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ORIGINAL RESEARCH

Impact of Middle Hepatic Vein Resection During Hemihepatectomy on Surgical Outcomes and Long-Term Prognosis in Hepatocellular Carcinoma: A Retrospective Study

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Purpose: This study aimed to evaluate the impact of middle hepatic vein (MHV) resection during hemihepatectomy on short-term surgical outcomes and long-term prognosis in patients with hepatocellular carcinoma (HCC).

Patients and Methods: Patients with HCC at Barcelona Clinic Liver Cancer (BCLC) stages 0-B who underwent hemihepatectomy between January 2016 and December 2022 were retrospectively screened. They were categorized into the MHV-preserved and MHV-resected groups. Intraoperative parameters, postoperative complications, liver function, overall survival (OS), and recurrence-free survival (RFS) were compared. Cox regression analyses were used to identified independent risk factors for OS and RFS.

Results: A total of 137 patients were included, of whom 107 (78.1%) had MHV preserved and 30 (21.9%) had MHV resected. Compared with MHV preservation, MHV resection was associated with a longer operative time (329.9 ± 108.0 vs 291.4 ± 88.9 min, $P = 0.048$), greater intraoperative blood loss (1025.0 [400.0–2075.0] vs 500.0 [300.0–800.0] mL, $P = 0.002$), and a higher need for intraoperative blood transfusion (43.3% vs 24.3%, $P = 0.041$). Postoperative serum ALT and AST levels on days 3 and 5 were significantly higher in the MHV-resected group (all $P < 0.05$). However, postoperative hospital stay, complication rates, and other liver function parameters (ALB, TBIL, DBIL, PT, INR) did not differ significantly between the two groups. No significant differences were found in OS or RFS (all $P > 0.05$).

Conclusion: MHV resection during hemihepatectomy increases operative time, blood loss, and postoperative liver enzyme levels, but does not significantly impact long-term survival in patients with HCC.

Keywords: liver cancer, liver function, liver resection, hepatic vein, survival

Introduction

Hepatocellular carcinoma (HCC) is the sixth most common cancer and the third leading cause of cancer-related death worldwide.[1,2] Notably, approximately half of all global HCC cases and deaths occur in China.[3–5] Hemihepatectomy is a standard anatomic resection for HCC involving either the left or right hepatic lobe.[6–8] It is typically performed along the plane of the middle hepatic vein (MHV), with the main trunk of MHV preserved in the remnant liver.[9,10] However, in some cases, the main trunk of the MHV must be resected due to tumor invasion, compression, or close proximity to the vein, which makes its preservation technically difficult.[11,12] In addition, intraoperative factors such as anatomical

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variation, poor exposure of the MHV, or unexpected vascular injury may also lead to inadvertent MHV damage during hemihepatectomy.[13,14]

Under physiological conditions, the MHV drains approximately 50% of the venous blood from the right anterior lobe of the liver, and about 75% from the left medial lobe of the liver.[15] Resection of the MHV may lead to significant venous congestion and ischemia in the corresponding hepatic lobe depending on the type of hepatectomy, thereby aggravating the injury associated with loss of liver parenchyma.[16] Several earlier studies have investigated the impact of the MHV resection during hemihepatectomy on intraoperative safety parameters, postoperative complications, liver function, and remnant liver regeneration.[17–19] However, more than half of the patients in these studies had non-HCC diseases, including metastatic liver tumors, cholangiocarcinoma, and benign hepatic lesions like hemangiomas.[17–19] Considering that liver function is particularly fragile in HCC patients with underlying chronic liver disease,[20–22] surgeons should be concerned about the impact of MHV resection beyond technical curiosity in these patients. Furthermore, little is known on the influence of the MHV resection during hemihepatectomy on long-term prognosis of HCC patients.

Given that HCC and its pathological background differ substantially from the aforementioned malignant and benign hepatic tumors,[23–27] this retrospective study investigated the safety of the MHV resection during hemihepatectomy and its impacts on short-term postoperative outcomes and long-term survival of HCC patients.

Materials and Methods

Patients

This study was approved by the Ethics Committee of the Second Affiliated Hospital of Kunming Medical University (approval no. PJ-SCIENCE-2025-47), and informed consent was waived due to its retrospective design. Data were anonymized and kept confidential. The study was conducted in accordance with the *Declaration of Helsinki*.[28–31] Patients with newly diagnosed HCC at Barcelona Clinic Liver Cancer (BCLC) stages 0-B, who underwent hemihepatectomy at the Second Affiliated Hospital of Kunming Medical University between January 2016 and December 2022, were retrospectively screened. Exclusion criteria included: R1 or R2 resections; preoperative transcatheter arterial chemoembolization (TACE), transcatheter arterial embolization (TAE), transcatheter arterial infusion (TAI), hepatic artery infusion chemotherapy (HAIC), radiotherapy, or systemic treatments, which may cause tumor shrinkage, alter the relationship between the tumor and adjacent MHV, or induce tumor necrosis, thereby increasing surgical difficulty;[32–35] concurrent diagnoses of other malignancies; other life-threatening diseases; or incomplete clinical or survival data.

Surgical Technique

The hemihepatectomy for individual HCC patients was routinely performed at our center, as previously described.[36] The liver was mobilized, and anaesthesia was maintained with central venous pressure between 0–5 cmH_2O during liver transection.[37] The Pringle maneuver was routinely applied to control bleeding during liver transection.[38] Energy-based devices were used at surgeon's discretion. The corresponding biliary ducts and vessels were divided and controlled using stapling devices or non-absorbable sutures. The transection plane was drawn along the border of the MHV if the tumors were located more than 1 mm from the MHV.[17] In contrast, when the tumor was located within 1 mm of the MHV, the MHV was considered to be involved in the resected liver.[17] In addition, intraoperative factors such as anatomical variation, poor exposure of the MHV, or unexpected vascular injury might also lead to inadvertent MHV damage during hemihepatectomy.[13,14] Patients with high risk of recurrence received 2–3 rounds of postoperative TACE according to China Liver Cancer Guidelines for the Diagnosis and Treatment of Hepatocellular Carcinoma.[39–41]

Grouping

MHV resection was defined as removal of the main trunk of the middle hepatic vein (MHV) starting from its root (Figure 1).[17] Patients were divided into the MHV-preserved and MHV-resected groups according to surgical records and postoperative three-phase contrast-enhanced liver CT or MRI.

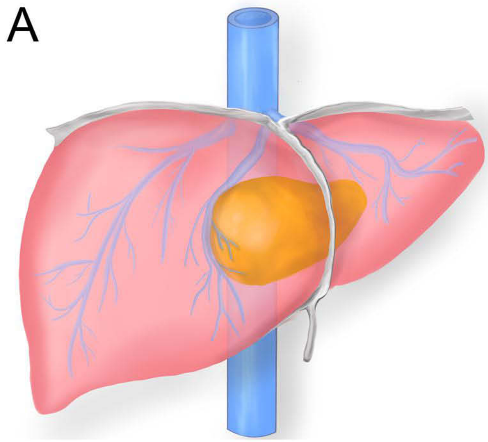

Figure 1 Diagram of middle hepatic vein resection, using left hemihepatectomy as an example. (**A**) preoperative liver and (**B**) postoperative liver.

Data Collection

The demographic and clinical data of individual patients were collected from the medical record system of our center. These data included age, stratified into ≤ 60 and > 60 years old;[42] sex;[43] hemoglobin (HGB);[44] hepatitis B and/or C virus infection, screened as positive for hepatitis B surface antigen and hepatitis C virus antibody, respectively;[45] serum levels of alanine aminotransferase (ALT); aspartate aminotransferase (AST);[46] albumin-bilirubin (ALBI) grade, classified as grades 1, 2, and 3;[47] prothrombin time (PT);[48] international normalized ratio (INR);[49] serum AFP, categorized as ≤ 400 ng/mL or > 400 ng/mL;[50,51] and preoperative imaging parameters, including liver cirrhosis, BCLC stage, and tumor location, classified as either the left or right lobe of the liver.[52,53] Blood levels of HBG, serum ALT, AST, albumin (ALB), total bilirubin (TBIL), PT, and INR were assessed in all the patients on postoperative days (PODs) 1, 3, and 5.

Intraoperative safety parameters included operative time, blood loss, and blood transfusion. Postoperative hospital stay and postoperative complications were assessed in all patients. Complications were classified according to the Clavien-Dindo classification of surgical complications.[54] Post hepatectomy liver failure was defined based on the criteria established by the International Study Group of Liver Surgery.[55]

Follow-Up

Patients were followed up every 1–2 months for the first 6 months after discharge, every 3–4 months thereafter until 2 years post-operation, and every 5–6 months after 2 years post-operation. The final follow-up is scheduled for December 2024. Patients received a detailed consultation, physical examination, liver function tests, tumor marker tests, chest X-ray or CT, and at least one abdominal imaging, including liver ultrasound, triphasic liver CT, or MRI at each follow-up visit.[56,57] Imaging evidence of HCC recurrence based on these tests was considered as recurrence.[58,59] Patients with recurrent HCC received liver transplantation, repeat hepatectomy, radio-frequency ablation, TACE, HAIC, systemic treatment, or best supportive care as appropriate.[47,60–62] Recurrence-free survival (RFS) was calculated from the date of hepatectomy to the date of recurrence or death.[63,64] Overall survival (OS) was measured from the date of hepatectomy to the date of death from any cause.[63,64]

Statistical Analysis

Statistical analysis was performed using SPSS 26.0 (SPSS, Chicago IL, USA). Quantitative variables were expressed as mean ± standard deviation or median (interquartile range, IQR), while qualitative variables were expressed as number (percentage). Inter-group differences were compared using Student's t-tests, Mann–Whitney *U*-tests, or χ^2-tests as appropriate. Survival curves were generated using the Kaplan-Meier method and compared with the Log rank tests. Potential risk factors for OS and RFS were analyzed using univariable Cox regression analysis. Factors with $P < 0.05$ from univariable Cox regression analysis were included in the multivariable Cox regression analysis, where independent risk factors were determined using the backward elimination method. A two-tailed *P-value of*< 0.05 was considered statistical significance.

Results

Baseline Characteristics of Patients

A total of 198 patients with HCC underwent radical hemihepatectomy at the Second Affiliated Hospital of Kunming Medical University between January 2016 and December 2022. Of them, 61 were excluded from the final analysis for the following reasons (Figure 2): R1 or R2 resection (n = 17), preoperative TACE or TAE (n = 12), incomplete clinical data (n = 12), missing survival data (n = 9), additional malignancies (n = 8), or other life-threatening diseases (n = 3). Data from the remaining 137 patients were analyzed, and their demographic and clinical characteristics are shown in Table 1.

The majority of patients were < 60 years old (74.5%), male (86.1%), positive for hepatitis B and/or C virus infection (101, 73.7%), and liver cirrhosis (88, 64.2%). Ninety-nine patients (72.3%) had serum AFP levels ≤ 400 ng/mL, 94 patients (68.6%) had HCC stages at BCLC stages 0-A, 43 patients (31.4%) were at stage B, Seventy-three patients (53.3%) had HCC in the left lobe of the liver, while 64 patients (46.7%) had HCC in the right lobe. The MHV was preserved in 107 patients (78.1%) and was resected in 30 patients (21.9%). There were no significant differences in these demographic and clinical characteristics between the two groups (all $P > 0.05$). The median follow-up period was 61.2 months, during which, 77 patients (56.2%) suffered from HCC recurrence, and 57 patients (41.6%) died.

Intraoperative Safety Parameters and Postoperative Complications

Compared with the MHV-preserved group, the operative time in patients who underwent MHV resection was significantly longer ($P = 0.048$; Table 2). The amount of intraoperative blood loss was also significantly greater in the MHV-resected group than in the MHV-preserved group ($P = 0.002$). In addition, the proportion of patients requiring intraoperative blood transfusion was significantly higher in the MHV-resected group ($P = 0.041$). However, there were no significant differences between the two groups in the postoperative hospital stay, or in the incidence and severity of common postoperative complications of hemihepatectomy, including fever, pleural effusion, ascites, and posthepatectomy liver failure (Table 3).

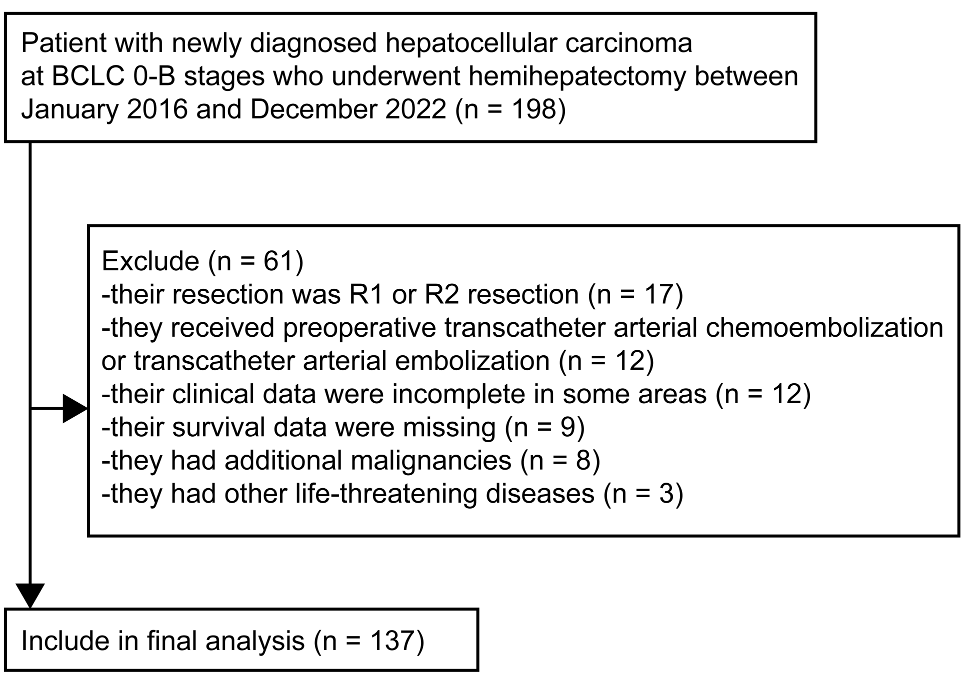

Figure 2 The flowchart for selecting patients.

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Table 1 The Demographics and Clinical Characteristics of 137 Patients Who Underwent Hemihepatectomy

Characteristic	Total	MHV Preserved (n = 107)	MHV Resected (n = 30)	P value
Age				0.753
<60	102 (74.5%)	79 (73.8%)	23 (76.7%)	
≥60	35 (25.5%)	28 (26.2%)	7 (23.3%)	
Sex				0.272
Male	118 (86.1%)	94 (87.9%)	24 (80.0%)	
Female	19 (13.9%)	13 (12.1%)	6 (20.0%)	
HGB	150.0 (138.0, 162.0)	149.0 (136.5, 159.8)	155.0 (139.3, 164.3)	0.343
HBV and/or HCV infection				0.956
Yes	101 (73.7%)	79 (73.8%)	22 (73.3%)	
No	36 (26.3%)	28 (26.2%)	8 (26.7%)	
ALT (U/L)	40.0 (26.0, 60.0)	38.0 (24.0, 60.0)	43.0 (32.3, 55.3)	0.479
AST (U/L)	42.0 (29.0, 62.0)	42.0 (28.0, 63.5)	44.0 (32.8, 60.5)	0.689
ALBI grade				0.797
1	84 (61.3%)	65 (60.7%)	19 (63.3%)	
2	53 (38.7%)	42 (39.3%)	11 (36.7%)	
PT	13.0 (11.9, 13.7)	13.1 (12.0, 13.7)	12.3 (11.7, 13.5)	0.181
INR	1.1 (1.0, 1.1)	1.1 (1.0, 1.1)	1.0 (1.0, 1.1)	0.486
AFP (ng/mL)				0.090
≤400	99 (72.3%)	80 (74.8%)	19 (63.3%)	
>400	38 (27.7%)	27 (25.2%)	11 (36.7%)	
Cirrhosis				0.456
Yes	88 (64.2%)	67 (62.6%)	21 (70.0%)	
No	49 (35.8%)	40 (37.4%)	9 (30.0%)	
BCLC				0.835
0-A	94 (68.6%)	73 (68.2%)	21 (70.0%)	
B	43 (31.4%)	34 (31.8%)	9 (30.0%)	
Location of the tumor				0.683
Left lobe of liver	73 (53.3%)	15 (20.5%)	58 (79.5%)	
Right lobe of liver	64 (46.7%)	15 (23.4%)	49 (76.6%)	

Abbreviations: AFP, alpha fetoprotein; ALBI, albumin and total bilirubin; ALT, alanine aminotransferase; AST, aspartate aminotransferase; BCLC, Barcelona Clinic Liver Cancer; HBV and/or HCV, hepatitis B virus and/or hepatitis C virus; HGB, hemoglobin; INR, international normalized ratio; MHV, middle hepatic vein; PT, prothrombin time.

Table 2 Intraoperative Safety Indicators

	MHV Preserved (n = 107)	MHV Resected (n = 30)	P value
Operative time (min)	291.4 ± 88.9	329.9 ± 108.0	0.048
Blood loss (mL)	500.0 (300.0, 800.0)	1025.0 (400.0, 2075.0)	0.002
Patients with transfusion (%)	26 (24.3%)	13 (43.3%)	0.041

Abbreviation: MHV, middle hepatic vein.

Postoperative Changes in Laboratory Data

Laboratory analyses showed that HGB levels on POD 1 were significantly higher in the MHV-preserved group than in the MHV-resected group (P = 0.017; Table 4). However, no significant differences in the median HGB levels were observed between the two groups on POD3 and POD5 (P = 0.116 and P = 0.130, respectively). Serum ALT levels on POD1 were similarly high in both groups (P = 0.415), whereas those on POD3 and POD5 were significantly higher in the MHV-resected group than those in the MHV-preserved group (P = 0.019 and P = 0.018, respectively). Likewise, serum AST levels on POD1 were comparably high between the two groups (P = 0.488), but on POD3 and POD5 they were significantly higher in the MHV-resected group (P = 0.037 and P = 0.025, respectively). There were no significant differences between the two groups in serum ALB, TBIL, DBIL, PT, or INR levels on POD1, 3, and 5.

Table 3 Postoperative Hospital Stay and Complications

	MHV Preserved (n = 107)	MHV Resected (n = 30)	P value
Postoperative hospital stay (day)	12.0 (10.0, 16.0)	13.5 (9.0, 19.0)	0.398
Fever (%)	55 (51.4%)	17 (56.7%)	0.610
Pleural effusion (%)	61 (57.0%)	19 (63.3%)	0.535
Pleural effusion ≥ III grade (%)	10 (9.3%)	6 (20%)	0.108
Ascites (%)	56 (52.6%)	18 (60.0%)	0.457
Ascites ≥ III grade (%)	8 (7.5%)	4 (13.4%)	0.316
Postoperative liver failure (%)	26 (24.3%)	7 (23.3%)	0.913

Abbreviation: MHV, middle hepatic vein.

Impact of MHV Resection on OS and RFS

The median OS was greater than 60.0 months in the MHV-preserved group, and 44.1 months in the MHV-resected group (HR = 1.182, 95% CI: 0.629–2.221, *P* = 0.587; Figure 3A). The 1-, 3-, and 5-year OS rates were 89.7%, 62.8%, and 60.2% in the MHV-preserved group, and 86.7%, 58.7%, and 48.4% in the MHV-resected group, respectively.

The median RFS was 16.8 months in the MHV-preserved group and 8.8 months in the MHV-resected group (HR = 0.689, 95% CI: 0.392–1.211, *P* = 0.148; Figure 3B). The 1-, 3-, and 5-year RFS were 53.2%, 36.2%, and 36.2% in the MHV-preserved group, and 43.5%, 25.4%, and 25.4% in the MHV-resected group, respectively.

Cox Regression Analysis of OS in HCC Patients Undergoing Hemihepatectomy

In the Cox regression analysis, MHV resection was not associated with OS (Table 5). Higher ALBI grade (HR = 2.240, 95% CI: 1.326–3.785, *P* = 0.003), elevated serum AFP level (HR = 2.113, 95% CI: 1.237–3.611, *P* = 0.006) and advanced BCLC stage (HR = 3.356, 95% CI: 1.983–5.679, *P* = 0.001) were identified as independent risk factors for poorer OS in HCC patients undergoing hemihepatectomy.

Cox Regression Analysis of RFS in HCC Patients Undergoing Hemihepatectomy

In the Cox regression analysis, MHV resection was not associated with RFS (Table 6). Elevated serum AFP level (HR = 2.903, 95% CI: 1.798–4.690, *P* = 0.001) and advanced BCLC stage (HR = 2.384, 95% CI: 1.494–3.804, *P* = 0.001) were identified as independent risk factors for poorer RFS in HCC patients undergoing hemihepatectomy.

Discussion

The MHV is a crucial drainage vein for segments 4, 5, and 8 of the liver. Although several earlier studies have preliminarily explored the impact of the MHV resection during hemihepatectomy on intraoperative safety indicators, postoperative complications, liver function, and remnant liver regeneration,[17–19] more than half of the patients had non-HCC diseases. Moreover, there is no report on the effect of the MHV resection on the long-term prognosis of HCC patients. Therefore, the study investigated the impact of MHV resection on intraoperative safety parameters, post-operative complications, liver function, and long-term prognosis of HCC patients following hemihepatectomy.

First, we found that MHV resection was associated with longer operative time, greater intraoperative blood loss and a higher need for transfusion during hemihepatectomy. This finding was further supported by the significantly higher HGB levels on POD1 in the MHV-preserved group compared to the MHV-resected group. Inoue et al also reported that MHV resection significantly prolongs operative time but does not increase blood loss during hemihepatectomy,[17] whereas Morioka et al found that MHV resection has no significant impact on either operative time or blood loss.[18] The difference in the impact of MHV resection on operative time may be explained by differences in tumor proximity to the MHV, as MHV resection in our study and that of Inoue et al involved tumors located within 1 mm of the MHV, whereas in Morioka et al, tumors within 1 cm were included. This closer tumor–vein relationship implies greater technical complexity during resection, which requires more operative time and increases the risk of massive bleeding and air embolism. Notably, MHV resection during hemihepatectomy for HCC did not increase the incidence or severity of

Table 4 Laboratory Characteristics After Hemihepatectomy

	MHV Preserved (n = 107)	MHV Resected (n = 30)	P value
HGB (g/L)			
HGB on POD1	118.0 (107.0, 129.5)	107.0 (96.0, 122.0)	0.017
HGB on POD3	116.0 (101.5, 126.0)	109.0 (100.3, 118.8)	0.116
HGB on POD5	114.0 (103.0, 124.0)	105.0 (95.5, 117.5)	0.130
ALT (U/L)			
ALT on POD1	155.0 (102.0, 254.0)	225.0 (110.0, 416.0)	0.415
ALT on POD3	130.0 (87.5, 230.5)	193.0 (120.0, 289.0)	0.019
ALT on POD5	74.0 (53.0, 112.0)	96.0 (68.5, 139.5)	0.018
AST (U/L)			
AST on POD1	190.0 (132.5, 293.8)	263.0 (128.5, 529.0)	0.488
AST on POD3	96.0 (63.3, 173.0)	98.0 (79.0, 250.0)	0.037
AST on POD5	42.0 (31.8, 58.0)	57.0 (31.0, 106.0)	0.025
ALB (g/L)			
ALB on POD1	32.7 (29.2, 36.8)	32.8 (31.4, 35.5)	0.787
ALB on POD3	35.6 (32.4, 38.4)	34.1 (31.3, 37.9)	0.290
ALB on POD5	35.7 (33.4, 38.8)	35.0 (31.5, 39.6)	0.689
TBIL (umol/L)			
TBIL on POD1	33.7 (22.5, 55.4)	38.1 (22.4, 51.9)	0.855
TBIL on POD3	29.2 (21.5, 45.4)	29.2 (24.5, 39.5)	0.780
TBIL on POD5	24.3 (18.4, 37.2)	28.1 (18.6, 33.3)	0.697
DBIL (umol/L)			
DBIL on POD1	14.0 (9.3, 19.2)	15.7 (10.9, 21.3)	0.578
DBIL on POD3	14.1 (11.4, 19.7)	14.9 (11.5, 19.6)	0.700
DBIL on POD5	13.4 (9.4, 18.8)	15.5 (8.1, 20.0)	0.830
PT (S)			
PT on POD1	16.4 (15.4, 19.0)	17.4 (16.4, 18.9)	0.335
PT on POD3	15.9 (14.6, 17.5)	16.4 (15.5, 17.7)	0.189
PT on POD5	14.8 (13.7, 15.9)	14.6 (13.9, 16.2)	0.983
INR			
INR on POD1	1.4 (1.3, 1.6)	1.4 (1.4, 1.6)	0.440
INR on POD3	1.4 (1.2, 1.5)	1.4 (1.3, 1.5)	0.190
INR on POD5	1.2 (1.2, 1.4)	1.3 (1.2, 1.3)	0.618

Abbreviations: ALB, albumin; ALT, alanine aminotransferase; AST, aspartate aminotransferase; DBIL, direct bilirubin; HGB, hemoglobin; INR, international normalized ratio; MHV, middle hepatic vein; POD, postoperative day; PT, prothrombin time; TBIL, total bilirubin.

common postoperative complications, nor did it prolong the postoperative hospital stay, consistent with previous observations.[17–19]

Second, during the postoperative recovery phase, we found that serum ALT and AST levels on POD3 and POD5 were significantly higher in the MHV-resected group compared to the MHV-preserved group, although these levels were similarly high on POD1. These findings suggest that MHV preservation may promote faster recovery in the postoperative phase for HCC patients undergoing hemihepatectomy. Mechanistically, MHV resection may significantly increase in portal pressure as venous flow in the remnant liver is redirected, leading to sinusoidal endothelial damage and reduce liver regeneration.[17,65] However, an

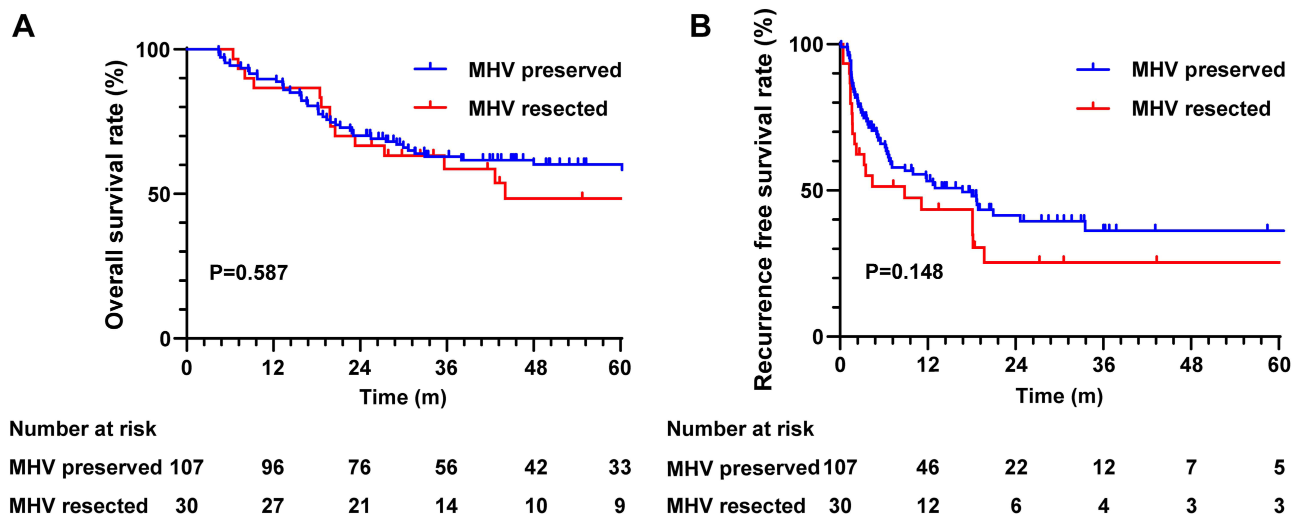

Figure 3 Survival curves of patients undergoing hemihepatectomy with MHV preservation or MHV resection. (**A**) overall survival and (**B**) recurrence-free survival.
Abbreviation: MHV, middle hepatic vein.

earlier study did not observe significant difference in serum aminotransferase levels between the MHV-preserved and resected groups.[19] This discrepancy may be due to the fact that the majority of patients in the earlier study suffered from colorectal cancer liver metastasis whose liver reserve function was likely better than that of HCC patient in our study.[66–68] Notably, MHV resection during hemihepatectomy for HCC did not significantly affect ALB, TBIL, PT and INR levels after operation, which are key indicators of liver reserve function.[69–71]

Third, we found that MHV resection did not influence long-term HCC recurrence and patient survival. The impact of MHV resection may be mitigated in the long term probably through venous drainage reallocation and/or venous collateralization.[19] Venous drainage reallocation can enhance hepatic venous flow in the remnant hepatic veins, while venous collateralization can redirect portal venous flow from areas without drainage to those with intact drainage through the intrahepatic portal vein.[19] These potential mechanisms were supported by an earlier study,[72] in which 28 patients undergoing surgical ligation of the MHV during right lobe living-donor liver transplantation, and 27 of them developed different degrees of congestion in the right anterior lobe of the liver, but most cases of congestion resolved within 2–6 months after operation.

Clinically, this evidence underscores that MHV resection should not be considered a contraindication to curative hemihepatectomy when required for tumor clearance. Instead, emphasis should be placed on preoperative assessment of venous anatomy and future liver remnant function to ensure sufficient outflow and parenchymal reserve. When MHV resection is unavoidable, adequate blood preparation, intraoperative strategies to reduce congestion and ischemia, and

Table 5 Cox Regression Analysis of OS in HCC Patients Undergoing Hemihepatectomy

Variables	Univariate Analysis			Multivariate Analysis		
	P	HR	95% CI	P	HR	95% CI
Age (≥60 year vs <60 year)	0.936	1.024	0.568–1.847			
Sex (female vs male)	0.284	0.630	0.270–1.468			
HBV and/or HCV infection (yes vs no)	0.790	0.924	0.518–1.648			
ALBI grade (2 vs 1)	0.007	2.045	1.214–3.443	0.003	2.240	1.326–3.785
AFP (> 400 ng/m vs ≤ 400 ng/m)	0.007	2.082	1.220–3.554	0.006	2.113	1.237–3.611
Cirrhosis (yes vs no)	0.128	1.567	0.879–2.793			
BCLC stage (B vs 0-A)	0.001	3.108	1.854–5.236	0.001	3.356	1.983–5.679
Location of the tumor (right lobe of liver vs left lobe of liver)	0.324	1.299	0.772–2.186			
MHV (preserved vs resected)	0.587	0.846	0.463–1.547			

Abbreviations: AFP, alpha fetoprotein; ALBI, albumin and total bilirubin; BCLC, Barcelona Clinic Liver Cancer; HBV, hepatitis B virus; HCV, hepatitis C virus; MHV, middle hepatic vein.

Table 6 Cox Regression Analysis of RFS in HCC Patients Undergoing Hemihepatectomy

Variables	Univariate Analysis			Multivariate Analysis		
	P	HR	95% CI	P	HR	95% CI
Age (≥60 year vs <60 year)	0.356	0.771	0.444–1.339			
Sex (female vs male)	0.152	0.566	0.260–1.234			
HBV and/or HCV infection (yes vs no)	0.052	1.710	0.994–2.939			
ALBI grade (2 vs 1)	0.224	1.332	0.840–2.113			
AFP (> 400 ng/m vs ≤ 400 ng/m)	0.001	2.870	1.786–4.612	0.001	2.903	1.798–4.690
Cirrhosis (yes vs no)	0.079	1.580	0.948–2.636			
BCLC stage (B vs 0-A)	0.001	2.169	1.375–3.424	0.001	2.384	1.494–3.804
Location of the tumor (right lobe of liver vs left lobe of liver)	0.193	1.352	0.859–2.130			
MHV (preserved vs resected)	0.151	0.687	0.412–1.146			

Abbreviations: AFP, alpha fetoprotein; ALBI, albumin and total bilirubin; BCLC, Barcelona Clinic Liver Cancer; HBV, hepatitis B virus; HCV, hepatitis C virus; MHV, middle hepatic vein.

postoperative hepatoprotective therapy may facilitate safer recovery and better preservation of liver function. These insights may aid surgical planning and perioperative management in complex HCC cases involving the MHV.

This study has some limitations. First, it was retrospective in nature. Second, it was conducted at a single-center. Third, the sample size of the study was relatively small, particularly in the MHV-resected group. Therefore, future prospective, multi-center studies with larger sample sizes are required.

Conclusion

MHV resection during hemihepatectomy increases operative time, blood loss, and postoperative liver enzyme levels, but does not significantly impact long-term survival in patients with HCC. MHV preservation should be attempted when feasible, but for patients who require planned or incidental MHV resection, careful preoperative blood preparation, meticulous intraoperative hemostatic control, and postoperative hepatoprotective management are recommended to minimize transient hepatic injury and optimize recovery. This evidence provides important guidance for surgical decision-making and perioperative management in HCC patients with tumors involving the MHV.

Data Sharing Statement

The datasets used and/or analyzed during the current study are available from the corresponding author Yang Ke upon a reasonable request.

Ethics Approval and Informed Consent

This study was approved by the Committee of Ethics at the Second Affiliated Hospital, Kunming Medical University (PJ-SCIENCE-2025-47). Written informed consent was waived by the Committee of Ethics as its retrospective collection. Data were anonymized and kept confidential. The study was conducted in accordance with the *Declaration of Helsinki.*

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Disclosure

All authors declare that they have no competing interests in this work.

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