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Oncological relevance of major hepatectomy with inferior vena cava resection for intrahepatic cholangiocarcinoma

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Abstract

Background

This study aimed to investigate the short- and long-term outcomes of patients undergoing major hepatectomy (MH) with inferior vena cava (IVC) resection for intrahepatic cholangiocarcinoma (ICC).

Methods

Data from all patients who underwent MH for ICC with or without IVC resection between 2010 and 2018 were analysed retrospectively. Postoperative outcomes, overall survival (OS), and recurrence-free survival (RFS) were compared in the whole population. A propensity score matching (PSM) analysis and an inverse probability weighting analysis (IPW) were performed to assess the influence of IVC resection on short- and long-term outcomes.

Results

Among the 78 patients who underwent MH, 20 had IVC resection (IVC patients). Overall, the mortality and severe complication rate were 8% and 20%, respectively. IVC patients required more extended hepatectomies ($p=0.001$) and had increased rates of transfusions ($p=0.001$), however they did not experience increased postoperative morbidity, even after PSM. The 1-, 3- and 5-years OS and DFS were 78%, 45%, and 32% and 48%, 20%, and 16%, respectively. IVC was not associated with decreased OS ($p=0.52$) and/or RFS ($p=0.85$), even after IPW.

Discussion

MH with IVC resection for ICC seems to provide acceptable short- and long-term results in a selected population of patients.

Keywords: major hepatectomy, inferior vena cava, intrahepatic cholangiocarcinoma

Introduction

Intrahepatic cholangiocarcinoma (ICC) is the second most common cancer-related hepatic resection for primary liver tumours after hepatocellular carcinoma and account for 10–15% of all liver resections.¹ The incidence of ICC has risen in recent decades.^{2,3} In contrast to extrahepatic cholangiocarcinoma, which presents with jaundice and biliary obstruction, ICC is typically detected incidentally or discovered during the evaluation of abnormal liver enzyme levels.² Approximately 20–40% of patients with ICC are eligible for surgical resection³. While operated ICC patients had a 5-year survival rate ranging from 20 to 35%, liver resection remains the sole curative treatment^{4,5}. High carbohydrate antigen 19-9 (CA 19-9) serum levels, lymph node metastasis, tumour size and margin status are the main prognostic predictors for patients with resectable ICC.^{4,6,7}

Tumour with invasion of the inferior vena cava (IVC) have been reported in 2% of the ICC patients.⁸ Due to the infiltrative nature of ICC, tumours which are developed in proximity to the IVC are likely to invade the venous wall and require extensive vascular reconstruction to ensure R0 resection. Thus, these patients with such locally advanced tumours are usually considered ineligible for surgery regarding the increased perioperative risk and the expected poor prognosis⁹. Since 1980, when the first major hepatectomy (MH) with IVC resection was performed,¹⁰ the advances in HPB surgery, liver transplantation and anaesthesiological techniques have increased the proportions of patients eligible for major vascular resection during liver surgery.⁸⁻¹¹

In the field of ICC, long term results of liver surgery with IVC resection are not well reported and there are probably some selected patients with controlled diseases who could benefit from this surgery. The present study aimed to investigate short- and long-term outcomes of patients undergoing MH with IVC resection for ICC.

Methods

Study population

All patients who underwent MH with IVC resection for ICC (IVC Patients) were retrospectively identified among all patients who underwent MH for ICC with a curative intent at two high volume centres in Marseille, France, between 2010 and 2018. Exclusion criteria included the patients younger than 18-year-old, a diagnosis of mixed cholangiocarcinoma and hepatocellular carcinoma and palliative intent resection such as R2 resection. MH was defined as the resection of three or more contiguous liver segments, according to Couinaud's classification.¹² This study was approved by the Institutional Review Board of the centre and conformed to the ethical guidelines of the 1975 Declaration of Helsinki.

Preoperative management

All patients underwent enhanced body computed tomography (CT) scans and magnetic resonance imaging (according to the year of treatment) a month before the scheduled surgery. Dedicated hepatobiliary radiologists evaluated all radiological images together with the surgeons; vena cava resection was anticipated if any contact or stenosis was associated with the tumour on imageries. Portal vein embolization was indicated in case of an anticipated remnant liver volume on imaging \leq 30-40% of the total non-tumorous liver volume, taking into account the underlying liver status (i.e. cirrhosis according to an F3 or F4 Metavir score, steatosis, and/or chemotherapy).^{13,14} **Some patients presenting with locally advanced ICC received a neoadjuvant chemotherapy. Locally advanced ICC was defined as tumour in contact with the future liver remnant or vascular involvement initially contraindicating the resection.** Since the ABC-02 trial in 2010, gemcitabine with or without cisplatin was the most used treatment regimen.¹⁵

Surgical procedure and IVC resection

All patients were operated through a Makuuchi J-shaped incision. Hepatic transection was performed under low central venous pressure (<5 mmHg) using an ultrasonic aspirator (Cavitron Ultrasonic Surgery Aspirator, CUSA™; Valley-Lab, Boulder, CO, USA). The complex procedures were performed by surgeons (YPLT, JH, JE, OT, JRD) with experience in IVC resection. Total vascular exclusion (TVE) of the liver was performed in cases of tumours involving the hepatocaval confluence.¹⁶ The suprahepatic vena cava was controlled below the diaphragm or by using the transdiaphragmatic extrapericardial approach.¹⁷ In case of limited IVC invasion, a lateral resection was performed with direct reconstruction using a side-biting clamp (**Figure 2A Supplementary**). In case of IVC invasion (>50% of the circumference) an IVC segmental resection was performed and venous replacement was always done using a synthetic graft (20 mm diameter ring-enforced polytetrafluoroethylene [PTFE] tube grafts [Gore-Tex®; W. L. Gore & Associates Inc., Flagstaff, AZ, USA]) (**Figure 2B Supplementary**). Subphrenic and periprosthetic spaces were covered with omental interposition between the graft and the resected viscera. Antibiotics were administered to all patients. Anticoagulation therapy using intravenous heparin was performed after surgery, and warfarin therapy relay was initiated before discharge and continued indefinitely. Enhanced CT scan evaluated vascular patency during the in hospital postoperative course, then one month after surgery, and later at the same frequency as the oncological follow-up.

Study criteria

The demographic characteristics of the patients, and type of induction therapy were recorded before surgery. Data regarding the type of MH, duration of surgery, Pringle manoeuvre (minutes), total vascular exclusion, and blood transfusions were also retrieved.

Pathological data, including underlying parenchymal changes (i.e. normal, severe fibrosis F3/F4¹³, steatosis and sinusoidal occlusion syndrome¹⁸), the type of ICC (mass-forming or infiltrative), tumour size, margin status, lymph node metastases, microvascular invasion, presence of satellite nodules and perineural invasion¹⁹ and IVC wall involvement, were assessed. Positive margins (R1) were defined as evidence of tumour within 1 mm of the inked margin.

Postoperative complications were assessed within 90 postoperative days using the Dindo Clavien classification.²⁰ Severe complications were defined as complications with a Dindo Clavien classification of 3, 4, or 5. Postoperative bile leakage and post-hepatectomy liver failure (PHLF) were defined according to the ISGLS classification.^{21,22} Postoperative mortality was described as death occurring during the same hospital admission or within 90 days of hepatic resection. The duration of stay in the hospital (days) was recorded.

Follow-up

After resection, all patients were followed up every 3 months by clinical examination and CT scan for the first 2 years and every 6 months thereafter. Follow-up data were obtained at routine clinic visits, or via personal contact. Overall Survival (OS) was defined as the time from surgery to the time of death due to any cause. Recurrence-free survival (RFS) was defined as the time from surgery to relapse. Location of recurrence (remnant liver or extra hepatic) was recorded. The end of follow-up was set 31 December 2019, or at time of death.

Statistical analysis

Continuous data were expressed as median with 25-75 interquartiles and compared using the Mann–Whitney or the Kruskal–Wallis test as appropriate. Categorical data were

expressed as percentages and compared using the Pearson's Chi-square test or Fisher's exact test as appropriate.

Estimated OS, RFS survivals, and length of follow-up were estimated using Kaplan–Meier estimations and compared using log-rank Mantel-Cox test. Hazard ratios and their confidence interval were estimated using Cox regression. Postoperatively (within the first 90 days) deceased patients were excluded from the RFS analysis.

To further assess the effect of IVC resection on the short terms results following MH for ICC, a propensity score matching (PSM) analysis was performed. Propensity score was estimated with the use of a logistic regression model, with 'IVC resection' as the dependent variable and matching variables as covariates: ASA score, tumour size, presence of a neoadjuvant treatment, portal vein embolization, CA19-9 level, mass forming ICC, biliary resection, lymphadenectomy and right-sided resection. For the matching, the continuous variable "tumour size" was categorized according to the dispersion parameters (median, 25th and 75th percentile) in the whole population. The continuous variable CA 19-9 was categorized according to its normal plasmatic threshold (37 UI/mL) and a clinically relevant prognostic threshold reported for ICC patients (>300 UI/mL)²³. Matching was performed with the use of a 1:2 nearest neighbour matching without replacement according to the propensity score. Balance of matching variables was assessed using standardized mean differences.

To further assess the effect of "IVC resection" on OS and RFS according to the other clinically relevant histo-prognostic factors (weighting variables), an inverse probability weighting analysis was performed (IPW). This method relies on estimating propensity scores with a logistic regression and then converting it into weights which are the inverse predicted probability of being in each exposure (IVC resection versus no-IVC resection) given the weighting variables. These weighting variables were tumour size, mass-forming, N status,

microvascular invasion, perineural invasion, satellites nodules and negative/positive margins. Balance of weighting variables was assessed using standardized mean differences.

A p value <0.05 was considered statistically significant for all tests or indicated otherwise. All statistical analyses were performed R statistical software version 3.6.3. The packages used were *tidyverse*, *broom*, *survival*, *survminder*, *MASS*, *MatchTiT*, *Weitghtit* and *cobalt*.

Results

Study population

During the study period, 85 patients underwent MH for ICC. Seven patients were excluded (3 for missing data and 4 were lost of follow-up), and none of them underwent vascular resection. The remaining 78 patients represented the whole study population. All patients had a single tumor, which was a mass-forming ICC in 64 patients (82%). The median tumour size was 8 cm (IQR: 6 – 10). Among the 14 (18%) patients treated with neoadjuvant chemotherapy, 12 received a combination of gemcitabine with cisplatin and two patients received a combination of 5-fluorouracil, irinotecan et oxaliplatin (FOLFIRINOX).

Right-sided resection was performed in 49 (63%) patients (15 right hepatectomy, 7 right hepatectomy extended to segment I and 27 right trisectionectomy +/- segment I). In left-sided resection, 15 patients had extension to segment I and 4 patients had left trisectionectomy + segment I. Lymphadenectomy was performed in 55 (70%) patients with a median number of harvested nodes of 5 (IQR:2-12), among the N+ patients (25%) the median number of positive nodes was 2 (IQR:1-3).

The rates of mortality, severe complications, and complications were 8%, 20%, and 83%, respectively.

Overall, 20 (25%) patients underwent MH with IVC resection (IVC patients) and 58 underwent MH without IVC resection (no-IVC patients). The comparison of demographic, preoperative, intra-operative data, as well as outcomes and pathological features between IVC and no-IVC patients are detailed in **Table 1**.

Intraoperative details and outcomes of IVC patients.

After PSM, the 20 IVC patients were matched with 40 no-IVC patients. IVC patients required more extended hepatectomies (median of resected segments: 6 vs. 4; $p=0.001$) and had increased rates of transfusions (55 vs 13%; $p=0.001$) and TVE (40 vs 2%; $p=0.001$). While they tended to have an increased rate of overall morbidity (100% vs. 77%; $p=0.055$), they did not experience increased rates of severe complication ($p=1.000$), PHLF ($p=0.831$) or mortality ($p=0.989$). IVC and no-IVC patients had similar characteristics regarding tumoral pathological features. The results of comparisons of intraoperative details, outcomes and pathological analysis between IVC and no-IVC patients in the matched population are displayed in **Table 2**.

Technical insights of IVC resection

Of the 20 IVC patients, seven IVC patients underwent IVC segmental resection with reconstruction using Gore-Tex®. All these patients underwent extended hepatectomy, including 5 or 6 liver segments. The intraoperative details of these 7 cases are reported in **Table 3**. The one- and three-years OS and RFS of the seven patients with IVC replacement were 71%, 54% and 33%, 17%, respectively.

Thirteen IVC patients underwent lateral IVC resection. In 11 cases, it required lateral IVC clamping only, while in two cases, it required TVE. Only one patient required IVC reconstruction using venous graft (Allograft), while the others had IVC reconstruction using

direct running suture. The one and three-years OS and RFS of the 13 patients with IVC lateral resection were 77%, 60% and 42%, 17%, respectively.

At the final follow-up, all patients had vascular patency, none of them experienced a partial or total IVC thrombosis, and all patients received long-term therapeutic anticoagulation. In pathological analysis, eight IVC patients (40%) had actual IVC wall invasion, and three of them (37%) had parenchymal positive margins.

Long term outcomes of IVC patients

After a median follow-up of 55 months (95% IC: 51.5-58.1), 52 patients (66%) experienced recurrence; 22 isolated intra hepatic, 13 isolated extra hepatic and 17 both intra and extra hepatic, and 42 patients died due to ICC recurrence. **No significant difference between patients who received neoadjuvant chemotherapy or not was noticed (median OS 32 vs 33 months respectively (p=0.097); median RFS 14 vs 11 months respectively (p=0.64)).** The 1-, 3- and 5-years OS and DFS were 78%, 45%, and 32% and 48%, 20%, and 16%, respectively. IVC was not associated with decreased OS (p=0.52) and/or RFS (p=0.85). The OS and RFS curves of IVC and no-IVC patients are displayed in Figure 1. Among the 30 patients who achieved 3 years of follow-up, median RFS was 17 months (95%CI: 9.1 to 43.1). Twelve patients (15%) were alive at five-years of follow-up including five IVC patients (25%). Five of these five-years survivors had no recurrence (6% of actuarial five-years RFS).

After IPW according to tumour size (SMD=0.025), mass-forming (SMD=0.022), N status (SMD: 0.020, 0.014 and 0.006 for N0, N1 and Nx status, respectively), microvascular invasion (SMD=0.006), perineural invasion (SMD=0.021), satellites nodules (SMS=0.005) and negative/positive margins (SMD= 0.010), the effective sample sizes were 20 IVC patients and 39 non-IVC patients. The median follow-up was 55 months (95% IC: 41.0-59.2). IVC

resection remained not associate with either OS (HR 0.69, 95%CI: 0.36 to 1.34; p=0.277) or RFS (HR 0.88, 95%CI: 0.49 to 1.58; p=0.676).

Discussion

This study reported short- and long-term outcomes of patients who underwent MH for ICC with or without IVC resection. Regarding this homogeneous series, surgery was mainly performed for mass-forming ICC (80%), requiring major or extended hepatectomies. Among the 78 patients, twenty (25%) had vena cava involvement and underwent liver resection with segmental or lateral vena cava resection. In this study, such procedures could be performed with similar rates of lymphadenectomy and negative margins than MH without IVC resection and these rates were consistent with those reported in the literature.^{24,25} Furthermore, IVC patients did not experience an increased post-operative morbidity, even after matching, while rates of mortality and severe complication were in line with other series in the field of ICC^{8,26,27} and other types of liver tumors.^{9,28} Altogether, these findings suggest that MH with IVC resection for ICC appears feasible and can be performed by achieving satisfying oncological quality.

As illustrated in this study, such advanced procedures are technically demanding and call for an experience regarding TVE, veno-venous **bypass** and caval or hepato-caval **confluence** reconstruction. In addition, IVC exposure/reconstruction²⁹ are likely to require extended hepatectomy including segment one to facilitate the vascular reconstruction. In this study, this substantial intra-operative difficulty was reflected by the increased blood loss, operative time and transfusion rate in patients with IVC resection. Therefore, **the benefit** risk equation of such indications ought to be based on the patient's tolerance to the surgery and appropriate pre-operative evaluation/selection remains of paramount importance. In this setting, the success of these procedures requires a highly experienced multidisciplinary environment and lie on the teamwork between anaesthesiologists and surgeons. Thereby, patients should be referred to dedicated centres and these surgeries should not be performed at the discretion of small volume facility.

Provided appropriate selection and management, the oncological results of this study suggested that these IVC patients could benefit from surgery. Indeed, IVC patients did not experience substantially jeopardized survivals and a quarter of them were alive at five years of follow-up. Even after weighting according to acknowledged histo-prognostic factors, IVC patients were not associated with decreased survival. These results were in line with those reported by the recent study of Conci *et al.* As a matter of fact, few studies only have focused on assessing the prognosis of such patients and generally have associated major and minor liver resections as well as IVC and portal vein resections together^{8,26,27} (**Table 4**). Despite these encouraging outcomes, overall survival remains disappointing, mainly due to the high recurrence rates^{30,31}. Our oncological results suggest that probably other strong prognosis factors as satellite nodules³², tumour size¹⁹ or lymph node metastasis^{33,34} get the upper hand of prognosis. Hence, IVC resection can be proposed on case-by-case basis provided expert surgical and oncological care quality including an intention to achieve negative margins and appropriate lymphadenectomy.

There are several limitations in this study that are inherent to the retrospective nature and the prolonged study period. Of note, prospective surgical series are unlikely to emerge considering the scarcity of ICC patients. Moreover, the design of this study provides various adjusting methods to reduce the source of bias. First, patients who did not undergo major liver resection were not included in this study, and the whole population was homogenous. As an example, the IVC and the control group were initially comparable regarding the demographic data and tumour characteristics. Second, the propensity scores matching methods allow to match all of the IVC patients on preoperative factors mimicking a randomisation and improving the relevance of the comparison. On the other hand, the inverse probability weighting analysis allowed for adjustment of IVC resection effect on survivals regarding acknowledged and strong histo-prognostic factors. Finally, such advanced liver procedures

raised inevitably the question of transportability of the results to other centres, especially since this series emerged from two centres with substantial experience in HPB surgery. Nevertheless, the importance of the surgical environment in the management of ICC patients is clearly acknowledged regardless of the presence or absence of IVC involvement³⁵.

Major hepatectomy with IVC resection for ICC is a challenging procedure which seems to provide acceptable short- and long-term results in a selected population of patients. Such indications should be limited to expert centres able to supply an appropriate peri-operative management.

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Table 1. Comparison of perioperative characteristics and post-operative outcomes of the patients in whole population

No-IVC Patients (n=58)	IVC Patients (n=20)	p
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Demographics and preoperative data			
Male sex	27 (47)	7 (35)	0.524
Age (years) †	66 [60, 72]	63 [53, 67]	0.072‡
BMI (kg/m ²)†	25 [23, 28]	24.00 [22, 26]	0.374‡
ASA Score ≥3	9 (16)	4 (20)	0.908
CA 19-9 level (UI/mL)†	70 [23, 508]	113 [36, 646]	0.514‡
Tumour size (cm) †	8[5, 24]	9 [4,17]	0.209‡
Neoadjuvant treatment	10 (17)	4 (20)	1.000
Portal Vein Embolization	9 (15)	3 (15)	1.000
Intraoperative characteristics			
Right side resection	34 (59)	15 (75)	0.299
Number of resected segments †	4 [4, 5]	6 [4, 6]	<0.001‡
Duration of surgery (min) †	253 [176, 326]	330 [229, 384]	0.065‡
Transfusion	7 (12)	11 (55)	<0.001
TVE	2 (3)	8 (40)	<0.001
Pringle manoeuvre	39 (67)	16 (80)	0.487
Pringle duration (min)†	7 [3, 18]	14 [5, 23]	0.085‡
Portal vein resection	5 (9)	3 (15)	0.701
Biliary reconstruction	20 (35)	6 (30)	0.927
Post-operative outcomes			
Overall complication	46 (79)	19 (95)	0.064
Severe complications	12 (21)	5 (25)	0.999
Ascites	6 (10)	2 (10)	1.000
PHLF (ISGLS)	16 (28)	5 (33)	0.823
Biliary fistula	9 (15)	3 (15)	1.000
Sepsis	11 (19)	4 (20)	1.000
Haemorrhage	1 (2)	0	1.000
Reoperation	7 (12)	2 (10)	1.000
Hospital length of stay, days †	12 [12–17]	17 [13–20]	0.026‡
Death within 90 days	4 (7)	2 (10)	0.999
Pathological analysis			
Underlying liver diseases	17 (29)	4 (20)	0.605
Mass forming	47 (81)	17 (85)	0.119
Microvascular invasion	28 (48)	10 (50)	1.000
Perineural invasion	27 (47)	10 (50)	0.989
Satellites nodules	22 (38)	5 (25)	0.443
Lymphadenectomy	41 (70)	14 (70)	1.000
Lymph node status			0.989
N0	26 (45)	9 (45)	
N1	15 (26)	5 (25)	

Nx	17 (29)	6 (30)	
Negative margins	41 (71)	9 (45)	0.071

Values are the headcount expressed with percentages in parentheses unless indicated otherwise; P values are from a Pearson's chi-square test unless indicated otherwise; †values are median (i.q.r.); ‡ Mann–Whitney

BMI, body mass index; ASA, American society of anesthesiologists; CA 19-9: carbohydrate antigen 19-9; TVE: Total Vascular Exclusion; PHLF: Post-operative liver failure

Table 2. Comparison of perioperative characteristics and post-operative outcomes of the patients in the matched population

	No-IVC Patients (n=40)	IVC Patients(n=20)	
Matching variables			SMD
ASA Score ≥ 3	8(20)	4 (20)	0.001
Neoadjuvant treatment	6 (15)	4 (20)	0.050
PVE	5 (13)	3 (15)	0.025
Tumour size (cm)			
< 6	8 (20)	3 (15)	0.050
6-8	13 (32)	5 (25)	0.075
8-10	8 (20)	6 (30)	0.100
> 10	11 (28)	6 (30)	0.025
CA 19.9 serum level (UI/mL)			
< 37	11 (27)	5 (25)	0.025
37-300	12 (30)	7 (35)	0.050
> 300	17 (43)	8 (40)	0.025
Right side resection	26 (65)	15 (75)	0.100
Biliary resection	14 (35)	6 (30)	0.050
Mass forming	33 (82)	17 (85)	0.025
Lymphadenectomy	29 (73)	14 (70)	0.025
Intraoperative characteristics			p
Number of resected segments [†]	4 [4, 5]	6 [4, 6]	0.001 [‡]
Duration of surgery (min) [†]	243 [175, 319]	330 [229, 384]	0.075 [‡]
Transfusion	5 (13)	11 (55)	0.001
TVE	1(2)	8 (40)	0.001
Pringle manoeuvre	30 (75)	16 (80)	0.914
Pringle duration (min) [†]	10 [4, 18]	14 [5, 23]	0.092 [‡]
Portal vein resection	3 (8)	3 (15)	0.648
Post-operative outcomes			
Severe complications	9 (23)	5 (25)	1.000
Ascites	6 (15)	2 (10)	0.893
PHLF (ISGLS)	11 (27.5)	5 (33)	0.831
Biliary fistula	5 (13)	3 (15)	1.000
Sepsis	8 (20)	4 (20)	1.000
Reoperation	5 (13)	2 (10)	1.000
Hospital length of stay, days [†]	12 [12–17]	17 [13–20]	0.021 [‡]
Death within 90 days	4 (7)	2 (10)	0.989
Pathological analysis			
Underlying liver diseases	11 (27)	4 (20)	0.753

Microvascular invasion	20 (50)	10 (50)	1.000
Perineural invasion	21 (52)	10 (50)	1.000
Satellites nodules	17 (42)	5 (25)	0.276
Lymph node status			0.846
N0	16 (40)	9 (45)	
N1	13 (33)	5 (25)	
Nx	11 (27)	6 (30)	
Negative margins	27 (68)	9 (45)	0.165

Values are the headcount expressed with percentages in parentheses unless indicated otherwise; P values are from a Pearson's chi-square test unless indicated otherwise; †values are median (i.q.r.); ‡ Mann–Whitney

BMI, body mass index; ASA, American society of anesthesiologists; CA 19-9: carbohydrate antigen 19-9; TVE: Total Vascular Exclusion; PHLF: Post-operative liver failure

Standardized mean difference of less than 0.100 indicates very small differences; value between 0.101-0.300 indicates small differences; value between 0.301 and 0.500 indicates moderate differences; value above 0.500 indicates considerable differences.

Table 3. Intraoperative details of segmental IVC replacement

	Type of Resection	Supra hepatic IVC control	Outflow clamping	Veno venous by pass	Associated resection
Case 1	Right Trisectionectomy + Segment I	TD-EP	TVE	No	Portal and biliary
Case 2	Right Trisectionectomy + Segment I	Suprahepatic	TVE	No	Portal and biliary
Case 3	Right Trisectionectomy + Segment I	TD-EP	TVE	No	Diaphragm, Portal and biliary
Case 4	Left Trisectionectomy + Segment I	Intra pericardiac	TVE	Yes	Right hepatic vein reconstruction with vein graft
Case 5	Right Hepatectomy + Segment I	Suprahepatic	TVE	No	Diaphragm
Case 6	Right Hepatectomy + Segment I	Suprahepatic	Below hepatic vein	No	-
Case 7	Right Trisectionectomy + Segment I	Suprahepatic	TVE	No	-

TD – EP: Trans diaphragmatic – Extra-Pericardiac; **TVE:** Total Vascular Exclusion

Table 4: Results of vascular resection in patients with ICC

<i>Authors</i>	<i>Year</i>	<i>Total patients (n)</i>	<i>Study period</i>	<i>Hepatectomy %</i>	<i>Vascular resection (n)</i>	<i>Postoperative Mortality (%)</i>	<i>5 years OS rate (%)</i>
Present	2020	78	2010-2018	Major 100	IVC 20	10	IVC: 30
Conci S ²⁷	2020	270	1995-2015	Minor 38 Major 62	IVC 16 PV 15	12.5	IVC: 30.1
Reams BN ⁸	2017	1087	1990-2016	Minor 39 Major 61	IVC 21 PV 98 MVR 9	VR: 7	VR: 36
Ali SM ²⁶	2013	121	1997-2011	Major 100	IVC 9 PV 5	IVC: 11 PV: -	VR: 44

IVC : inferior vena cava resection, **PV** : portal vein resection, **MVR** : multiple vascular resections, **VR** :

vascular resection IVC+PV

Figure 1: Kaplan Meyer Survival curves for patients after MH for ICC in the whole population A: Overall Survival. B: Recurrence Free Survival

