±8.14	57.04±10.20	0.951	0.346
Gender(male/female, case)	15/14	18/12	0.409	0.523
ASA stageI/II (case)	17/12	20/10	0.408	0.523
Left hemihepatectomy (case)	11	11	0.000	1.000
Right hemihepatectomy (case)	6	8	0.055	0.815
Partial hepatectomy (case)	13	11	0.139	0.709
Hypertension (case)	12	14	0.022	0.883
Diabetes (case)	8	6	0.143	0.705

1.4 Fluid Therapy Protocol

Fluid management in the group S and group C during surgery was implemented in two phases: the pre-hepatectomy and hepatectomy phase was the first phase, and the post-hepatectomy phase was the second phase.

First phase: After intubation in the group S, an esophageal cardiac ultrasound probe was placed orally and adjusted to the proper position. The transesophageal cardiac ultrasound was performed using the dual-chamber venous view, with the measurement sited approximately 2 cm from the junction of the SVC and right atrium. The measurement mode used M-mode. During mechanical ventilation, the diameter of the SVC changes with the respiratory cycle, and the SVC-CI (superior vena cava collapse index) was calculated using the formula:

$$SVC\text{-}CI = (SVC_{max} - SVC_{min}) / SVC_{max}.$$

When SVC-CI>36%, it indicated volume responsiveness. Fluid administration was guided by SVC-CI, maintaining SVC-CI>36% and mean arterial pressure (MAP)>65 mmHg. In the group C, fluid administration was guided by CVP, maintaining CVP 65 mmHg. The specific protocol was shown in **Figure 2**.

Second phase: Both groups received compound sodium chloride infusion, maintaining SVC-CI 1 mL/(kg·h). If hemoglobin was<70 g/L, red blood cells were transfused. All members of the research team underwent systematic training in TEE to ensure technical standardization.

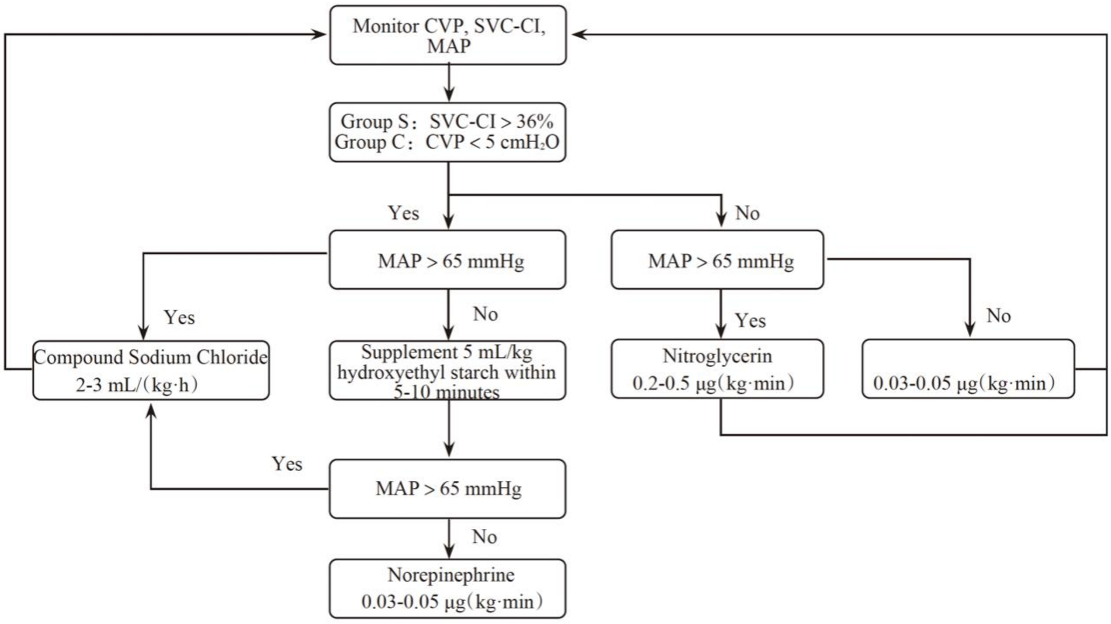

Fig.2 Intraoperative fluid management in patients in group S and group C during the first stage

1.5 Data Collection

The following data were collected:

(1) General information: gender, age, height, body weight, ASA classification, type of surgery, comorbidities, surgery duration, anesthesia duration.

(2) Primary outcome: intraoperative blood loss.

(3) Secondary outcomes: PACU residence time, length of hospital stay.

(4) Other outcomes: intraoperative infusion volume of hydroxyethyl starch and compound sodium chloride; intraoperative use of norepinephrine and nitroglycerin; MAP and heart rate at anesthesia induction (T_0), after anesthesia induction (T_1), after pneumoperitoneum (T_2), during hepatectomy (T_3), after hepatectomy (T_4), and at the end of surgery (T_5); blood gas analysis indicators at T_0, T_3, and T_5, including blood glucose, lactate; blood urea nitrogen (BUN) and serum creatinine (Scr) levels at T_0, T_5, 24 hours after surgery (T_6), and 48 hours after surgery (T_7); postoperative first flatus time and ambulation time.

1.6 Statistical Methods

Statistical analysis was performed using SPSS 24.0 software. Normally distributed continuous variables are presented as $\bar{x} \pm s$, and intergroup comparisons were performed using independent samples *t*-test. Non-normally distributed variables are presented as $M(P_{25},P_{75})$, and intergroup comparisons were conducted using rank sum tests. Repeated-measures analysis of variance and LSD-t tests for pairwise comparisons were used to compare the same indicators at different time points. Categorical data are presented as cases (%), and comparisons between groups were performed using the chi-square test. A P value of <0.05 was considered statistically significant.

2 Results

2.1 Comparison of Intraoperative Blood Loss, Anesthesia Duration, Surgery Duration, Intraoperative Fluid Input and Output, and Use of Vasoactive Drugs

There was no statistically significant difference between the two groups in terms of anesthesia time, surgery time, or intraoperative blood loss (P>0.05).

However, the group S had a higher intraoperative urine output and a higher hydroxyethyl starch infusion volume compared to the group C, while the compound sodium chloride infusion volume was lower in the group S, and the difference was statistically significant (P<0.05). Additionally, the group S used less norepinephrine and nitroglycerin during surgery compared to the group C, and the difference was statistically significant (P<0.05). **See Table 2**.

2.2 Comparison of MAP and Heart Rate at Different Time Points During Surgery

The MAP at T_3 and T_4 in the group S was higher than in the group C, and the heart rate was lower than in the group C, with a statistically significant difference (P<0.05). See **Table 3**.

2.3 Comparison of Arterial Blood Gas Indicators, Blood Glucose, and Lactate

At T_3, blood glucose and lactate levels were lower in the group S than in the group C, while pH, bicarbonate (HCO_3^-), and base excess (BE) were higher in the group S, with a statistically significant difference (P<0.05). However, at T_6, there was no statistically significant difference in Scr levels between the groups, while BUN levels were higher in the group S compared to the group C, with a statistically significant difference (P<0.05). See **Table 5**.

2.5 Comparison of PACU Residence Time, Ambulation Time, First Flatus Time, and Length of Hospital Stay

The PACU residence time was shorter in the group S compared to the group C, and the first flatus time was earlier in the group S compared to the group C, with a statistically significant difference (P<0.05). See **Table 6**.

Tab.2 Comparison of anesthesia time, operation time, intraoperative fluid intake, and use of vasoactive drugs between the two groups of patients ($\bar{x}\pm s$)

Indicators	Group S (n=29)	Group C (n=30)	t value	P value
Anesthesia time (min)	243.15±22.36	239.17±12.65	0.845	0.402
Surgical duration (min)	225.43±18.25	226.48±13.17	0.254	0.800
Intraoperative bleeding volume (mL)	366.65±24.69	358.45±33.26	1.072	0.288
Intraoperative urine output (mL)	376.15±35.48	344.17±28.64	3.816	<0.001
Hydroxyethyl starch infusion volume (mL)	740.28±32.86	360.63±55.08	32.013	<0.001
Compound sodium chloride infusion volume (mL)	2 035.49±23.86	2 486.94±26.75	68.328	<0.001
Intraoperative dose of norepinephrine (μ g)	164.46±34.54	355.68±28.36	23.276	<0.001
Intraoperative usage of nitroglycerin (μ g)	126.43±27.48	412.38±16.40	48.728	<0.001

Tab.3 Comparison of MAP and heart rate between two groups at different time points ($\bar{x}\pm s$)

Indicators	Group	T_0	T_1	T_2	T_3	T_4	T_5	F/P_{group} value	F/P_{time} value	$F/P_{interaction}$ value
MAP (mmHg)	Group S (n=29)	92.32±11.21	75.13±9.90	80.42±9.67	77.42±8.53[a]	77.32±9.91[a]	85.32±7.31	17.467	45.885	9.212
	Group C (n=30)	93.31±6.22	78.32±7.34	82.62±8.97	65.82±10.47	62.42±11.75	83.55±10.92	/<0.001	/<0.001	/<0.001
Heart rate (beats/min)	Group S (n=29)	73.51±9.74	63.91±9.74	75.83±10.72	70.70±9.85[a]	74.62±9.08[a]	76.61±7.45	22.198	53.000	53.000
	Group C (n=30)	76.42±7.90	66.42±11.51	73.45±9.86	79.93±6.24	85.92±8.53	77.93±5.97	/<0.001	/<0.001	/<0.001

Note :Compared with Group C at the same timepoint, [a]P<0.05.

Tab.4 Comparison of blood gas indices, blood glucose and lactate at different time points between two groups ($\bar{x}\pm s$)

Indicators	Group	T_0	T_3	T_5	F/P_{group} value	F/P_{time} value	$F/P_{interaction}$ value
pH	Group S (n=29)	7.39±0.03[a]	7.37±0.08[a]	7.36±0.03	42.590/<0.001	96.566/<0.001	17.374/<0.001
	Group C (n=30)	7.45±0.05	7.18±0.04	7.35±0.05			
PaO_2 (mmHg)	Group S (n=29)	87.67±11.23	324.27±75.34	319.67±11.23[a]	12.663/0.001	938.881/<0.001	11.350/<0.001
	Group C (n=30)	90.33±10.12	331.38±81.93	269.33±10.12			
$PaCO_2$ (mmHg)	Group S (n=29)	39.86±5.33	37.11±6.87	38.86±5.33	0.300/0.586	0.680/0.509	1.621/0.202
	Group C (n=30)	39.23±6.71	38.76±4.72	36.23±6.71			
HCO_3^-(mmol/L)	Group S (n=29)	24.89±1.87	23.24±1.22[a]	23.89±1.87	6.596/0.013	43.401/<0.001	11.277/<0.001
	Group C (n=30)	25.22±1.51	20.59±1.87	24.22±1.51			
BE (mmol/L)	Group S (n=29)	-0.39±0.91	-0.18±0.03[a]	-0.39±1.91	21.871/<0.001	79.254/<0.001	92.289/<0.001
	Group C (n=30)	0.37±0.63	-4.46±0.09	0.37±1.63			
Blood Glucose (mmol/L)	Group S (n=29)	5.28±1.98	6.69±1.27[a]	5.28±1.98[a]	56.463/<0.001	45.300/<0.001	17.316/<0.001
	Group C (n=30)	5.14±2.61	10.72±1.38	8.14±2.59			
Lactate (mmol/L)	Group S (n=29)	0.77±0.13[a]	1.56±0.36[a]	0.97±0.13[a]	716.059/<0.001	936.008/<0.001	335.955/<0.001
	Group C (n=30)	0.91±0.12	3.89±0.42	1.28±0.12			

Note :Compared with Group C at the same timepoint, [a]P<0.05.

Tab.5 Comparison of Scr and BUN between two groups ($\bar{x}\pm s$)

Group	Scr(μmol/L)				BUN(mmol/L)			
	T_0	T_5	T_6	T_7	T_0	T_5	T_6	T_7
Group S (n=29)	79.31±14.92	81.93±13.75	76.61±11.52	78.56±11.47	5.42±0.97	7.33±1.34	6.72±1.35[a]	5.28±1.16
Group C (n=30)	80.33±24.52	86.45±30.36	75.62±17.56	78.45±12.54	5.42±1.30	7.84±0.65	5.35±1.13	5.37±0.68
F/P_{group} value	0.243/0.624				1.390/0.243			
F/P_{time} value	2.000/1.121				54.670/<0.001			
$F/P_{interaction}$ value	0.255/0.843				8.417/<0.001			

Note :Compared with Group C at the same timepoint, [a]P<0.05.

Tab.6 Comparison of PACU stay, time to ambulation, time to first flatus, and hospital stay between two groups ($\bar{x}\pm s$)

Group	PACU duration (min)	Time to leave bed (h)	Time to exhaust (h)	Length of hospital stay (d)
Group S (*n*=29)	56.21±12.11	15.41±5.73	32.31±7.64	8.32±2.46
Group C (*n*=30)	76.33±15.26	17.84±4.62	35.66±4.29	9.86±3.57
t value	5.598	1.796	2.086	1.923
P value	<0.001	0.078	0.041	0.059

3 Discussion

Laparoscopic liver resection is widely used due to its minimal invasiveness and fast recovery [4-5]. However, because of the difficulty in achieving intraoperative hemostasis, and the high risks of bleeding and gas embolism, appropriate volume management is required to ensure perfusion of vital organs and reduce wound bleeding. Current volume management strategies are gradually shifting from traditional restrictive fluid therapy to individualized GDFT) Controlled low central venous pressure (CLCVP), defined as CVP <5 cmH_2O, is commonly used in GDFT. Previous studies have confirmed that CLCVP can effectively reduce intraoperative bleeding during laparoscopic liver resection [6], and expert consensus also recommends the routine use of CLCVP to minimize intraoperative blood loss [7]. However, its application remains controversial [8-9], as it has limited sensitivity in assessing volume status, is affected by numerous interfering factors, and prolonged low CVP may impair organ perfusion and increase the risk of embolism [10-13].

Besides CVP, other commonly used clinical indicators for volume assessment include stroke volume variation (SVV), respiratory variation in the inferior vena cava (ΔIVC), and SVC-CI. SVV is influenced by vascular elasticity, pneumoperitoneum, and changes in body position, and its applicability is limited in patients with atherosclerosis [14]. Factors affecting ΔIVC include tidal volume <8 mL/kg, continuous positive airway pressure, and increased intra-abdominal pressure, and its accuracy and specificity for assessment are suboptimal. In contrast, the SVC, as an intrathoracic vein, is unaffected by intra-abdominal pressure, and its respiratory variation is less subject to interference. However, because it requires measurement via TEE, there are relatively few studies on it currently [15]. A large-scale study found that the accuracy of SVC-CI for volume assessment is higher than that of ΔIVC [16]. A recent meta-analysis of 857 patients showed that SVC-CI is a reliable predictor for assessing fluid responsiveness in mechanically ventilated patients in the intensive care unit and operating room [17]. Vieillard-Baron *et al.* [18] found that the optimal diagnostic threshold for SVC-CI in predicting volume responsiveness was 36%. Therefore, this study selected SVC-CI as the indicator for intraoperative volume assessment and used 36% as the cut-off value.

The results of this study showed no statistically significant difference in intraoperative blood loss between the two groups, but there were clear differences in fluid management strategies: In the group S, preload was dynamically optimized based on SVC-CCI >36%. Although the fluid infusion volume was higher during the pre-resection phase, it did not increase the risk of bleeding, and MAP was more stable. In the group C, restrictive fluid infusion during the liver resection phase led to hemodynamic fluctuations and tissue hypoperfusion. Postoperatively, these patients required substantial fluid infusion combined with norepinephrine to maintain MAP, which subsequently increased systemic vascular resistance and decreased cardiac output. The significantly lower usage of vasoactive drugs in the observation group compared to the control group confirms the effectiveness of SVC-CI-guided volume management.

This study showed that the total fluid infusion volume was similar between the two groups, but the lactate concentration at the end of liver resection was lower in the observation group. This indicates that SVC-CI guidance via TEE can optimize the patient's volume status, helping to reduce arterial blood lactate at the end of liver resection and improve tissue perfusion. In the control group, the lactate value reached as high as (3.89 ± 0.42) mmol/L at the end of hepatectomy but decreased during the second phase of fluid management; therefore, no specific treatment was administered in this study regarding this change. Although the clinical significance of lactate changes remains debated, a retrospective study suggested that hyperlactatemia is associated with hospital stay length and mortality, and postoperative lactate level is a key indicator determining patient outcomes [19]. Therefore, its significant reduction may hold clinical value.

Intraoperative fluid restriction and the use of norepinephrine may reduce renal blood flow and even impair renal function. A large-scale study of 2,116 patients found that among those undergoing CLCVP liver resection, 336 cases (16%) experienced renal impairment, suggesting that CLCVP-associated renal injury is not uncommon [8]. In this study, there were no statistically significant differences in Scr and BUN levels at 48 hours postoperatively between the two groups. Only the BUN level at 24 hours postoperatively was slightly higher in the group S than in the group C. The authors analyze that this might be due, on one hand, to the small sample size, and on the other hand, to the timely fluid resuscitation in both groups during the second intraoperative phase, which restored renal perfusion.

Regarding early postoperative recovery, the PACU stay time and time to first flatus were shorter in the group S than in the group C. At the end of surgery, the PaO_2 in the group C was significantly lower than in the group S. This reflects the impairment of pulmonary gas exchange function caused by the inappropriate fluid strategy and timing in the group C and might be one reason for the prolonged PACU stay in the group C. Simultaneously, blood glucose at the end of surgery was significantly higher in the group C than in the group S. Whether this indicates that intraoperative high-stress status prolongs PACU stay warrants further study. The time to first flatus was significantly earlier in the group S than in the group

C, possibly because optimized volume management in the group S ensured gastrointestinal perfusion, and gastrointestinal motility was not significantly suppressed. Additionally, elevated blood glucose can also slow gastrointestinal peristalsis and delay flatus. There were no statistically significant differences in time to ambulation and hospital stay between the two groups, which might be related to the multitude of factors influencing these outcomes. The next step will involve increasing the sample size for further research.

In summary, SVC-CI-guided fluid therapy can optimize intraoperative volume management in patients undergoing laparoscopic liver resection, improve organ perfusion, and shorten postoperative recovery time, providing a clinically applicable, dynamically assessed, individualized GDFT.

Conflict of Interest None

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·论 著·

上腔静脉塌陷指数指导与中心静脉压指导的目标导向液体治疗在腹腔镜肝切除术中的比较

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摘要：目的 比较上腔静脉塌陷指数(SVC-CI)指导的目标导向液体治疗(GDFT)与中心静脉压(CVP)指导的GDFT对腹腔镜肝切除术中出血及术后早期恢复的影响。**方法** 纳入2023年3月至2024年3月江苏大学附属高淳医院行腹腔镜肝切除术患者70例,采用随机数字表法将患者分为两组:S组采用SVC-CI＞36%为目标指导术中液体治疗;C组采用CVP＜5 cmH_2O为目标指导术中液体治疗。比较两种治疗方案对患者术中出血、液体出入量、血管活性药物使用量、动脉血气指标、肾功能、麻醉复苏室(PACU)驻留时间、下床时间、首次排气时间及住院时间的影响。**结果** S组和C组患者术中出血量差异无统计学意义[(366.65±24.69)mL *vs* (358.45±33.26)mL,t=1.072,P=0.288],除术后24 h外,两组血肌酐、尿素氮水平差异均无统计学意义(P>0.05)。S组术中复方氯化钠输注量小于C组,羟乙基淀粉输注量和术中尿量大于C组(P＜0.05);S组切肝时和切肝后平均动脉压高于C组,心率低于C组(P＜0.05);术中去甲肾上腺素及硝酸甘油使用量低于C组[(164.46±34.54)μg *vs*(355.68±28.36)μg, t=23.276, P＜0.01;(126.43±27.48)μg *vs*(412.38±16.40)μg, t=48.728, P＜0.01];手术结束时动脉乳酸水平低于C组[(0.97±0.13)mmol/L *vs*(1.28±0.12)mmol/L, P＜0.05],术后PACU驻留时间短于C组,首次排气时间早于C组,差异有统计学意义(P＜0.05)。两组术后下床时间、住院时间差异均无统计学意义(P>0.05)。**结论** 在腹腔镜肝切除术中SVC-CI指导的GDFT可优化术中容量管理,改善组织灌注,缩短术后早期恢复时间,可为腹腔镜肝切除术提供更精准的液体治疗策略。

关键词：腹腔镜肝切除术；上腔静脉塌陷指数；中心静脉压；目标导向液体治疗；容量管理；组织灌注；术后恢复
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Comparison of goal-directed fluid therapy guided by superior vena cava collapsibility index versus central venous pressure in laparoscopic hepatectomy

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Abstract: Objective To compare the effects of superior vena cava collapsibility index (SVC-CI) guided goal-directed fluid therapy (GDFT) and central venous pressure (CVP) guided GDFT on bleeding and early postoperative recovery during laparoscopic hepatectomy. **Methods** Seventy patients who underwent laparoscopic hepatectomy in Gaochun Hospital Affiliated to Jiangsu University from March 2023 to March 2024 were included. The patients were randomly divided into two groups using a random number table method. Group S received intraoperative liquid therapy guided by SVC-CI>36% as the target, group C used CVP <5 cmH_2O as the target to guide intraoperative liquid therapy. The effects of two treatment options on intraoperative blood loss, fluid input and output, use of vasoactive drugs, arterial blood gas indicators, renal function, postanesthesia care unit (PACU) stay, time to ambulation, time to first anal exhaust and hospital stay in patients. **Results** There was no significant difference in intraoperative blood loss between patients in group S and group C [(366.65±24.69) mL *vs* (358.45±33.26) mL, t=1.072, P=0.288], except for 24 hours after

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surgery, no statistically significant difference was found in serum creatinine and urea nitrogen levels between the two groups (P>0.05). Compared with group C, the intraoperative amount of compound sodium chloride infusion in group S was lower, while the intraoperative amount of hydroxyethyl starch infusion and intraoperative urine volume were higher (P<0.05); the mean arterial pressure at and after hepatectomy in group S were higher, and the heart rate was lower (P<0.05); intraoperative dosage of norepinephrine and nitroglycerin were lower [(164.46±34.54)μg *vs* (355.68±28.36)μg, t=23.276, P<0.01; (126.43±27.48) μg *vs* (412.38±16.40) μg, t=48.728, P<0.01]; arterial lactate level at the end of the operation was lower [(0.97±0.13) mmol/L *vs* (1.28±0.12) mmol/L, P<0.05], postoperative PACU stay was shorter, and time to ambulation was earlier; all with statistical significances (P<0.05). There was no significant difference in postoperative time to ambulation and hospital stay between the two groups (P>0.05). **Conclusion** In laparoscopic hepatectomy, SVC-CI guided GDFT optimizes intraoperative volume management, improves tissue perfusion, shortens early postoperative recovery time, and offers a more precise fluid therapy strategy for laparoscopic hepatectomy.

Keywords: Laparoscopic hepatectomy; Superior vena cava collapsibility index; Central venous pressure; Goal-directed fluid therapy; Capacity management; Tissue perfusion; Postoperative recovery

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腹腔镜肝切除术因创伤小、恢复快等优点,成为肝占位切除最常见的治疗手段。但由于肝血供丰富,出血仍是腹腔镜肝切除术最大的问题[1]。有报道指出,在腹腔镜肝切除过程中,维持低中心静脉压(central venous pressure, CVP),可以最大限度地减少出血[2]。因此目前以低CVP指导的目标导向液体治疗(goal-directed fluid therapy,GDFT)技术是减少肝切除术中出血的重要手段。但CVP作为静态参数,评估容量灵敏性较低,还会受到血管活性药物、机械通气、腹内压等多种因素的影响,临床应用存在一定的限制。

上腔静脉塌陷指数(superior vena cava collapsibility index, SVC-CI)是指上腔静脉(superior vena cava, SVC)内径随机械通气周期性规律塌陷变化的百分率。SVC内径随机械通气周期性的变化在容量不足时表现更明显,同时其不受气腹和腹部手术影响,评估容量的灵敏度及准确度更高。但SVC-CI需要运用经食管超声心动图(transesophageal echocardiography,TEE)测量,因此运用较少。TEE是一种实时、连续、直接、可视化的心脏结构与功能的微创监测技术,广泛用于高危手术中评估心血管状态及液体负荷,还能够快速识别气体栓塞,降低风险[3]。本研究通过TEE测量SVC-CI,探讨其在腹腔镜肝切除术中容量治疗的指导作用以及对患者术后早期恢复的影响,为腹腔镜肝切除术患者的容量治疗提供参考。

1 资料与方法

1.1 *研究对象* 本研究经过南京市高淳人民医院伦理委员会批准(伦理审查号:2023-091-01),选择该院2023年3月至2024年3月拟行择期腹腔镜肝切除术患者70例。纳入标准:(1)术前诊断肝肿瘤;(2)年龄30~75岁;(3)身体质量指数(BMI)<30 kg/m^2;(4)美国麻醉医师协会(American Society of Anesthesiologists, ASA)分级Ⅰ~Ⅱ级。排除标准:(1)心肺肝肾功能不全者;(2)心脏结构或心室内径异常者;(3)出血倾向和凝血功能障碍者;(4)术前接受放化疗、免疫抑制剂、输血治疗者;(5)食管静脉曲张及其他TEE检查绝对禁忌者。剔除标准:(1)受试者撤回知情同意书;(2)研究中终止GDFT;(3)转开放式手术;(4)围手术期突发严重并发症(空气栓塞、循环衰竭等);(5)失访。

1.2 *样本量计算及分组* 使用PASS 21软件估计样本量。以术中出血量作为主要研究终点来评估样本量。根据既往文献以及预实验结果,C组术中出血量为(350±70)mL,S组术中出血量为(300±60)mL,设定双侧α=0.05,把握度为80%。通过计算,每组需要28例的样本,两组共需56例样本。考虑可能存在20%的脱落,因此计划招募70例的患者,每组计划招募35例。

在70例患者中,有4例患者被排除,共66例患者按照随机数字表法随机分配到观察组(S组,n=33)或对照组(C组,n=33)。S组接受以SVC-CI指导的GDFT治疗,C组接受以CVP指导的GDFT治疗。共有7例患者因转换为开放式手术(n=3)和失访(n=4)而退出本试验。因此,由S组29例受试者和C组30例患者组成的59例患者完成了本试验并被纳入最终分析。见图1。两组患者年龄、体质量、性别、ASA分级、肝切除部位、高血压、糖尿病比较差异无统计学意义(P>0.05)。见表1。

1.3 *麻醉方法* 患者入室后予心电监护,给予复方

氯化钠2～3 mL/(kg·h)背景维持。行桡动脉穿刺监测有创动脉压，右颈内静脉置双腔管测量CVP。麻醉诱导：静脉注射咪达唑仑(国药准字H19990027，规格1 mL:5 mg，江苏恩华药业)0.05 mg/kg，舒芬太尼(国药准字H20054171，规格1 mL:50 μg，宜昌人福药业)0.5 μg/kg，依托咪酯(国药准字H20020511，规格10 mL:20 mg，江苏恩华药业)0.3 mg/kg，罗库溴铵(国药准字H20213778，规格5 mL:50 mg，广东星昊药业有限公司)0.8 mg/kg，待患者意识消失、肌松满意后行气管内插管，并机械通气，潮气量设为8~10 mL/kg，氧流量2 L/min，吸入氧浓度(FiO_2)60%，呼吸频率10~14次/min，呼气末二氧化碳分压($ETCO_2$)35~45 mmHg。采用保温毯加温，保持正常体温。所有患者行脑电监测，维持一定的麻醉深度。维持用药为丙泊酚(国药准字H20223914，规格20 mL:0.2 g，江苏盈科生物制药)4~6 mg/(kg·h)、瑞芬太尼(国药准字H20030197，规格1 mg，宜昌人福药业)0.2 μg/(kg·min)，按需追加罗库溴铵0.2 mg/kg。昂丹司琼(国药准字H10970065，规格2 mL:4 mg，齐鲁制药)4 mg预防术后恶心呕吐。手术结束停止丙泊酚及瑞芬太尼输注并转入麻醉复苏室(post anesthesia care unit，PACU)进行复苏。两组患者均采用静脉自控镇痛，配方为舒芬太尼2 μg/kg加生理盐水至100 mL，背景输注量2 mL/h，锁定时间10 min，自控给药量2 mL。

1.4　*液体治疗方案*　S组和C组患者术中液体管理分两阶段实施，切肝前期及切肝期为第一阶段，切肝后期为第二阶段。第一阶段：S组气管插管后经口置入食管心脏超声探头并调整到合适位置，选择经食管心脏超声的双房腔静脉切面，测量部位在SVC与右心房交界处约2 cm，测量模式采用M超。机械通气时SVC直径随呼吸周期改变，并计算SVC-CI，计算公式：$SVC\text{-}CI=(SVC_{max}-SVC_{min})/SVC_{max}$。当SVC-CI＞36%时提示有容量反应性。根据SVC-CI指导补液，维持SVC-CI＞36%，平均动脉压(MAP)＞65 mmHg；C组根据CVP指导补液，维持CVP＜5 cmH_2O，MAP＞65 mmHg。具体如图2所示。第二阶段：两组均采用复方氯化钠输注，维持SVC-CI＜36%或CVP 5~10 cmH_2O，维持术中尿量>1 mL/(kg·h)，血红蛋白＜70 g/L时输注红细胞。本研究团队人员均通过系统化TEE操作培训以确保技术规范性。

1.5　*数据收集*　收集以下资料。(1)一般资料：性别、年龄、身高、体质量、ASA分级、手术类型、合并症、手术时间、麻醉时间。(2)主要结局指标：术中出血量。(3)次要结局指标：PACU驻留时间、住院时间。(4)其他结局指标：术中羟乙基淀粉及复方氯化钠输注量；术中去甲肾上腺素、硝酸甘油用量；麻醉前(T_0)、麻醉诱导后(T_1)、气腹后(T_2)、切肝时(T_3)、切肝后(T_4)、手术结束(T_5)时的MAP、心率；T_0、T_3、T_5时的血气分析指标，包括血糖、乳酸等；T_0、T_5、术后24 h(T_6)、术后48 h(T_7)的血尿素氮(BUN)、血肌酐(Scr)水平；术后排气时间、下床时间。

1.6　*统计学方法*　采用SPSS 24.0软件进行数据分析。符合正态分布的计量资料以$\bar{x}\pm s$表示，组间比较采用独立样本t检验；非正态分布的计量资料以$M(P_{25},P_{75})$表示，组间比较用秩和检验。同一指标不同时间点的比较采用重复测量方差分析及两两比较的LSD-t检验。计数资料以例(%)表示，组间比较采用χ^2检验和校正χ^2检验。$P<0.05$为差异有统计学意义。

2　结　果

2.1　*两组患者术中出血量、麻醉时间、手术时间、术中液体出入量及血管活性药物使用情况比较*　两组患者麻醉时间、手术时间、术中出血量比较差异无统计学意义($P>0.05$)；S组患者术中尿量、术中羟乙基淀粉输注量大于C组，复方氯化钠输注量小于C组，差异有统计学意义($P<0.05$)；S组术中去甲肾上腺素及硝酸甘油使用量低于C组，差异有统计学意义($P<0.05$)。见表2。

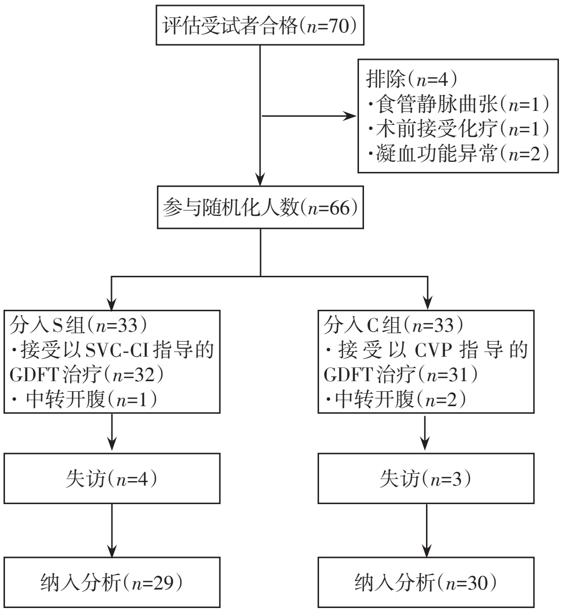

图1　受试者纳入情况
Fig.1　Inclusion of subjects

2.2　两组患者术中不同时点MAP、心率的比较　S组患者T_3、T_4时点MAP高于C组，心率低于C组，差异有统计学意义($P < 0.05$)。见表3。

2.3　两组患者不同时点动脉血气指标、血糖及乳酸比较　T_3时点S组血糖、乳酸低于C组，酸碱度(pH)、碳酸氢根(HCO_3^-)、碱剩余(BE)高于C组，差异有统计学意义($P < 0.05$)；T_5时点S组动脉血氧分压(PaO_2)高于C组，血糖及乳酸低于C组，差异有统计学意义($P<0.05$)。见表4。

2.4　两组患者不同时点肾功能比较　两组患者T_0、T_5、T_7时点Scr及BUN比较差异无统计学意义($P>0.05$)。两组患者T_6时Scr比较差异无统计学意义($P>0.05$)，而BUN水平S组高于C组，差异有统计学意义($P < 0.05$)。见表5。

2.5　两组患者PACU驻留时间、下床时间、首次排气时间及住院时间的比较　S组患者PACU驻留时间短于C组，首次排气时间早于C组，差异有统计学意义($P<0.05$)；两者患者术后下床时间及住院时间比较差异无统计学意义($P > 0.05$)。见表6。

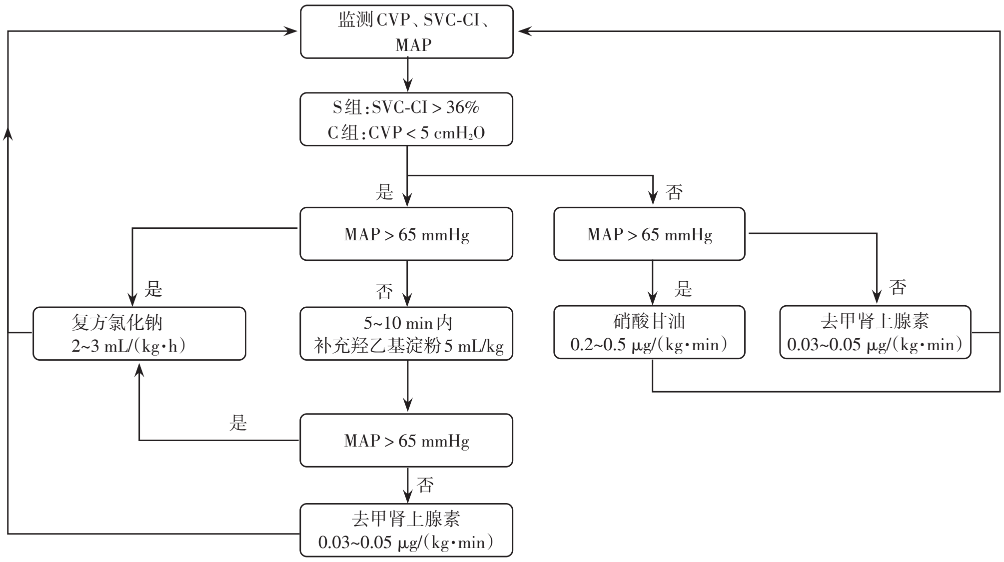

图2　第一阶段S组和C组患者术中液体管理

Fig.2　Intraoperative fluid management in patients in groups S and C during the first stage

表1　两组患者一般情况比较

Tab.1　Comparison of general characteristics between two groups

指标	S组(n=29)	C组(n=30)	t/χ^2值	P值
年龄(岁，$\bar{x}\pm s$)	52.13±11.24	49.35±12.76	0.887	0.379
体质量(kg，$\bar{x}\pm s$)	59.33±8.14	57.04±10.20	0.951	0.346
性别(男/女，例)	15/14	18/12	0.409	0.523
ASA Ⅰ/Ⅱ级(例)	17/12	20/10	0.408	0.523
切除部位(例)				
左半肝切除术	11	11		
右半肝切除术	6	8	0.312	0.855
肝部分切除术	12	11		
高血压(例)	12	14	0.022	0.883
糖尿病(例)	8	6	0.143	0.705

表2　两组患者麻醉时间、手术时间、术中液体出入量及血管活性药物使用情况比较　($\bar{x}\pm s$)

Tab.2　Comparison of anesthesia time, operation time, intraoperative fluid intake and output, and use of vasoactive drugs between the two groups　($\bar{x}\pm s$)

指标	S组(n=29)	C组(n=30)	t值	P值
麻醉时间(min)	243.15±22.36	239.17±12.65	0.845	0.402
手术时间(min)	225.43±18.25	226.48±13.17	0.254	0.800
术中出血量(mL)	366.65±24.69	358.45±33.26	1.072	0.288
术中尿量(mL)	376.15±35.48	344.17±28.64	3.816	<0.001
羟乙基淀粉输注量(mL)	740.28±32.86	360.63±55.08	32.013	<0.001
复方氯化钠输注量(mL)	2 035.49±23.86	2 486.94±26.75	68.328	<0.001
术中去甲肾上腺素用量(μg)	164.46±34.54	355.68±28.36	23.276	<0.001
术中硝酸甘油用量(μg)	126.43±27.48	412.38±16.40	48.728	<0.001

表3　两组患者不同时点MAP、心率比较　($\bar{x}\pm s$)

Tab.3　Comparison of MAP and heart rate between two groups at different time points　($\bar{x}\pm s$)

指标	组别	T_0	T_1	T_2	T_3	T_4	T_5	$F/P_{组间}$值	$F/P_{时间}$值	$F/P_{交互}$值
MAP (mmHg)	S组(n=29)	92.32±11.21	75.13±9.90	80.42±9.67	77.42±8.53^a	77.32±9.91^a	85.32±7.31	17.467/<0.001	45.885/<0.001	9.212/<0.001
	C组(n=30)	93.31±6.22	78.32±7.34	82.62±8.97	65.82±10.47	62.42±11.75	83.55±10.92			
心率 (次/min)	S组(n=29)	73.51±9.74	63.91±9.74	75.83±10.72	70.70±9.85^a	74.62±9.08^a	76.61±7.45	22.198/<0.001	18.124/<0.001	4.689/<0.001
	C组(n=30)	76.42±7.90	66.42±11.51	73.45±9.86	79.93±6.24	85.92±8.53	77.93±5.97			

注：与同时点C组比较，$^aP<0.05$。

表4　两组患者不同时点动脉血气指标、血糖及乳酸比较　（$\bar{x}\pm s$）

Tab.4　Comparison of arterial blood gas indicators，blood glucose and lactate at different time points between two groups　（$\bar{x}\pm s$）

指标	组别	T_0	T_3	T_5	$F/P_{组间}$值	$F/P_{时间}$值	$F/P_{交互}$值
pH	S组（n=29）	7.39±0.03[a]	7.37±0.08[a]	7.36±0.03	42.590/＜0.001	96.566/＜0.001	17.374/＜0.001
	C组（n=30）	7.45±0.05	7.18±0.04	7.35±0.05			
PaO_2（mmHg）	S组（n=29）	87.67±11.23	324.27±75.34	319.67±11.23[a]	12.663/0.001	938.881/＜0.001	11.350/＜0.001
	C组（n=30）	90.33±10.12	331.38±81.93	269.33±10.12			
$PaCO_2$（mmHg）	S组（n=29）	39.86±5.33	37.11±6.87	38.86±5.33	0.300/0.586	0.680/0.509	1.621/0.202
	C组（n=30）	39.23±6.71	38.76±4.72	36.23±6.71			
HCO_3^-（mmol/L）	S组（n=29）	24.89±1.87	23.24±1.22[a]	23.89±1.87	6.596/0.013	43.401/＜0.001	11.277/＜0.001
	C组（n=30）	25.22±1.51	20.59±1.87	24.22±1.51			
BE（mmol/L）	S组（n=29）	−0.39±0.91	−0.18±0.03[a]	−0.39±1.91	21.871/＜0.001	79.254/＜0.001	92.289/＜0.001
	C组（n=30）	0.37±0.63	−4.46±0.09	0.37±1.63			
血糖（mmol/L）	S组（n=29）	5.28±1.98	6.69±1.27[a]	5.28±1.98[a]	56.463/＜0.001	45.300/＜0.001	17.316/＜0.001
	C组（n=30）	5.14±2.61	10.72±1.38	8.14±2.59			
乳酸（mmol/L）	S组（n=29）	0.77±0.13[a]	1.56±0.36[a]	0.97±0.13[a]	716.059/＜0.001	936.008/＜0.001	335.955/＜0.001
	C组（n=30）	0.91±0.12	3.89±0.42	1.28±0.12			

注：二氧化碳分压（$PaCO_2$）；与同时点C组比较，[a]P<0.05。

表5　两组患者Scr及BUN比较　（$\bar{x}\pm s$）

Tab.5　Comparison of Scr and BUN between two groups　（$\bar{x}\pm s$）

指标	组别	T_0	T_5	T_6	T_7	$F/P_{组间}$值	$F/P_{时间}$值	$F/P_{交互}$值
Scr（μmol/L）	S组（n=29）	79.31±14.92	81.93±13.75	76.61±11.52	78.56±11.47	0.243/0.624	2.000/1.121	0.255/0.843
	C组（n=30）	80.33±24.52	86.45±30.36	75.62±17.56	78.45±12.54			
BUN（mmol/L）	S组（n=29）	5.42±0.97	7.33±1.34	6.72±1.35[a]	5.28±1.16	1.390/0.243	54.670/＜0.001	8.417/＜0.001
	C组（n=30）	5.42±1.30	7.84±0.65	5.35±1.13	5.37±0.68			

注：与同时点C组比较，[a]P<0.05。

表6　两组患者PACU驻留时间、下床时间、首次排气时间及住院时间比较　（$\bar{x}\pm s$）

Tab.6　Comparison of PACU stay，time to ambulation，time to first flatus，and hospital stay between two groups　（$\bar{x}\pm s$）

组别	例数	PACU驻留时间（min）	下床时间（h）	首次排气时间（h）	住院时间（d）
S组	29	56.21±12.11	15.41±5.73	32.31±7.64	8.32±2.46
C组	30	76.33±15.26	17.84±4.62	35.66±4.29	9.86±3.57
t值		5.598	1.796	2.086	1.923
P值		<0.001	0.078	0.041	0.059

3　讨　论

腹腔镜肝切除术因创伤小、恢复快而广泛应用[4-5]，但由于术中止血难度大、出血、气体栓塞风险高等，需实施恰当的容量管理，以保障重要脏器灌注，减少创面渗血。目前容量管理方案逐渐从传统的限制性液体治疗转向个体化的GDFT。GDFT中常用控制性低中心静脉压（controlled low central venous pressure，CLCVP），即CVP＜5 cmH_2O。已有研究证实在腹腔镜肝切除术中CLCVP能够有效减少术中出血[6]，且在专家共识中也推荐常规使用CLCVP，以最大限度地减少术中出血量[7]。但是其应用还存在一定争议[8-9]，其评估容量状态的灵敏度有限，干扰因素较多，且长时间低CVP可能损害器官灌注并增加栓塞风险[10-13]。

临床上常用的容量评估指标除了CVP，还有每搏输出变异度（stroke volume variation，SVV）、下腔静脉呼吸变异度（respiratory variation in the inferior vena cava，ΔIVC）、SVC-CI。SVV受血管弹性、气腹及体位变化影响，同时动脉粥样硬化患者适用性受限[14]；ΔIVC影响因素包括潮气量＜8 mL/kg、持续气道正压、腹内压增大等，其评估的准确性、特异性欠佳。而SVC作为胸腔内静脉不受腹内压影响，其呼吸变异度受干扰较小，但因需要在TEE下测量所以目前研究相对较少[15]。一项大样本的研究发现，SVC-CI对于容量评估的准确性比ΔIVC高[16]。近年的一项857例患者的荟萃分析显示，SVC-CI是重症监护病房和手术室机械通气患者评估液体反应的可靠预测指标[17]。Vieillard-Baron等[18]发现SVC-CI预测容量反应的最佳诊断阈值为36%。故本研究选择SVC-CI作为术中容量评估的指标，并以36%作为截断值。

本研究结果显示，两组术中出血量差异无统计学意义，但液体管理策略存在明显不同：S组通过SVC-CI＞36%动态优化前负荷，尽管切肝前期补液量较多，但未增加出血风险，且MAP更加平稳；C组因切肝阶段限制性输液导致血流动力学波动及组织低灌注，术后需大量补液联合去甲肾上腺素以维持MAP，进而增加全身血管阻力并降低心输出量。观察组血管活性药物使用量显著低于对照组，印证了SVC-CI导向容量管理的有效性。

本研究显示，两组总输液量相当，但观察组在切

肝结束时的乳酸浓度更低。表明通过TEE指导的SVC-CI可优化患者容量状态,有助于降低切肝结束时动脉血乳酸,改善组织灌注。对照组在肝切除结束时乳酸值高达(3.89±0.42) mmol/L,但在液体管理第二阶段降低,故本研究未给予针对处理。尽管乳酸变化的临床意义尚存争议,但一项回顾性研究提示高乳酸与住院时间及死亡率相关,且术后乳酸水平是决定患者转归的关键指标[19],故其显著降低可能具有临床价值。

术中容量限制及使用去甲肾上腺素可能减少肾血流量,甚至损害肾功能。一项2 116例的大样本研究发现,CLCVP肝切除术患者中,发生肾功能损害者336例,占16%,提示CLCVP相关肾功能损害并非罕见[8]。而在本研究中,两组术后48 h Scr、BUN差异无统计学意义,仅术后24 h的BUN水平S组稍高于C组。笔者分析一方面可能由于样本量较小,另一方面和两组术中第二阶段均及时补液恢复肾灌注有关。

术后早期恢复方面,S组PACU驻留时间及首次排气时间短于C组。手术结束时C组患者PaO_2明显低于S组,这反映了C组不当输液策略及输液时机对机体肺换气功能造成损伤,并可能是C组患者PACU驻留时间延长的原因之一。同时C组患者手术结束时的血糖明显高于S组,是否说明术中的高应激状态会延长PACU驻留时间,仍值得进一步研究。S组患者首次排气时间明显早于C组,这可能是因为在S组中容量优化保障了胃肠灌注,胃肠运动未受明显抑制。此外,血糖的增高也同样会减慢胃肠蠕动,推迟排气。两组下床及住院时间差异无统计学意义,可能和这两者的影响因素较多有关,下一步将增加样本量进一步研究。

综上,SVC-CI指导的液体治疗可优化腹腔镜肝切除术患者的术中容量管理,改善器官灌注,缩短术后恢复时间,为临床提供了一种基于动态评估的个体化GDFT方案。

利益冲突 无

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