DOI: 10.31276/VJSTE.2023.0109

Hepatectomy using a bipolar vessel-sealing scalpel with Takasaki's Glissonean pedicle transection method in hepatocellular carcinoma: A single-centre short-term outcome

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Received 22 November 2023; revised 5 February 2024; accepted 11 April 2024

Abstract:

Purpose: The study aimed to evaluate the results of a bipolar vessel-sealing (LigaSure™) scalpel application for parenchymal resection combined with Glissonean pedicle transection using the Takasaki method in the treatment of hepatocellular carcinoma (HCC). Patients and methods: A prospective descriptive study was performed on 67 patients from August 2021 to April 2022 (6 months). Results: The mean age was 56±12 years (14-76). Durations for right and left Glisson pedicle control were 3.44±1.65 and 4.58±4.05 minutes, respectively, while those for anterior and posterior pedicle control were 6.12±4.05 and 6.08±3.79 minutes, respectively. The mean blood loss during pedicle control was 21.88±14.02 ml; there were no complications during pedicle transection. The average time of parenchymal resection was 33.96±12.32 minutes, the average intraoperative blood loss was 211.79±125.41 ml, and there was one patient requiring intraoperative blood transfusion. All 3 cases of intraoperative complications were hepatic vein laceration. The overall rate of postoperative complications was 2.98%, of which postoperative liver failure accounted for 1.49%. The average number of days in hospital postoperatively was 8 days, the shortest was 6 days and the longest was 15 days. The rate of in-hospital mortality was 0%. Conclusion: The bipolar vessel-sealing (LigaSure™) scalpel application for parenchymal resection combined with Glissonean pedicle transection using the Takasaki method in the treatment of HCC is safe and effective.

Keywords: **bipolar vessel-sealing scalpel, hepatocellular carcinoma, Takasaki method.**

Classification number: **3.2**

1. Introduction

Hepatocellular carcinoma is the most common primary liver cancer, ranking top in incidence and mortality rate worldwide [1]. Hepatectomy remains the most basic curative treatment for HCC. However, hepatectomy is also associated with many complications including bleeding, acute liver failure, and bile leakage, which may adversely affect survival and mortality. First described by K. Takasaki (1998) [2], Takasaki pedicle transection allowed a precise anatomical method of liver resection based on the ischemic line on the liver surface, as well as minimal intraoperative blood loss. This method is now widely applied around the world, especially in Vietnam and East Asia. Intraoperative bleeding is common in liver parenchymal resection, raising questions about the optimal bleeding-control cutting device. Among current instruments like the LigaSure™, Harmonic Scalpel™, the Cavitron Ultrasonic Surgical Aspirator® (CUSA), and staplers, which allow the least blood loss and are the most cost-effective, etc., is still a matter of controversy.

Many studies confirm the role of the LigaSure™ scalpel in reducing operative time, morbidity rate of bile leakage, and bleeding compared with other means. On the other hand, many studies have shown LigaSure™'s comparable results over other devices (Harmonic Scalpel™, CUSA scalpel, Aquamantys®, or Stapler) in parenchymal resection

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and decrease in intraoperative blood loss [3-5]. However, there are currently no studies evaluating the efficacy of the combination of Takasaki's pedicle transection method with the LigaSure™ scalpel for parenchymal resection. Our study aimed to find out whether this combination would enhance the effectiveness of hepatectomy for HCC, by illustrating highlights pictures as well as short-term outcomes.

2. Materials and methods

These case series have been reported in line with the process guideline at the end of the methods section (and included in the references section) [6] and were registered in accordance with the Declaration of Helsinki. The study was conducted on 67 patients undergoing liver resection with the Takasaki technique using a LigaSure™ scalpel at Bach

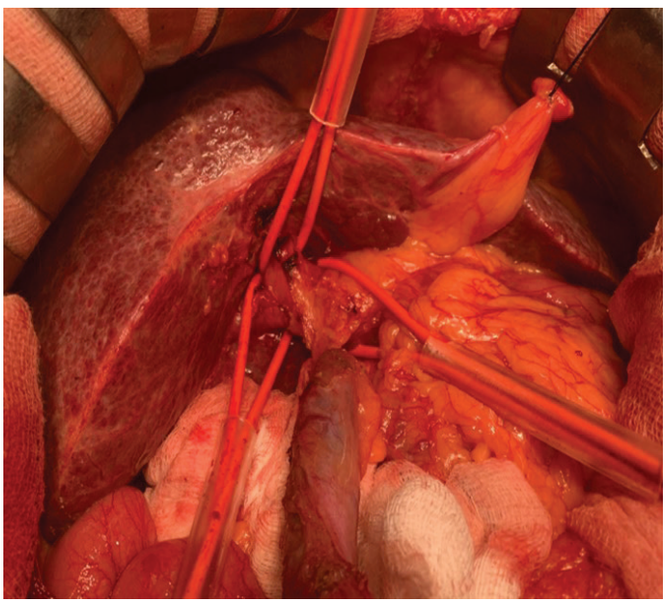

Fig. 1. Pedicle control with Takasaki's method.

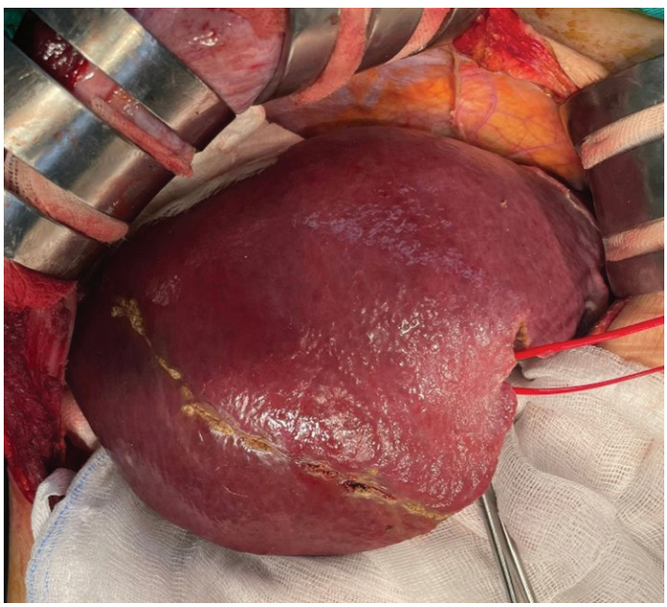

Fig. 2. Posterior hepatectomy transection plan marked based on ischaemic line on liver surface after posterior pedicle control.

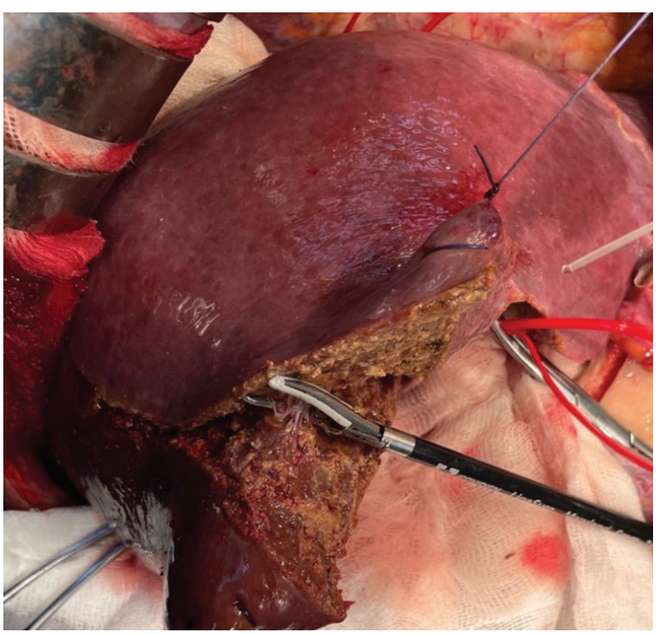

Fig. 3. Segment 6 hepatic vein cut and sealed with vessel sealing LigaSure™ scalpel.

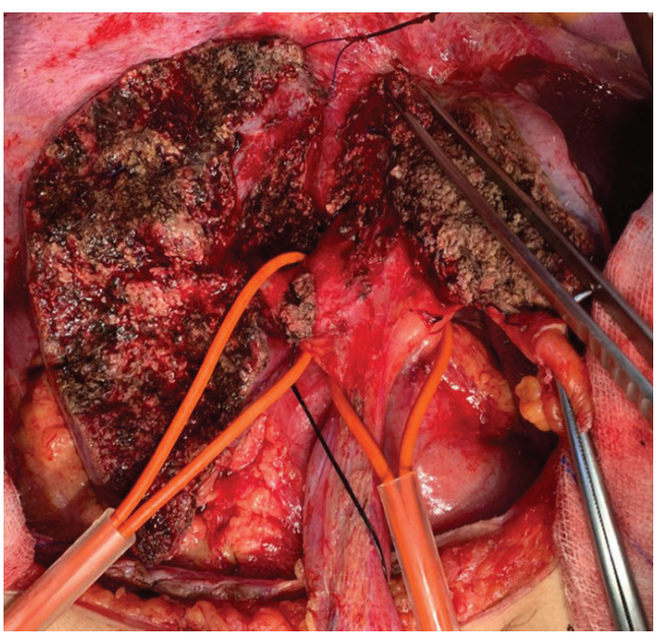

Fig. 4. Liver resection margin after performing liver parenchymal resection with Ligasure™ scalpel (Central hepatectomy).

Mai Hospital from August 2021 to April 2022 (6 months). The preoperative diagnosis was histologically confirmed as HCC, and staging was classified based on the Barcelona Clinic Liver Cancer Staging and Treatment Strategy in 2022 [7] and the Guideline for Diagnosis and Treatment of HCC of the Ministry of Health of Vietnam in 2020.

Inclusion criteria include: Patients are selected for surgery according to the Barcelona Clinic Liver Cancer 2022 criteria and Guideline for Diagnosis and Treatment of HCC of the Ministry of Health of Vietnam in 2020; Postoperative pathology confirmed HCC; and hepatectomy was performed with Takasaki pedicle transection method with a LigaSure™ scalpel.

Exclusion criteria include: secondary liver tumour resected, simultaneous extrahepatic biliary tract resection and biliary-enteric anastomosis, and hepatectomy with intraoperative radiofrequency ablation for other liver lesions.

Research method: Descriptive study.

3. Surgical protocol

Stage 1: Abdominal exploration:

- Open the abdomen with the right J line or the middle white line above and below the umbilicus.
- Evaluate the liver tumour and its invasion into the surrounding organs. Assess peritoneal metastasis.

Stage 2: Cholecystectomy, lower gallbladder bed and liver hilum.

Stage 3: Mobilise the liver depending on the type of surgery to be performed.

Stage 4: Pedicle control with Takasaki's method (Fig. 1). Selective clamping of the hepatic pedicle, defining the resection border of the liver parenchyma according to the ischemic line on the liver surface (Fig. 2).

Stage 5: Liver parenchymal resection with LigaSure™ scalpel (Fig. 3). Determine the transection plane based on ischemia line on liver surface. Cut the liver parenchyma with Kelly forceps and LigaSure™ scalpel. Dissect blood vessels less than 5 mm with LigaSure™ scalpel. Larger vessels are sutured with 3.0 nonabsorbable monofilament suture.

Stage 6: Cut the corresponding Glisson pedicle and hepatic vein with a stapler or suture with a nonabsorbable, monofilament suture.

Stage 7: Apply haemostats, check for bile leaks, place drainage at the transection plane, close abdomen (Fig. 4).

4. Data analysis

Collected data included: demographical characteristics such as age, gender, past medical history of liver disease, and other comorbidities, clinical and subclinical characteristics of tumour location, size, number, and liver function classified according to Child-Pugh classification; Technical characteristics and developments in surgery such as pedicle control time, parenchymal resection time, blood loss, and intraoperative complications; Postoperative complications, for example, liver failure, bile leak, bleeding, ascites, and mortality; and Length of hospital stay after surgery.

Using the criteria of the International Study Group on Liver Surgery, a biliary leak was defined as bile detected in abdominal drainage or incisional separation. Similarly, post-hepatectomy liver failure was defined as exogenous coagulation prothrombin less than 50% and elevation of total bilirubin above 50 µmol/l from the 5th postoperative day.

Data were analysed using SPSS 24.0. All qualitative data were presented in percentage. Quantitative data were presented as mean and standard deviation (SD).

5. Results

Sixty-seven patients (male/female ratio is 4:1) underwent liver resection with Takasaki's technique using the LigaSure™ scalpel. The mean age was 56±12 years. 73% had a history of hepatitis B. All patients were classified as Child-Pugh A, with platelet counts above 100,000 per mm^3 and normal coagulation status. The median values of preoperative tumour markers - AFP, AFP-L3, PIVKA II - were 8.2 ng/ml, 6.5%, and 138.5 mAU/ml, respectively.

The morphologies of liver resection in our study group varied, from segmentectomy to multi-segmentectomy, encompassing segments 1 to 8. Minor hepatectomy accounted for the majority (68.7%) (Table 1). Right posterior segmentectomy contributed the highest proportion (26.9%), followed by left hepatectomy (19.4%).

Table 1. Morphology of liver resection.

Morphology		Number of patients (n)	Percentage (%)
Major hepatectomy (21)	Right hepatectomy	5	7.5
	Left hepatectomy	13	19.4
	Central hepatectomy	3	4.5
Minor hepatectomy (46)	Left sectionectomy	2	3.0
	Anterior sectionectomy	11	16.4
	Posterior sectionectomy	18	26.9
	Bisegmentectomy	8	11.9
	Segmentectomy	7	10.4

Table 2. Pedicle control and parenchymal resection time.

Pedicle control time			
Pedicle	***Mean time (minutes)***	***Min (minutes)***	***Max (minutes)***
Right	3.44±1.65	2	10
Left	4.58±4.05	1	15
Right anterior	6.12±4.05	1	20
Right posterior	6.08±3.79	1	20
Parenchymal resection time [(n) Mean time±SD] (minutes)			
Mean parenchymal resection time		(67) 33.96±12.32	
Major hepatectomy		(38) 36.05±13.26	
Minor hepatectomy		(29) 31.21±10.58	
Mean operative time		(67) 130.79±29.62	
Major hepatectomy		(38) 131.53±28.93	
Minor hepatectomy		(29) 129.83±30.98	

The mean time for right and left pedicle control was 3.44±1.65 minutes and 4.58±4.05 minutes, respectively, for anterior and posterior segment pedicles was 6.12±4.05 minutes and 6.08±3.79 minutes, respectively. The mean time of overall parenchymal resection was 33.96±12.32 minutes. The mean time for major hepatectomy was 36.05±13.26 minutes; minor hepatectomy was 31.21±10.58 minutes (Table 2). Three patients (4.48%) experienced complications during parenchymal resection, all of which were hepatic vein lacerations, well managed intraoperatively. The mean operative time was 130.79±29.62 minutes, with 131.53±28.93 minutes for major hepatectomy and 129.83±30.98 minutes for minor hepatectomy. After surgery, all our patients were able to sit up and start feeding on the first day post-surgery.

The results from Table 3 showed that the mean blood loss during pedicle control was 21.88±14.02 ml, the overall mean intraoperative blood loss was 211.79±125.41 ml, and only one patient required an intraoperative blood transfusion.

In Table 4, the postoperative overall complication rate was 2.98%: One case of postoperative liver failure and one case of wound infection. Both cases were graded Clavien-Dindo II without the need for surgical intervention.

Table 3. Intraoperative blood loss.

	Mean±SD (ml)
Blood loss during pedicle control	21.88±14.02
Intraoperative blood loss	211.79±125.41
Major hepatectomy	202.63±133.21
Minor hepatectomy	164.14±107.22

Table 4. Postoperative complications.

Postoperative morbidities	Cases	Percentage (%)	Clavien-Dindo
Bleeding	0	0	
Biliary leakage	0	0	
Ascites	0	0	
Wound infection	1	1.49	II
Liver failure	1	1.49	II
Total	2	2.98	

6. Discussion

In liver resection surgery, most authors acknowledge that three factors need to be controlled to limit blood loss and reduce intra- and postoperative complications: (1) inflow control, i.e., control of blood entering the liver; (2) outflow control, i.e., control of the hepatic veins and central venous pressure; (3) control of blood vessels during parenchymal resection.

6.1. Takasaki's technique of pedicle control

Takasaki's technique of pedicle control is one of the most common inflow control methods being applied. This technique not only determines a precise transection plan based on the ischaemic line on the liver surface but also facilitates anatomical liver resection. First introduced in 1986 in a case of right hepatectomy, Takasaki's technique is now well adopted worldwide in both laparoscopic and open surgery [2]. The technique was defined as successful when the surgeon could well expose the entire pedicle and place the control device precisely on the corresponding pedicle (left, right anterior, right posterior, and even segmental pedicles).

Our study reported a rate of successful pedicle control of 100% of the cases. The mean time to control the right and left pedicles was 3.44±1.65 and 4.58±4.05 minutes, respectively; for anterior or posterior segmental pedicles it was 6.12±4.05 minutes. Blood loss during pedicle control is negligible. Assessing the amount of blood loss during this technique is also very difficult and relatively precise due to minimal blood loss. Dissection into the correct anatomical layer between the Glisson capsule and the Laennec capsule will not cause bleeding.

Our research results were consistent with domestic and international studies: K. Takasaki (2007) [8]'s data on more than 2,000 cases of HCC report a pedicle control success rate of 100% and no adverse events. In Vietnam, a study by V.Q. Vu, et al. (2022) [9] on 106 patients showed a success rate of 100% and a complication rate of 1.9% due to right portal vein laceration. Portal vein laceration is the most common complication during pedicle dissection, possibly due to portal hypertension in cirrhotic patients. According to K. Takasaki (2007) [8], during pedicle control, it is advisable to completely control the pedicle first to reduce bleeding from small vessels in the hilar area, especially in cirrhotic patients with portal hypertension. This approach not only helps limit bleeding but also maintain a clean surgical field, and therefore, avoiding further complications in pedicle dissection.

6.2. The role of LigaSure™ scalpel

First introduced in 1998, LigaSure™ by Covidien (Medtronic, USA) utilises a combination of pressure and bipolar radiofrequency energy to induce vascular sealing up to 7 mm in diameter. The application of the LigaSure™ system in liver parenchymal resection offers significant benefits, including reduced blood loss, blood transfusion rates, operating time, and shortened postoperative hospital stays in established surgeries, which has been confirmed in many studies [3, 10-12].

During hepatectomy, after the liver parenchyma was crushed with a Kelly forceps, the blood vessels and small biliary tracts were left exposed. Instead of traditional suturing, we resected the connective tissue and small blood vessels (less than 5 mm) (mainly small liver veins) with a LigaSure™ scalpel. This technique not only reduced bleeding due to vessel laceration during suture binding but also shortened parenchymal resection time. LigaSure™ has also been proven to reduce the risk of biliary leakage due to its ability to seal small biliary tracts [3]. When performing the Takasaki pedicle control technique before parenchymal resection, the transection plan between anatomical units was clearly defined to minimise the risk of large blood vessel injury. The most important vascular component commonly encountered is the hepatic vein, which can be effectively sealed with LigaSure™. Therefore, the combination of pedicle control technique along with the application of LigaSure™ scalpel makes liver resection safe and effective.

According to our study, the mean time for parenchymal resection was 33.96±12.32 minutes, and the mean intraoperative blood loss was 211.79±125.41 ml, which was comparable with other studies [3, 13]. Several studies worldwide have shown no difference in the duration of liver parenchymal resection between LigaSure™ scalpel

and other devices, even in laparoscopic liver resection [11]. A recent systematic review with data from 22 randomised controlled trials involving 2360 patients has shown that bipolar cautery techniques (with LigaSure™ scalpel as a typical example) provide the best outcomes in reducing blood loss and shortening operating time [14]. In our study, three cases encountered complications during parenchymal resection; all the morbidities were hepatic vein lacerations during parenchymal crushing with Kelly forceps in cases with tumours near dilated blood vessels due to cirrhotic portal hypertension. These complications were not related to the use of LigaSure™. In our opinion, liver cirrhosis or a tumour adjacent to large blood vessels were prognostic factors for difficult parenchymal resection.

The LigaSure™ scalpel seals tissue and creates adhesion. Therefore, if applied to parenchymal resection, liver tissue would become adhesive, which prevents the scalpel tip from moving flexibly and increases the risk of vessel injury. Consequently, we recommend using Kelly forceps, instead of LigaSure™, to break the parenchyma and before using the LigaSure™ scalpel to cut connective tissues and blood vessels.

6.3. Short-term outcome

The mean postoperative hospital stay was 7.9 days (6-15 days). This result is consistent with other authors applying Takasaki's hepatectomy method and the SonaStar Ultrasonic Aspiration System for parenchymal resection, reported a mean hospital stay of 8±5.2 days [9]. The mean postoperative blood loss was 211.79±125.41 ml, compared to Y. Sakamoto, et al. (2004) [12]'s result of 200 ml when using the LigaSure™ scalpel, and V.L. Ho, et al. (2021) [13]'s result of 250 ml when using an ultrasonic scalpel.

Our postoperative complications included two cases (accounting for 2.98%), all of which were mild complications and did not require surgical intervention. No mortality was observed. This result is consistent with studies worldwide: M. Ikeda, et al. (2009) [10] studied 60 hepatectomy cases using the LigaSure™, and A. Saiura, et al. (2006) [15] reported the same number of patients, with neither witnessing intraoperative nor postoperative mortality.

Although the results in our study were very positive, this was only a retrospective observation of short-term outcomes on limited numbers of hepatectomy cases. Therefore, a longer follow-up period is required in future studies to elucidate the potential benefits of the LigaSure™ scalpel and the Takasaki technique for HCC.

7. Conclusions

Hepatectomy using the LigaSure™ scalpel combined with Takasaki's Glissonean pedicle control method in the treatment of HCC is feasible and effective. This approach allows liver resection to be precise with sufficiently safe margins, minimal intraoperative blood loss and blood transfusion, and a low complication rate. Further investigations and follow-up must proceed to evaluate the long-term outcomes of this technique.

Ethics approval and consent to participate

Ethics approval of this study was given by the Research Ethics Committees of Bach Mai Hospital. Written informed consent for publication of their clinical details and clinical images was obtained from the patients' family.

CRediT author statement

Ham Hoi Nguyen, Thanh Khiem Nguyen contributed equally as co-first authors, the main doctors to operate the patients, Conceptualisation; Van Duy Le, Kim Khue Dang, Van Minh Do: Performing the operations, Editing; Tuan Hiep Luong: Performing the operations, Writing; Hoan My Pham, Kim Khue Dang: Collecting data, Editing; Cong Long Nguyen, Ngoc Hung Nguyen: Conceptualisation, Data analysis, Editing.

COMPETING INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this article.

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