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Comparing the closure of hepatocaval ligament using stapler or suturing in liver surgery

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ABSTRACT

Objectives: Hepatocaval ligament is localized on the posterior and lateral side of the retrohepatic Inferior Vena Cava (IVC) , above the right adrenal vein. Bleeding due to retro-hepatic cava injury could sometimes occur during the dissection and closure of hepatocaval ligament (HCL). We aim to determine closing methods of HCL in terms of cost, ease of application and safety.

Methods: The study population included 90 recipient hepatectomy patients who had cadaveric and live-donor liver transplantation at Organ Transplant Center of Acıbadem Hospital between 2017 and 2019. The patients were divided into two groups. The first group contained 40 patients who were closed with 25 mm EndoTA 30 stapler. The second group contained 50 patients who were closed by continuous double- layer suturing with 5/0 propylene.

Results: In the group closed by endovascular stapler, reinforcement suturing was performed in eight patients (20%) using 5/0 propylene suture due to mild blood leakage in the closing line. In two patients (5%), on the other hand, the staple device could not be used due to the fact that HCL was very close to the right hepatic vein and the distance between the liver and the vena cava was short. There were no perioperative and postoperative HCL-associated liver and vena cava bleeding complications in both groups. However, the cost was significantly higher in the stapler group than in the suturing group.

Conclusions: The present study is the first to compare the stapler or suturing techniques for closing HCL in the receiver hepatectomy of liver transplantation. The results indicated that the closure with suturing was at least as useful and convenient in terms of cost, ease of application and safety.

Keywords: Liver transplantation, hepatocaval ligament, hepatectomy, suture, stapler

Major hepatic resection is more complicated due to blood loss of high volumes and associated mortality and morbidity. Although bleeding could arise during liver transection and control of hilar vessels, hepatic vein and retro-hepatic vena cava injuries are the most common mortality cause of major intraoperative bleeding. Bleeding due to retro-hepatic cava injury could sometimes occur during the dissection and closure of hepatocaval ligament (HCL). During embryogenesis, inferior vena cava (IVC) is surrounded by hepatic parenchyma. At the end of embryogenesis, the parenchymal bridge connecting the right and left liver behind the IVC starts to atrophy and turns into a hepatocaval ligament [1, 2].

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In the 1950s, some liver surgeons were aware of the existence and importance of HCL, describing it as the posterior bed of the IVC , which allows control of small retrohepatic veins. This is a structure that always completely envelops Vena cava inferior and extends to its posterior [3, 4]. This ligament, which covers the retrohepatic IVC, makes it difficult to expose the hepatic veins without cutting the hepatic parenchyma. HCL is localized on the posterior and lateral side of the retrohepatic IVC, above the right adrenal vein. It partially or completely blocks the entry of right hepatic vein (RHV) into IVC. Especially with the development of liver surgery with total vascular exclusion and microsurgical techniques, surgical interest in HCL and its relationship with hepatic veins have increased in recent years. In addition to its relationships with IVC and RHV, relationships of HCL with techniques in liver surgery, especially with elective vascular exclusion, during right hemi-liver and recipient hepatectomy surgery have gained importance.

METHODS

This study was conducted retrospective and one center study. The study population included consecutively 90 recipient hepatectomy patients who had cadaveric and live-donor liver transplantation at Organ Transplant Center of Bursa Acıbadem Hospital between 2017 and 2019. Hepatocaval ligament (HCL) was dissected and closed safely during the hepatectomy in these patients (Fig. 1). Two different methods were used to close the HCL larger than 10 mm width. The patients were divided into two groups. The first group contained 40 patients who were closed with 25 mm EndoTA 30 stapler (Group I). The second group contained 50 patients who were closed by continuous double-layer suturing with 5/0 propylene (Group II). We defined morbidity and death which occurred within 90 days after surgery as postoperative complications and mortality, respectively. We also defined mild, moderate and severe estimated blood loss. Patient short-term outcomes evaluated at 30 days postoperatively. Postoperative complications were classified according to the Dindo-Clavien classification [5]. The hospital reimbursement is calculated considering all issues in a liver transplantation settings as operating time, ITU (intensive therapy unit) stay, hospital stay, etc. as fixed fee policy our hospital. Safety and applicability, cost, perioperative and postoperative estimated blood loss on the closed line were evaluated among the groups.

The study was approved by the Acıbadem University Ethical Review Board. For the present study. No informed consent was required.

Statistical Analysis

Mean, standart deviation, median, minimum, maximum value frequency and percentage were used for

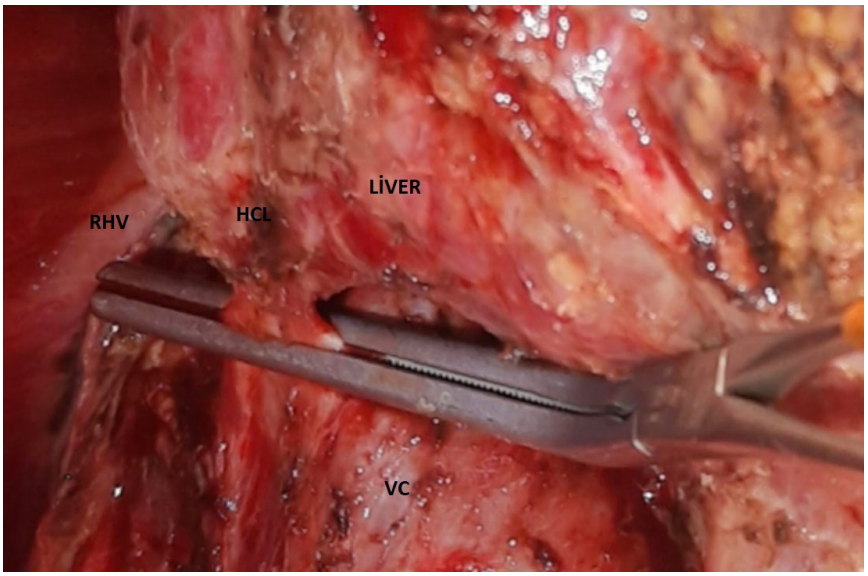

Fig. 1. Right lateral view to the liver during the dissection of the HCL, IVC and the RHV.

Tablo 1. Demographic and clinical characteristics of recipients at transplantation

	n (%)	Median (min-max)	Mean ± SD
Age (years)		57.0 (41.0-69.0)	56.9 ± 7.3
Gender			
Female	26 (26.0)		
Male	64 (64.0)		
Primary disease			
Budd-Chiari	3 (3.0)		
Alcohol-related	13 (13.0)		
HBV	33 (33.0)		
HCC	9 (9.0)		
HCV	12 (9.0)		
Kriptogenic	15 (15.0)		
NASH	4 (4.0)		
PBS	1 (1.0)		
Procedure time (s)			
Hepatectomy time (min)			
MELD score			
LT		58.0 (45.0-70.0)	57.7 ± 7.3
DDLT	21 (21.0)	240.0 (190.0-300.0)	239.9 ± 26.0
LDLT	69 (69.0)	22.0 (12.0-28.0)	21.7 ± 3.8
Perioperative blood loss			
(-)	82 (82.0)		
(+)	8 (8.0)		
Postoperative blood loss			
(+)	0 (0.0)		
(-)	100 (100.0)		
Clavien-Dindo (grade)			
I	50 (50.0)		
II	33 (33.0)		
IIIA	4 (4.0)		
IIIB	3 (3.0)		
Mortality			
(-)	88 (88.0)		
(+)	2 (2.0)		
Cost ($)		2.0 (2.0-152.0)	68.0 ± 74.2

HBV = Hepatit B Virus, HCC = Hepatocelluler carcinoma, HCV = Hepatit C virüs, NASH = Nonalcoholic Steatohepatitis, PBS = Primary biliary sclerosis, LT = Liver transplantation, DDLT = Deceased donor liver transplantation, LDLT = Living donor liver transplantation, Cost = Cost of surgery. Postoperative blood loss was determined as a complication including clavien-dindo grade IIIA and IIIb

descriptive statistics. The distribution of variables was checked with kolmogorov-simirnov test. Independent Samples t test and Mann - Whitney U test were used for the comparison of quantitative data. Chi-square test was used for the comparison of the comparison of qualitative data. SPSS 27.0 was used for statistical analyses.

RESULTS

Sixty-four percent of the hepatectomy patients were male and 26% were female. Median age was 57 years (range: 41-69 years). All patients underwent total hepatectomy shows the baseline characteristics of the 40 Group I and 50 Group II recipients. No significant differences existed between the groups in terms of recipient age, gender, model for end-stage liver disease (MELD) score and underlying cause of cirrhosis (Table 1).

Postoperative morbidity and mortality were similar in both groups. Operation time was significantly higher in the Group II than in the Group I. But hepatectomy time was similar in both groups. The LDLT rate in Group II was significantly higher than the DLDT rate Group I. In the group closed by endovascular stapler, reinforcement suturing was performed in eight patients (20%) using 5/0 propylene suture due to mild blood leakage (1-5 mL) in the closing line. In two patients (5%), on the other hand, the staple device could not be used due to the fact that HCL was very close to the right hepatic vein and the distance between the liver and the vena cava was short. Two of patients died from sepsis within one month. There were no perioperative and postoperative HCL-associated liver and vena cava moderate and severe bleeding complications in both groups. However, the cost was significantly higher in the stapler group than in the suturing group (Table 2).

DISCUSSION

Detailed anatomical knowledge of HCL and its relationship with IVC and hepatic veins is important in split liver and live donor transplantations as well as in hepatic resections. The safe dissection and closure of HCL relieves elective vascular control while maintaining the IVC flow. Makuuchi *et al*. [6] reported for the first time that RHV control was possible in 89% of cases whose HCL ligament was resected during the right hepatic resection. HCL could not be resected only in 34% of cases. During the right hepatectomy with elective vascular control, it was anatomically possible in 85% of cases HCL should be dissected in 85/77% of livers with HCL. This was challenging or impossible in 15% of cases [7]. The presence of HCL is also important during the liver bi- or tri-partitioning and in control and pediculation of hepatic veins in split liver transplantations and live donor transplantations. The dissection and ligation of HCL exposes the retrohepatic part of IVC and the terminal parts and entrances of the main hepatic veins. One study found HCL in livers of 33 patients out of 43 (77%), but it was not observed in 20% of the cases. Only 3% of the cases had parenchymatous bridge in IVC posterior.

HCL was different in all cases. The average length was 22 ± 10 mm (range: 12-35 mm), while the average width was 8 ± 5 mm (range: 3-18 mm), and its thickness was approximately 0.5-2 mm. In two cases (5%), it contained small retrohepatic veins larger than 1 mm in diameter [7]. At the same time, reports from Gadžijev *et al*. [8] that HCL was of hepatic origin and that bile ducts were found in the ligament were supported by the similar studies of Mackenzie *et al*. [9]. Rosset *et al*. [10] showed that in 25% of cases hepatocytes were present in HCL. In order to prevent an unexpected bleeding in an associated caudate vein, which exists in 69% of the cases, control of the ligament with clips or suture ligation is necessary [9]. However, during the closure of the large HCL without ligament, there could be uncontrollable bleeding if they are dislocated or do not overlap. This could be important in terms of cutting and closing the HCL near the retrohepatic cava during the cancer surgery. Details of both methods were clearly stated in our surgical records.

Therefore it is not difficult to compare the surgical outcome in using between endostapler and suturing because of the different background in the retrospective study. With the combination of advances in intra- and post-operative methods including surgical technique, the use of microsurgery and vascular closure instruments as well as advances in blood transfusion, liver surgery has been a safer and more effective procedure. The average blood loss was reported to be 848 ± 972 mL (range: 40 to 9000 mL) in a review which

Tablo 2. Operative outcomes of the matched Group I and Group II

	Group I		Group II		*p* value
	Mean ± SD/ n (%)	median	Mean ± SD/ n (%)	median	
Age (years)	56.5 ± 7.2	56.0	57.3 ± 7.4	57.5	0.636[t]
Gender					0.499[x²]
Female	13 (32.5)		13 (21.7)		
Male	27 (67.5)		37 (61.7)		
Procedure time (s)	52.5 ± 4.6	54.0	61.8 ± 5.0	62.5	**0.000[t]**
Hepatectomy time (min)	243.7 ± 27.8	244.0	236.9 ± 24.4	237.5	0.290[m]
MELD Score	22.6 ± 3.6	24.0	21.0 ± 3.8	20.0	**0.041[m]**
LT					**0.019 [x²]**
DDLT	14 (35.0))		7 (11.7)		
LDLT	26 (65.0)		43 (71.7)		
Perioperative Blood Loss					**0.001[x²]**
(-)	32 (80.0)		50 (83.3)		
(+)	8 (20.0)		0 (0.0)		
Postoperative Blood Loss					1.000[x²]
(+)	0 (0.0)		0 (0.0)		
(-)	40 (60.0)		60 (100)		
Clavien-Dindo (Grade)					0.568[x²]
I	23 (57.5)		27 (45.0)		
II	14 (35.0)		19 (31.7)		
IIIA	2 (5.0)		2 (3.3)		
IIIB	1 (2.5)		2 (3.3)		
Mortality					1.000[x²]
(-)	39	97.5%	49	81.7%	
(+)	1	2.5%	1	1.7%	
Cost ($)	150.4 ± 0.8	150	2.0 ± 0.0	2.0	**0.000[m]**

LT = Liver transplantation, DDLT = Deceased donor liver transplantation, LDLT = Living donor liver transplantation, Cost = Cost of surgery. Perioperative blood loss determined.

[t]t test /[m] Mann-whitney u test/ [x²] Chi-square test

included major liver resections performed at Memorial Sloan-Kettering cancer center between 1991 and 1997. More than 13% of the patients had blood loss of more than a quarter of their estimated blood volumes during surgery [10]. Even in a more contemporary major hepatectomy series, an average blood loss of 700 mL (range: 400-1050 mL) was observed [11]. It was reported that 30-47% of patients received allogenic blood components during major hepatectomy or within the first 24 hours [11, 12]. This is not a benign intervention. What's more, the immunomodulatory effect of blood transfusion can lead to increased infection predisposition and a decrease in cancer-free disease survival [13, 14]. Since all of the patients in the present study had cirrhosis and had different amounts of acid, there were different degrees of adhe-

sion between the liver and the diaphragm and the retrohepatic cava. Moreover, in those who are subjected to the receiver hepatectomy due to Budd-Chiari syndrome, fibrous thickening could also be observed in vena cava around HCL. In this case, the dissection, closure and cutting of HCL, an important step in the mobilization of the liver to reach hepatic veins, can often be difficult. In cases where HCL is wide and short, the increased risk of massive retrohepatic hemorrhage makes it imperative to perform this dissection and subsequent cutting and closing more carefully and meticulously. We carried out extensive hepatic mobilization through exposing the major hepatic veins before we engaged in the major hepatic resection. This procedure facilitates the control of veins in challenging cases with intraoperative bleeding and provides the necessary exposure in major hepatic resection and receiver hepatectomy. On the other hand, in order to ensure a sufficient tumor cleaning with an adequate bleeding control in tumors of central location which is close to inferior vena cava (IVC) and hepatic vein confluence, the dissection and safe closure of HCL with subsequent hepatic vein control and isolation is especially critical. In addition to the right hepatic vein, the complete exposure of the retrohepatic vena cava necessitates the splitting of vena cava ligament, which generally contains fibrous tissue but could also include liver tissue, bile ducts and small hepatic veins and which is adjacent to the right hepatic vein [7]. In addition, due to its connection with VCI, its dissection could lead to injury and breakage in VCI. Therefore, we chose to close especially the HCLs larger than 10 mm. Ramacciato *et al*. [15] proposed the use of vascular endostapler for controlling the inferior diaphragmatic vein of considerable size right adjacent to the ligament. In another study, Dudeja and Jarnagin [16] reported that they closed HCL successfully with endovascular stapler. In the present study, HCL was closed with a vascular endostapler during the receiver hepatectomy of 30 patients with underlying chronic liver disease. In eight of these patients (20%), slight blood leakage was observed on the closing line, and consequently reinforcement suturing was performed for these leaks. However, the use of endostapler was not technically possible in two patients (5%) because the HCL was short, wide or very close to the right hepatic vein. The duration of operation was extended due to additional suturing in eight patients. Dudeja and Jarnagin [16] reported that they mostly achieved successful closing of HCL with endovascular stapler. However, none of the patients who were closed with suturing technique had any leaks that would require additional control. Besides, the cost was significantly higher in the group closed with stapler. There were no bleeding or bleeding-associated complications during surgery or in the postoperative early periods in any groups. In the endovascular stapler group, the procedure time was slightly, though not significantly, longer in eight patients (20%) who needed additional suturing.

Stapler could not be used in two patients due to the anatomical and technical difficulties. In terms of cost- benefit balance, the closure with suturing was more advantageous. This method can be used as a more viable, effective and safe method for the closure of the HCLs wider than 1 cm during liver transplantation with live donors in which the receiver hepatectomy is performed as open surgery, during right hepatectomy and during tumor-related major hepatectomies. The mild perioperative bleeding seen in the stapler closure group is due to the stapler not firmly attaching to the area between the vena cava and the HCL, as the HCL was thin and short.

Limitations

Our study had limitations because it was single-centered and retrospective. The study included patients receiving hepatectomy. The division of the major hepatic veins and the HCL using devices such as 'ENDO-PATH Stapler Echelon white cartridge' has currently become the standart and routine surgical procedure at least in japan during not only laparascopic but also open surgical hepatectomy. Therewithal, the vast majority of north American Centers use a laparascopic stapler (EndoGIA 30mm for example) given its ease of use and slim profile. Although the present study had homogeneity, more prospective studies should be performed in patients with the right liver surgery with normal liver structure.

CONCLUSION

Safe and effective control of intraoperative bleeding and blood loss has been the challenging side of liver surgery. Numerous techniques have been developed to

minimize the bleeding. HCL is a common anatomical structure. Dissection of the HCL exposes the terminal extrahepatic part of RHV, and provides elective vascular control during the receiver hepatectomy surgery in the right hemi-liver and liver transplantation. In some cases where HCLs greater than 1 cm are not closed, retrohepatic hemorrhages that are difficult to control could develop. The present study is the first to compare the stapler or suturing techniques for closing HCL in the receiver hepatectomy of liver transplantation. The results indicated that the closure with suturing was at least as useful and convenient in terms of cost, ease of application and safety.

Authors' Contribution

Study Conception: UT; Study Design: İBB; Supervision: İBB, UT; Funding: N/A; Materials: İBB, UT; Data Collection and/or Processing: İBB; Statistical Analysis and/or Data Interpretation: UT; Literature Review: UT; Manuscript Preparation: İBB, UT and Critical Review: İBB.

Conflict of interest

The authors disclosed no conflict of interest during the preparation or publication of this manuscript.

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