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# Benefits of a modified local precision liver resection using intraoperative laparoscopic ultrasound in the treatment and prognosis of patients with liver cancer.

*Yansong Xu[1] and Lin Shen[2]*

[1]Department of Hepatobiliary Surgery, Affiliated Hospital of Beihua University, Jilin, China.
[2]Department of Anesthesiology, Affiliated Hospital of Beihua University, Jilin, China.

**Keywords:** precision hepatectomy; liver function; hepatic venous injury; immune factors; immune response; cytokines; Karnofsky performance scale.

**Abstract**. The incidence and mortality rate of liver cancer has increased significantly. Recently, intraoperative laparoscopic ultrasound (LUS) has been used in hepatectomy, in addition to open liver resection, as the most common treatment method. The current research aims to address this issue. Seventy-six patients with liver cancer who were admitted to the Hospital of Beihua University from February 2018 to September 2021 were randomly divided into two groups of 38 patients, one group undergoing conventional laparoscopic surgery (control group) and the other group undergoing a precise laparoscopic liver resection after placing an intraoperative LUS instrument (study group). Blood loss and hepatic vein damage during surgery were less in the study group ($p<0.05$). Seven days after surgery, liver function indices (albumin, total bilirubin, and alanine and aspartate aminotransferases) and indices related to immune function interleukin 6, tumor necrosis factor α, CD3+ and CD4+ T lymphocytes and NK cells level in the study group improved compared to the control group. The postoperative complications were less in the study group, and the nine-month follow-up showed that the recurrence rate was lower and the survival rate was higher in this group. This study shows that precise laparoscopic hepatectomy modified with the use of intraoperative laparoscopic ultrasound results in better intraoperative and postoperative outcomes for the prognosis and survival rate of patients with liver cancer, which makes this surgical technique worth generalizing in clinical practice.

**Corresponding author:** Yansong Xu, Department of Hepatobiliary Surgery, Affiliated Hospital of Beihua University, Jilin, 132012, Jilin, China. E-mail: tonggubu9822@163.com

# Beneficios de la resección hepática de precisión local modificada, utilizando ecografía intraoperatoria laparoscópica en el tratamiento y pronóstico de pacientes con cáncer de hígado.

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**Palabras clave:** hepatectomía de precisión; función hepática; lesión venosa hepática; factores inmunológicos; respuesta inmune; citocinas; escala de desempeño de Karnofsky.

**Resumen.** La tasa de incidencia y mortalidad del cáncer de hígado ha aumentado drásticamente. Además de la resección hepática abierta como método de tratamiento más común, la ecografía laparoscópica intraoperatoria (LUS) se ha utilizado recientemente en la hepatectomía. El objetivo de la investigación actual es responder a esta pregunta. 76 pacientes con cáncer de hígado ingresados en el Hospital de la Universidad de Beihua entre febrero de 2018 y septiembre de 2021 fueron asignados aleatoriamente a dos grupos de 38 pacientes, un grupo sometido a cirugía laparoscópica convencional (grupo control) y el otro grupo sometido a resección hepática laparoscópica precisa, después de colocar un instrumento LUS intraoperatorio (grupo de estudio). La pérdida de sangre y el daño a las venas hepáticas durante la cirugía fueron menores en el grupo de estudio ($p < 0,05$). Siete días después de la cirugía, los índices de función hepática (albúmina, bilirrubina total y alanina y aspartato aminotransferasas) e índices relacionados con la función inmune, interleucina 6, factor de necrosis tumoral α, linfocitos T CD3+ y CD4+ y nivel de células NK en el grupo de estudio mejoraron en comparación con el grupo control. Las complicaciones postoperatorias fueron menores en el grupo de estudio, y el seguimiento a los 9 meses mostró que la tasa de recurrencia fue menor y la tasa de supervivencia fue mayor en este grupo. Este estudio demuestra que la hepatectomía laparoscópica precisa modificada con el uso de la ecografía laparoscópica intraoperatoria da como resultado mejores resultados intraoperatorios y postoperatorios para el pronóstico y la tasa de supervivencia de los pacientes con cáncer de hígado, y hace que valga la pena generalizar esta técnica quirúrgica en la práctica clínica.

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## INTRODUCTION

Liver cancer is a malignant tumor that seriously affects Chinese residents' health, and its incidence is relatively high[1,2]. The early stage of hepatocellular carcinoma courses with insidious characteristics and rapid growth, but it is often diagnosed in the middle and late stages. At the same time, liver cancer has high recurrence and mortality rates [3,4]. At present, liver cancer is mainly treated through surgery. In clinical practice, different treatment measures are adopted according to the different liver function reserve abilities, the physical conditions of people with liver cancer, and the different stages of cancer the patients present. Liver resection is preferred for patients with localized liver cancer without accompanying cirrhosis [5]. Hepatectomy is the most common surgical method for radical liver cancer treatment, which can notoriously reduce the recurrence and spread of liver tumors and effectively prolong the survival time of sufferers [6,7]. Conventional open liver resection is a standard clinical method. However, the patient's postoperative recovery and prognosis are unsatisfactory due to the extensive surgical trauma and the risk of acquiring a postoperative infection [8]. With the development of science and technology and the enhancement of medical standards, the application value of laparoscopy in various surgical operations has become increasingly apparent. In the 1990s, Reich performed the world's first laparoscopic liver resection. Since then, the door has been opened to minimally invasive surgery through laparoscopy [9].

In contrast with conventional open liver resection, laparoscopic liver resection has the advantages of less trauma and quick postoperative recovery, which surgeons and patients favor. However, laparoscopic surgery also has limitations since the laparoscopic surgeon operates only through a few holes and cannot directly contact and manipulate the related visceral structure, and because of the reduced abdomen's display, the surgeon may not fully understand the abdominal situation, leading to a limited surgical field. At the same time, the lack of palpation increases the risk in laparoscopic surgery [10]. In addition, because the field is not comprehensive, it is easy to ignore some small lesions, and it can easily result in the presence of tumor residues, leading to a high recurrence rate in patients. Enhanced local precision resection was developed based on a conventional laparoscopic resection. Using laparoscopic ultrasound (laparoscopic ultrasonography, LUS) can help the operator detect complex lesions. It can synchronously guide the surgeon to operate, reduce damage to related organs and tissues, and make up for the deficiencies of conventional laparoscopic surgery. Relevant studies have shown that laparoscopic surgery with LUS is more effective [11,12]. In recent years, ultrasound examination has been gradually applied to laparoscopic surgery. The period of clinical use has not been very long, and since the related studies are few, the therapeutic effect of laparoscopic surgery on liver cancer still needs further analysis [13]. Therefore, this study aimed to evaluate the clinical benefits of modified precision hepatectomy using intraoperative LUS in patients with liver cancer so that this new treatment technique can be tested to find a better way to treat liver cancer.

## PATIENTS AND METHODS

### General Information

In this study, all eighty-seven patients with liver cancer admitted to the Hospital of Beihua University, China, from February 2018 to September 2021 were selected for this study. The inclusion criteria were as follows: met the diagnosis and implications of liver cancer, according to the Guidelines on the diagnosis and treatment of primary liver cancer (2011 edition) [14]. Relevant criteria in TNM stages I, II, and III; Child-Pugh grades A or B; no associated surgery or radiofrequency ablation for six months; and nine months of telephone follow-up after laparoscopic surgery. Exclusion criteria were tumor involvement of adjacent organs or metastases; severe abdominal adhesion; patients with cardiac or renal failure; abnormal mental status; diabetes; women during pregnancy or lactation; and patients with an allergic condition. All patients signed the informed consent form, and the medical ethics committee of our hospital approved this study. Of the eighty-seven patients who were accepted at the beginning of the study, after checking the study conditions and the inclusion and exclusion criteria, seventy-six patients were finally included. Seventy-six patients were randomly selected as control variables according to the random number table method and randomly divided into two groups of 38 patients.

## METHODS

**Surgical method:** Our institution's chief surgeon has been the same physician for over eight years. We used a conventional laparoscopic liver resection for the control group: a preoperative-related imaging (MRI or CT) examination in the supine position was performed to determine the lesion site, size, and number. This examination was followed by the conventional implementation of an artificial pneumoperitoneum (pressure 12-14 mmHg), the construction of the conventional "five-port technique" according to the location and size of the tumor, abdominal exploration, to free the perihepatic ligament and to fully reveal the tumor focus, the first portal vascular implication, the left hepatic artery and portal branch, according to the liver ischemia line or the anatomy Cantilie-line mark as a resection line [9,11,15-17].

For the Study group, we used a modified laparoscopic precision liver resection. After a preoperative imaging (MRI or CT) examination to determine the lesion location, size, and number in the supine position, we established an arc incision approximately 10 mm below the umbilicus. This incision was followed by the conventional implementation of an artificial pneumoperitoneum (pressure 12-14 mmHg) and placed the LUS (HITACHI ALOKA Noblus; with an L44LA soft probe, probe frequency of 7.5 MHz). Different liver parts were scanned successively, and the tumor location, size, number, and the relationship between the tumor body and the peripheral vasculature and tissues were determined again. The proper liver blood flow blocking method and liver parenchyma disconnection method were selected. For severe liver parenchyma lesions, it was not appropriate to block the blood flow into the liver and use an ultrasonic knife to stop the liver parenchyma and the bipolar electrocoagulation wound. Selective blood flow into the liver was blocked for patients with mild liver parenchymal lesions, and the liver parenchyma was severed along the ischemic line with an ultrasound knife. The vascular structure was fully exposed for the liver resection, then treated accordingly to the vascular diameter [17-21].

**Blood tests:** In the early morning, 5 mL of cubital venous blood was extracted and centrifuged at 3500 rpm for 10 min, with a centrifugation radius of 10 cm, and the serum was collected for indicator determinations.

### Observation Indicators and Evaluation Criteria

(1) Perioperative-related indicators: data and blood samples were collected by the same nurse working in our hospital for over three years. The operation time, intraoperative blood loss, hepatic vein injury rate, lesion resection edge distance, drainage tube extubation time, and anal exhaust time were recorded.

(2) Fasting venous blood was collected before and seven days after the intervention, and an analysis was performed using a fully automatic biochemical analyzer (Beckman Coulter AU5800). Liver function-related indicators were measured in both groups of patients: albumin (ALB), alanine aminotransferase (ALT), aspartate aminotransferase, AST), and total bilirubin (TBIL), as well as the immune factor-related indicators interleukin 6 (IL-6), tumor necrosis factor α (TNF-α). T lymphocyte subsets were analyzed by flow cytometry (Beckman Coulter EPICS XL) to detect T lymphocytes ($CD3^+$), inducible T cells ($CD4^+$), and human natural killer (*NK*) *cells* (NK cell standard). The same physician performed the specific operations according to the instructions.

(3) The incidence of related complications (infection, abdominal hemorrhage, bile leakage, pleural effusion, etc.) in the two groups of patients was reported by the same nurses working for over three years.

(4) We used the Karnofsky scoring method (KarnofskyPerformance Status, KPS) 22 to assess the recovery of quality of

life in the two groups of patients. If the score increased by more than ten points after the procedure, the activities of daily living (ADL) were better; if it lessened by more than ten, it was worse; if it increased or lessened by ten, it was stable.

(5) The survival and recurrence rates of both groups were recorded by telephone follow-ups at three months (T1), six months (T2), and nine months (T3) after surgery by the same nurse.

**Statistical analysis**

The required data of this study were sorted and entered into a Microsoft® Excel® table. We used the SPSS26.0 software to analyze the data. If the data ($\bar{x}$±SD) were normally distributed, we compared the groups with the independent sample *t*-test for the group's data and paired sample *t*-test; count data was analyzed by percentages and Chi-square test ($\chi^2$ test). The *Kaplan-Meier* survival curves were employed to determine sufferers' survival and recurrence rates in the two groups. When $p \leq 0.05$, the data's differences were considered statistically significant.

## RESULTS

This study was conducted to investigate the benefits of modified precise hepatectomy using intraoperative LUS in patients with liver cancer.

The clinical and demographic characteristics of the two groups of patients under investigation are presented in Table 1. The sex distribution among the study group patients showed that 21 (55.3%) were male and 17 (44.7%) were female; whereas, in the control group, there were 20 (52.6%) male and 18 (47.4%) female patients. The mean age of the study group was 51.52±6.95 years, while the mean age of the control group was 52.36±8.32 years. The mean body mass index (BMI) in the study group patients was 22.36±2.68 kg/m$^2$; whereas, in the control group, it was 22.63±3.01 kg/m$^2$. The two groups had no significant differences regarding sex distribution, mean age, and mean BMI.

The staging of patients based on TNM revealed that in the study group, 14 (36.8%) patients were in stage I, 13 (34.2%) patients were in stage II, and 11 (29%) patients were in stage III. Similarly, in the control group, there were 14 (36.8%) patients in stage I, 15 (39.5%) patients in stage II, and 9 (23.7%) patients in stage III. There were no significant differences between the two groups regarding cancer staging based on TNM. The tumor diameter in the study group patients was 5.16±1.49 cm, while in the control group, it was 5.09±1.53 cm, and there was no significant difference in tumor diameter between the two groups. The results of the Child Grade in the two groups of examined patients showed that 29 (76.3%) patients in the study group and 27 (71%) patients in the control group were classified as Group A. Additionally, 9 (23.7%) patients in the study group and 11 (29%) patients in the control group were classified as Group B, with no significant difference observed between the two groups.

**Comparison of perioperative indicators between the two groups of patients**

The mean duration of surgery in the study group was 103.59±19.12 minutes, while in the control group, it was 98.59±20.16 minutes. There was no significant difference in the duration of surgery between the two groups. Hepatic venous injury was observed in two (5.26%) patients in the study group and ten (14.28%) patients in the control group, showing there was a significant difference (p=0.013). The blood loss volume in the study group was 183.38±29.71 mL; whereas in the control group, it was 233.56±24.28 ml, and the two groups did not differ significantly in blood loss volume. Other preoperative indicators are presented in Table 2.

**Table 1**
Comparison of the clinical and demographic characteristics between the two groups of liver cancer patients.

| Group | Sex* | | Age** (years) | BMI** (kg/m$^2$) | TNM& by stages (n) | | | Tumor diameter (cm) | Child Grade (n) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Men | Women | | | I designated time | II designated time | III designated time | | A | B |
| Study group (n=38) | 21 (55.3%) | 17 (44.7%) | 51.52±6.95 | 22.36±2.68 | 14 (36.8%) | 13 (34.2%) | 11 (29%) | 5.16±1.49 | 29 (76.3%) | 9 (23.7%) |
| Control group (n=38) | 20 (52.6%) | 18 (47.4%) | 52.36±8.32 | 22.63±3.01 | 14 (36.8%) | 15 (39.5%) | 9 (23.7%) | 5.09±1.53 | 27 (71%) | 11 (29%) |
| $t/x^2$ | 0.818 | | 0.769 | 0.185 | | 0.267 | | 0.486 | 1.32 | |
| $p$ | 0.500 | | 0.436 | 0.498 | | 0.782 | | 0.512 | 0.329 | |

*Frequency :n (%) , ** Mean± (SD). &TNM [classifies cancers by the size and extent of the primary tumor (T), involvement of regional lymph nodes (N), and the presence or absence of distant metastases (M)].

**Table 2**
Perioperative indicators of the two groups of liver cancer patients.

| Group | Sample number | Time of surgery (min)** | The rate of hepatic venous injury (%)& | Intraoperative blood loss volume (mL)** | Margin distance (cm)** | Drainage tube extubation time (d)** | Anal exhaust time (d)** |
|---|---|---|---|---|---|---|---|
| Study group | 38 | 103.59±19.12 | 2(5.26) | 183.38±29.71 | 2.97±1.15 | 5.93±1.28 | 3.74±1.03 |
| Control group | 38 | 98.59±20.16 | 10 (14.28) | 233.56±24.28 | 3.21±0.84 | 6.13±1.65 | 4.06±1.38 |
| $t/x^2$ | | 1.425 | 8.725 | 13.125 | 0.541 | 1.683 | 1.532 |
| p* | | 0.163 | 0.013 | <0.01 | 0.423 | 0.113 | 0.136 |

***p t-test,** ** Mean± (SD), &Frequency: n(%).

**Indexes of liver function**

The examination of liver function indicators before and after surgery in the two groups of liver cancer patients revealed that the mean blood albumin level in the study group before surgery was 39.38±2.19 g/L, while in the control group was 39.44±2.17 g/L, showing no significant difference. However, the mean blood albumin level in the study group after surgery was 64.41±2.91 g/L, compared to 52.91±2.69 g/L in the control group, indicating a significant difference in albumin levels between the two groups after surgery ($p=0.032$). The mean alanine transaminase level in the study group before surgery was 39.61±5.42 U/L, and in the control group, it was 39.64±5.49 U/L, with no significant difference observed. However, the mean alanine transaminase level in the study group after surgery was 10.85±2.36 U/L, while in the control group, it was 15.16±2.42 U/L, demonstrating a significant difference in the mean alanine transaminase levels after surgery between the two groups ($p=0.037$).

The mean preoperative aspartate aminotransferase (AST) levels in the study group of patients were 42.95±3.51 U/L, while in the control group, it was 43.13±3.57 U/L, showing there was no statistically significant difference observed in the preoperative AST levels between the two groups. On the other hand, the postoperative mean AST levels in the study group were 28.47±2.92 U/L, whereas, in the control group, it was 34.94±2.35 U/L. These results indicated a significant difference in the postoperative AST levels between the study and control groups ($p=0.041$). No significant difference was observed in the preoperative total bilirubin levels between the control group (20.44±2.66 μmol/L) and the study group (20.43±2.64 μmol/L). However, the mean total bilirubin level in the study group after surgery was 4.38±1.43 μmol/L, while in the control group, it was 7.34±2.17 μmol/L. These findings demonstrated a significant difference in the postoperative total bilirubin levels between the two groups ($p=0.031$). The relevant data are presented in Table 3.

**Comparison of immune factor indicators**

The investigation of immune factor indices before and after surgery in the two groups of patients with liver cancer revealed that the mean concentration of interleukin-6 (IL-6) in the study group prior to surgery was 92.83±12.59 pg/mL, while in the control group, it was 92.89±12.68 pg/mL, showing no statistically significant difference. However, the mean IL-6 concentration in the study group after surgery was 101.28±15.28 pg/mL, whereas, in the control group, it was 124.49±14.68 pg/mL, demonstrating a significant difference in IL-6 levels between the two groups after surgery ($p=0.023$).

Regarding tumor necrosis factor-alpha (TNFα), the mean concentration in the study group before surgery was 12.06±1.29 ng/mL, while in the control group was 15.68±2.41 ng/mL, with no significant difference observed. However, the mean TNFα concentration in the study group after surgery was 12.09±1.32 ng/mL, whereas, in the control group, it was 19.82±2.39 ng/mL, indicating a significant difference in the mean TNFα levels between the two groups after surgery ($p=0.037$).

The preoperative levels of $CD3^+$ (cluster of differentiation 3), $CD4^+$ (cluster of differentiation 4), and NK (Natural killer cells) did not show a significant difference between the study group and the control group. However, the postoperative percentage of $CD3^+$ in the study group was 56.28±7.79%, whereas, in the control group, it was 50.22±4.63%. The postoperative percentage of $CD4^+$ in the study group was 27.13±5.38%, while in the control group was 20.51±4.29%. Additionally, the postoperative level of NK in the study group was 10.33±1.19 pg/mL, and in the control group was 8.29±1.12 pg/mL. These differences in $CD3^+$, $CD4^+$, and NK levels after surgery were statistically significant between the two groups ($p<0.05$). The relevant data are presented in Table 4.

**Table 3**
The preoperative and postoperative liver function indicators in the two groups of liver cancer patients.

| set | ALB (g/L)** | | ALT (U/L)** | | AST (U/L)** | | TBIL (μmol/L)** | |
|---|---|---|---|---|---|---|---|---|
| | Preoperative | Postoperative | Preoperative | Postoperative | Preoperative | Postoperative | Preoperative | Postoperative |
| Study Group | 39.38±2.19 | 64.41±2.91 | 39.61±5.42 | 10.85±2.36 | 42.95±3.51 | 28.47±2.92 | 20.43±2.64 | 4.38±1.43 |
| Control Group | 39.44±2.17 | 52.91±2.69 | 39.64±5.49 | 15.16±2.42 | 43.13±3.57 | 34.94±2.35 | 20.44±2.66 | 7.34±2.17 |
| *t* | 0.956 | 2.239 | 0.853 | 2.204 | 0.933 | 2.228 | 0.821 | 2.245 |
| *p** | 0.425 | 0.032 | 0.328 | 0.037 | 0.379 | 0.041 | 0.455 | 0.031 |

*P-Value t-test, ** Mean±SD.

ALB: albumin, ALT: alanine amino transferase, AST: aspartate amino transferase, TBIL: total bilirrubin.

**Table 4**
Preoperative and postoperative immune factor indicators in the two groups of liver cancer patients.

| Group | IL-6 ( pg/mL)** | | TNF-α ( ng/mL)** | | CD3+ (%)** | | CD4+ (%)** | | NK (pg/mL)** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Preoperative | Postoperative | Preoperative | Postoperative | Preoperative | Postoperative | Preoperative | Postoperative | Preoperative | Postoperative |
| Study Group | 92.83±12.59 | 101.28±15.28 | 12.06±1.29 | 12.09±1.32 | 61.19±5.81 | 56.28±7.79 | 35.19±3.32 | 27.13±5.38 | 13.31±1.49 | 10.33±1.19 |
| Control Group | 92.89±12.68 | 124.49±14.68 | 15.68±2.41 | 19.82±2.39 | 62.39±4.91 | 50.22±4.63 | 34.25±3.17 | 20.51±4.29 | 13.29±1.61 | 8.29±1.12 |
| *t* | 0.826 | 9.265 | 0.756 | 7.531 | 0.930 | 4.283 | 1.242 | 5.58 | 0.813 | 4.361 |
| *p** | 0.425 | 0.023 | 0.328 | 0.046 | 0.375 | <0.01 | 0.219 | <0.01 | 0.465 | 0.019 |

*p-value t-test, ** Mean±SD.

**Postoperative complications in both sets**

The analysis of surgical complications among the two groups of patients revealed notable findings (Table 5). Only one patient (2.63%) experienced infection in the study group, while another patient (2.63%) developed pleural effusion following the operation. Conversely, within the control group, complications were comparatively higher. Specifically, three patients (7.89%) encountered postoperative infection, two patients (5.26%) suffered from postoperative hemorrhage, three patients (7.89%) experienced bile leak, and one patient (2.63%) developed pleural effusion. These contrasting complication rates indicate a statistically significant difference between the two groups (p=0.022).

**Quality of life score**

There were no significant differences when comparing the postoperative KPS standard scores between the two groups, $p>0.05$ (Table 6).

**Postoperative survival and recurrence rates**

The comparison of survival and recurrence rates in the two groups of patients is shown in Table 7. The analysis of survival rates among the two patient groups yielded significant statistical differences (p=0.033). In the study group, the survival rate was remarkably high, with 37 patients (97.4%) surviving during the first and second follow-up periods. Only one patient died in the period. As the study progressed to the third follow-up, 35 patients (92.1%) remained alive, while three patients succumbed to their condition. In comparison, the control group exhibited slightly lower survival rates, with 36 patients (94.7%) surviving the initial follow-up and 35 patients (92.1%) in the second follow-up. However, by the third follow-up, the number of surviving patients decreased to 28 (73.68%).

The study group showcased favorable outcomes regarding disease recurrence, as no recurrences were observed during the

**Table 5**
Contrast of the incidence of postoperative complications in the two groups.

| Group | Sample number | Infections | Postoperative hemorrhage | Bile leak | Pleural effusion |
|---|---|---|---|---|---|
| Study Group | 38 | 1 (2.63%) | 0 | 0 | 1 (2.63%) |
| Control Group | 38 | 3 (7.89%) | 2 (5.26%) | 3(7.89%) | 1(2.63%) |
| $x^2$ | | | 5.208 | | |
| $p$* | | | 0.022 | | |

*p-value Chi-square ($\chi^2$ tests).

**Table 6**
Comparison of the quality of life in the two groups.

| Group | Sample number | KPS grade | |
|---|---|---|---|
| | | Preoperative** | Postoperative** |
| Study Group | 38 | 60.52 ± 12.88 | 69.03 ± 14.02 |
| Control Group | 38 | 60.46 ± 12.78 | 68.92 ± 12.43 |
| $t$ | | 2.366 | 1.563 |
| $p$* | | 0.652 | 0.312 |

*p-value t-test, ** Mean±SD.

**Table 7**
Comparison of survival and recurrence rates in the two groups of patients.

| Group | Sample number | Survival rate n (%) | | | Recurrence rate n (%) | | |
|---|---|---|---|---|---|---|---|
| | | T1 | T2 | T3 | T1 | T2 | T3 |
| Study Group | 38 | 37 (97.4) | 37 (97.4) | 35 (92.1) | 0 (0.0) | 1 (2.6) | 2 (5.3) |
| Control Group | 38 | 36 (94.7%) | 35 (92.1) | 28 (73.68) | 1 (2.6) | 2 (5.3) | 7 (8.16) |
| $x^2$ | | | 4.57 | | | 5.029 | |
| $p$* | | | 0.033 | | | 0.025 | |

*p-value Chi-square ($\chi^2$ tests).

first follow-up. However, during the second follow-up, a marginal recurrence rate of one patient (2.6%) was identified, which increased slightly to two patients (5.3%) during the third follow-up. In contrast, the control group exhibited higher recurrence rates, with one patient (2.6%) experiencing a recurrence during the first follow-up, followed by two patients (5.3%) during the second follow-up, and a more significant number of seven patients (8.16%) during the third follow-up. These contrasting patterns in recurrence rates between the study and control groups were statistically significant ($p=0.025$). Over time, the control group exhibited lower survival rates than the study group. Conversely, the disease recurrence rate in the control group was higher than in the study group. These disparities in survival rates and disease recurrence between the two groups were statistically significant ($p<0.05$).

## DISCUSSION

Liver cancer is one of the most common malignant tumors in China. One of the main options for liver cancer treatment is surgery[10]. With the development of technology, laparoscopic hepatectomy has become widely used in clinical practice, and many studies have proved that this surgical technique proceeds with less significant trauma, shorter recovery time, and a better prognosis [11]. However, the limited field of laparoscopy and the complex vascular and bile duct systems in the liver have brought many difficulties to laparoscopic liver resection, such as how to reduce liver vascular damage, avoid tumor residues, and reduce the postoperative recurrence rate and mortality, which have always been significant in liver surgery[12]. In order to preserve more normal liver tissue, the pursuit of the concept of an accurate liver resection has gradually become an objective to accomplish [13]. In surgery, the LUS probe can reach deeper lesions, allowing more comprehensive liver information to be presented to the operator. Because of the physical characteristics of ultrasound, it can effectively avoid the interference of irrelevant factors. Furthermore, it can show the tumor size and depth in the liver, reduce the number of tumor contacts and extrusion, allow for complete tumor removal, avoid residual tumors, and reduce the postoperative recurrence rate [14,23,24].

Fu *et al.* [21] found that under the guidance of LUS, the hepatic vein can be located accurately, which could avoid damage and reduce the risk of postoperative bleeding. Following the results of that study, it was found that intraoperative blood loss and hepatic vein injury rates during peri-surgery were lower than those in the conventional surgery group. However, other perioperative indicators (operative time, drainage tube extubation time, anal exhaust time, etc.) were not significatively different, indicating that the addition of ultrasound assistance during the operation would not prolong the operation time, which was in contrast with Lubner *et al.* [25].

The Allaire *et al.* [23] study found that the resection of liver tumors retained sufficient residual liver volume to ensure the sufficient compensatory capacity of postoperative liver function, which is also the key to enhancing the clinical prognosis. However, in this study, the liver function standard in the study group was notoriously higher than in the control group. The reasons may be attributable to the guidance of ultrasound. The tumor and tumor liver vein branches were cut down, achieving the purpose of accurate resection, effective partition lesions of blood flow, and reducing the remaining liver affected by blood flow reperfusion, thus reducing the damage to liver function and retaining more liver tissue with normal function.

In evaluating immune function indicators in this study, the immune indicators of the study group were higher than that of the control group after seven days, indicating that the precise resection resulted in less loss of immune function for sufferers, and the postoperative recovery was faster. Joliat *et al.* [26] and Tayar *et al.* [27] confirmed in their study that laparoscopic hepatectomy under LUS caused less tissue damage than conventional laparoscopic hepatectomy, producing less intraoperative bleeding, less postoperative stress response and a relatively mild degree of immunosuppression in postoperative patients. The mechanism may be that after the damage to the body, immune cells will synthesize and secrete IL-6 and TNF-α factors to regulate the related stress conditions. Increasing IL-6 and TNF- α levels will aggravate the body's inflammatory response and reduce the human body's immune capacity. CD3+ and CD4+ are indicators of the reactive T cell levels; the lower the levels, the more severely compromised immune capacity. NK cells are also essential cells involved in the immune response, together with $CD3^+$ and $CD4^+$ T-lymphocytes, and similarly, the lower the levels, the worse the decline in the immune function. By comparing the study and the control groups, the study group's IL-6 and TNF α concentrations were lower than in the control. $CD3^+$, $CD4^+$, and NK cells were higher than those in the control group, indicating that laparoscopic precision liver resection results in less immune damage [28,29].

Some studies have shown that the immune function has a particular relationship with postoperative complications, and the less the postoperative immune function damage, the lower the incidence of postoperative complications [30,31]. In this study, the rate of postoperative complications in the study group was lower than that in the control, and this result also reflects this relationship, which is consistent with the results of Shazly's *et al.* [32] studies. Comparing the postoperative morbidity and survival rate of both groups, they were higher in the control group, possibly because the precise liver resection accomplished a complete resection of liver tumors and avoided the occurrence of tumor residues[33]. The higher indicators of postoperative liver function show that the study group can retain more normal liver tissue, which is more beneficial for the patient's postoperative rehabilitation [34], consistent with the above scholars' research results.

In conclusion, the modified laparoscopic precision liver resection can effectively reduce the amount of intraoperative bleeding, reduce the impairment of liver and immune functions, reduce the incidence of complications, and reduce the postoperative recurrence rate of liver cancer, which shows that it is worth generalizing the use of this technique in clinical practice. Although this study has obtained relatively important results, it still needs to be improved to use these research conclusions as the gold standard. For example, only 76 patients with liver cancer were included in this study, and the research results will inevitably be biased, so the sample size should be expanded for further demonstration.

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## Conflict of competence

The authors declare no conflict of interest.

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## ORCID of the authors

- Yansong Xu: 0000-0002-1915-8014
- Lin Shen: 0000-0003-4192-2493

## Contribution of authors

In the present study, both authors made equal contributions and collaborated closely throughout the research process.

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