


Hepatectomy with Takasaki's Technique Using SonaStar Ultrasonic Aspiration System: An Experience from 58 Cases

Van Linh Ho¹

Nhu Hien Pham²

Thanh Xuan Nguyen² 

An Phong Tran¹

Nhu Thanh Dang³

Nhu Hiep Pham¹

¹Digestive Surgery Department, Hue Central Hospital, Hue City, Vietnam;

²Department of Abdominal Emergency and Pediatric Surgery, Hue Central Hospital, Hue City, Vietnam; ³Surgery Department, Hue University of Medicine and Pharmacy, Hue City, Vietnam

Objective: This study aims to explore the short-term results of hepatectomy with Takasaki's technique using Sonastar ultrasonic aspiration system.

Materials and Methods: We retrospectively examined data of 58 patients who underwent hepatectomy with Takasaki's technique using Sonastar ultrasonic aspiration system at Hue Central Hospital from 01/2018 to 02/2021.

Results: The mean age was 60.7 ± 10.5 years (25–80) and the male/female ratio was 6:1. Patients with solitary tumor accounted for 79%; 68.4% had tumor size greater than 5 cm. Pringle maneuver was used in 57.9%, while selective right or left Glissonean pedicle occlusion was used in 69.0% and 32.8%, respectively. Final transection surface reinforcement was achieved by Surgicel and BioGlue in 78.9% and 21.5% of cases, respectively. Major liver resection accounted for 73.7%. The mean parenchymal transection time was 50 (45–110) minutes, while mean total operative time was 125 (90–280) minutes. Mean operative blood loss was 250 (150–650) mL. Mean post-operative hospital stay was 8 days (7–23). Post-operative complication rate was 15.9% and mortality rate was 1.7%.

Conclusion: Hepatectomy using Takasaki technique with Sonastar ultrasonic aspiration system is safe, effective, allowing an anatomical resection with sufficient safety margin and resulting in low complication rates (liver failure, biliary leakage) and good survival outcomes.

Keywords: liver tumor, SonaStar, Takasaki's technique

Background

Hepatectomy is the most popular radical treatment for hepatic malignancies which offers resectable patients better survival rates.^{1,2} However, hepatectomy is also associated with numerous complications including bleeding, acute liver failure and bile leakage ... which can adversely affect survival result and mortality rate.³

Among many Glissonean pedicle approaches, Takasaki's extrafascial approach provides a safe, quick dissection of Glissonean pedicle compared to intrafascial approach by Lortat-Jacob and Robert⁴ and transfissural approach by Ton That Tung in Vietnam⁵ and Tien-Yu Lin in Taiwan⁶ as it follows the natural plane between Glisson's and Laennec's capsules. The Takasaki technique has been widely adopted in anatomical resection for hepatocellular carcinoma as well as other liver tumors.⁷ Besides a traditional clamp-crush technique, novel parenchymal transection technology of Sonastar (Misonix Inc., Farmingdale, NY, USA) provide precise ultrasonic aspiration with high tissue selectivity and preservation of Glissonean pedicle

Correspondence: Thanh Xuan Nguyen
Department of Abdominal Emergency
and Pediatric Surgery, Hue Central
Hospital, 16 Le Loi Street, Hue City,
Vietnam
Tel +84945313999
Email thanhxuanbvh@hotmail.com

elements. Furthermore, anatomic liver resection has been demonstrated to provide better recurrence-free survival in hepatocellular carcinoma, as well as better preservation of healthy liver parenchyma and limiting bile leakage by accurate dissection in the intersegmental planes.⁸

A combination of these above-mentioned factors could theoretically allow safer and more efficient liver resection. Therefore, we conducted this study to evaluate the short-term postoperative results of hepatectomy with Takasaki's technique using Sonastar ultrasonic aspiration system (Sonastar).

Materials and Methods

A retrospective study was conducted on 58 patients who underwent hepatectomy with Takasaki's technique using Sonastar in Hue Central Hospital from 01/2018 to 02/2021. The recorded information included (1) general information: age, gender, history of liver diseases and past liver-directed therapy; (2) laboratory tests: hepatic function was classified using Child-Pugh classification; (3) tumor characteristics: site, size, number, and Barcelona Clinic Liver Cancer (BCLC) staging; (4) technical characteristics and complications.

Using the International Study Group of Liver Disease (ISGLS) criteria, bile leakage was defined as a bilirubin concentration in the drain fluid at least three times the serum bilirubin concentration measured at the same time) from postoperative day 3 onwards or the need for re-intervention (radiologic or surgical) for biliary collections or peritonitis. Similarly, posthepatectomy liver failure was defined as an increased international normalized ratio and concomitant hyperbilirubinemia on or after postoperative day 5.

Surgical Procedure

Step 1: Patients were all placed in supine position with both arms tucked alongside the body. A J-shaped incision was used. After placement of Kent retractor, the abdomen was carefully explored for any contraindications for a curative resection (eg unresectable local invasion, distant metastasis). Liver mobilization was performed based on which type of hepatectomy was planned. Cholecystectomy was routinely performed to facilitate hilar dissection.

Step 2: A combination of blunt and sharp dissection allowed us to enter the avascular plane between Glisson's and Laennec capsules. The bifurcation was first lower from the inferior surface of segment 4. Left and right pedicle could then be easily encircled and taped using

right angle dissector. Further dissection of the right anterior and posterior sections could also be proceeded based on the types of hepatectomy. Pringle maneuver can be selectively used during this step. Dissection of higher level Glissonian pedicles usually required an intrahepatic approach after localisation by intraoperative ultrasound.

Step 3: The Glissonian pedicle supplying the to-be-resected segment was clamped and the demarcation line was marked with electrocautery. Sonastar system was then used for parenchymal transection. The rapid forward and backward movement of the tip of the handpiece would create a cavitation effect resulting in fragmentation of tissue with higher water content (eg hepatocytes) and preservation of fibrous tissue (biliary tracts and blood vessels). All biliary and vascular elements were then clipped or suture – ligated before division. Sonastar was also equipped with aspiration and electrocautery components, which further facilitated a bloodless and safe transection.

Step 4: Final inspection was performed to identify sites of bile leak or hemorrhage from the transection surface, which were then reinforced by suture. Surgicel or BioGlue was then placed on the transection surface. An abdominal drain was placed under the liver and exteriorized on the right flank.

Step 5: Abdominal closure.

Data Analysis

Data were analyzed using SPSS 16.0 (IBM, Chicago, IL, USA). All descriptive Descriptive data were presented as means and standard deviations (SDs) and percentages.

Results

Patient Characteristics

Fifty-eight patients (50 men and 8 women) underwent hepatectomy with Takasaki's technique using Sonastar. The mean age was 60.7 ± 10.5 (25–80) years. There were 57 (98.3%) patients with a medical history of hepatitis B or C (51 hepatitis B). Most patients were classified as Child-Pugh Stage A and Performance Status (PS) 0. All patients had platelet counts over $100,000/\text{mm}^3$ and normal coagulation panel. The mean of serum AFP level was 379 ± 110.7 (11.5–1660) ng/mL.

Tumor Characteristics

The majority of patients had solitary tumor (79.3%), tumor that is more than 5cm in size (68.4%), and distinct tumor capsule (89.5%) (Table 1).

Table 1 Tumor Characteristics

Tumor Characteristics		n = 58	Percentage (%)
Number	Solitary	46	79.3
	Two and above	12	20.7
Diameter	> 5 cm	40	68.4
	≤ 5 cm	18	31.6
Tumor capsule	Present	52	89.5
	Absent	6	10.5
BCLC Staging	BCLC A	46	79.3
	BCLC B	12	20.7

Technical Characteristics

Pringle maneuver was used in 11 patients (19%), while selective right and left Glissonean pedicles occlusion was used in 40 (69%) and 19 (32.8%), respectively. Surgical was used to reinforce the transection surface in 49 (84.5%), and Bioglue was used in 21.5% of cases. Anatomical liver resection was performed in 51 patients (87.9%). Major liver resection (≥ 3 segments) was done in 74.1% of cases (Table 2). The mean of liver parenchyma transection time was 50 (45–110) minutes. The mean operative time was 125 (90–280) minutes. The amount of blood lost during operation was 250 (150–650) mL.

Surgical results and Early Outcomes

Postoperative characteristics were listed in Table 3. Most patients experienced an uneventful postoperative course. In the majority of patients, liver function tests showed slight disturbances during the first 5 postoperative days and gradually normalized from day 5 onwards.

Postoperative complications occurred in 5 patients (8.5%) (Table 4). One patient (1.7%) experienced bile leakage which lead to bile peritonitis requiring second operation in the fifth day postoperatively. The patient was dead in the two days after the second operation cause of nonrecoverable septic shock. The posthepatectomy liver failure was reported in 1/58 patient (1.7%), which was treated conservatively with fresh frozen plasma and human albumin transfusion.

The overall 24-month survival rates were 31% (18/58 patients). 15.3% (9/58 patients) patients had recurrences and were treated by ultrasound guided percutaneous

Table 2 Characteristics of Liver Resection Technique

Technical Characteristics		n = 58	Percentage (%)
Resection margin			
	<0.5 cm	3	5.2
	≤ 1 cm	34	58.6
	> 1 cm	21	36.2
Reinforcement materials			
	Surgicel	49	84.5
	Bioglue	9	15.5
Control of the Glissonean pedicle			
	Pringle maneuver	11	19.0
	Selective right pedicle occlusion	40	69.0
	Selective left pedicle occlusion	19	32.8
Type of liver resection			
	Right hepatectomy	24	41.4
	Left hepatectomy	12	20.7
	Central hepatectomy	7	12.1
	Single segmentectomy	15	25.8
Parenchymal transection time (minutes)		50 ± 6 (45–110)	
Operative time (minutes)		125 ± 65.3 (90–280)	
Bleeding volume (mL)		250 ± 190.5 (150–650)	

Radiofrequency Ablation (RFA), all of whom were still alive still the end of the study period (Table 5)

Discussions

Surgical Technique

The Takasaki's technique helps reduce bleeding in hepatic parenchyma transection as well as easily detect the

Table 3 Postoperative Characteristics

	Mean (SD)	Range
Clinical characteristics		
Time to first bowel movement (days)	3 (1.0)	2–5
Time to drain removal (days)	6 (2.0)	5–11
Postoperative hospital stay (days)	8 (5.2)	7–23
Laboratory tests on day 5		
Albumin (g/l)	33 (0.5)	29–45
Bilirubin (mmol/L)	1.5 (2.0)	3.5–23
AST (U/L)	165 (50.0)	115–537
ALT (U/L)	119 (47)	98–455
Prothrombin rate (%)	79.5 (14.3)	65–129
Platelets (K/mm ³)	155.1 (35)	126–457

Table 4 Post-Operative Complications

Complications	n = 58	(%)	Management		
			Conservative	Minimally Invasive	Reoperation
Biliary leakage	1	1.7	0	0	1
Hepatic failure	1	1.7	1	0	0
Ascites	2	3.4	1	0	0
Abscess	1	1.7	1	0	0
Mortality	1	1.7			

Table 5 Survival Prognosis

Overall Survival Time (Months)	n = 58	Percentage (%)
0–3	58	100.0
3–6	55	78.9
6–12	47	57.9
12–18	33	36.8
18–24	26	15.8
> 24	18	31.0
Recurrences		
≤ 6	1	1.7
6–12	1	1.7
12–18	2	3.4
> 24	5	8.5
Total	9	15.3

anatomical boundaries of hepatic segments. Therefore, it help minimize the ischemia of remnant hepatic parenchyma and avoid the spread of malignant cells to the adjacent liver segments.

The application of Sonastar ultrasonic aspiration system in the liver parenchymal transection provides many significant advantages including preservation of small blood vessels and bile ducts at the transection surface which then be subsequently controlled by clipping or ligation to prevent hemorrhage and bile leak. It also facilitate dissection close to important vascular and biliary structures when the tumor is nearby. On the other hand, the maximal preservation of healthy liver parenchymal help ensure sufficient remnant liver volume to prevent postoperative liver failure.

Morbidity and Mortality

The overall morbidity rate was 8.5%. Our study reported one case (1.7%) with postoperative bile leak which lead to bile peritonitis requiring second operation on day 5. The patient was dead on the second day after the second operation due to nonrecoverable septic shock. The postoperative

hepatic failure was reported in only 1/58 patient (1.7%), which was treated conservatively with fresh frozen plasma and human albumin transfusion. Two patients (3.4%) had ascites and were treated human albumin transfusion and diuretic (furosemide 40 mg per day). All other patients recovered after 7–10 days postoperatively. Patients with residual abscess complication were treated with ultrasound guided drainage and broad-spectrum antibiotics.

Recent improvements in anesthesia and intensive care along with updated techniques and tools help reduce the morbidity and mortality rates significantly. According to recent studies, hepatectomy complications accounted for 25% to 50%,⁹ with common complications related to surgery including bleeding, bile leakage, prolonged abdominal distention, hepatic dysfunction, prolonged pleural effusion and abscess below the diaphragm. Mild and severe bleeding and the need of blood transfusion were the factors that increased the rate of morbidity and mortality.^{10,11} Retrospective study and multivariate analysis in major liver resections revealed that Pringle maneuver technique and blood transfusion were risk factors for patients, especially those with chronic comorbidities. Moreover, blood transfusion was the independent risk factor of postoperative mortality¹². Liver failure was associated closely with preoperative hepatic functions, extent of liver resection and future liver remnant volume (FLRV). Hepatic failure was the main cause of postoperative mortality. Right portal vein embolization (PVE) was a procedure that induces regrowth on left liver to accomplish the required FLRV.

Postoperative Survivals

The survival rates of liver resection in patients with tumor more than 5 cm in diameter was approximately 68.4%. In fact, the tumor size, in most case, did not result in significant difficulty intraoperatively. Studies showed that the overall survival was dependent on the tumor size and the

stage of disease as well as the preoperative hepatic function. Patients with less-than-5cm tumors had the 5-years survival rate was about 70%, meanwhile, patients with hepatocellular carcinoma and hepatitis, the 5-years survival rate after hepatectomy was just 60%, and the rate of mortality related to surgery was about 2 to 3%.¹³

The recurrence rate in the current study was 15.3%. However, because only 18 patients in our study were followed longer than 24 months, longer follow-up time is required to accurately reflect the survival prognosis. In the current literature, recurrence rate in 5-year follow-up was about 50 to 80%. Despite of the application of updated techniques and supported tools, there was not much improvement in limiting recurrence.¹⁴ Therefore, a multidisciplinary approach to recurrence is important to prolong posthepatectomy survival.¹⁵

This is only a retrospective observation of short-term outcomes of the current technique of hepatectomy on a limited number of patients. A longer follow-up time and a control group is required in future study to clarify the potential benefits of Sonastar system and Takasaki technique.

Conclusions

Hepatectomy using Takasaki technique with Sonastar ultrasonic aspiration system is safe, effective, allowing an anatomical resection with sufficient safety margin and resulting in low complication rates (liver failure, biliary leakage) and good survival outcomes.

Ethics Approval and Consent to Participate

This study has been reviewed by the Ethics Committee of Hue Central Hospital; all procedures performed in studies involving human participants were conducted according to the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Consent for Publication

Written informed consent for publication of the clinical details were obtained from each patient.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or

critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

There is no funding to report.

Disclosure

The authors declare that they have no competing interests.

References

- Andel D, Dassen MG, Reinders-Hut MTM, et al. Surgical outcomes of major hepatectomy following "radiation lobectomy" for hepatic malignancies and insufficiently functional future liver remnant: initial experience. *Br J Surg*. 2020;107(12):e609–e610. doi:10.1002/bjs.11828
- Lu WP, Dong JH. Hepatectomy for hepatocellular carcinoma in the era of liver transplantation. *World J Gastroenterol*. 2014;20(28):9237–9244. doi:10.3748/wjg.v20.i28.9237
- Ishii M, Mizuguchi T, Harada K, et al. Comprehensive review of post-liver resection surgical complications and a new universal classification and grading system. *World J Hepatol*. 2014;6(10):745–751. doi:10.4254/wjh.v6.i10.745
- Lortat-Jacob JL, Robert HG. [Well defined technic for right hepatectomy]. *Presse Med*. 1952;60(26):549–551. Noewegian.
- Tung T, Quang N. A new technique for operating on the liver. *Lancet*. 1963;26(7274):192–193. doi:10.1016/S0140-6736(63)91210-8
- Lin TY, Chen KM, Liu TK. Total right hepatic lobectomy for primary hepatoma. *Surgery*. 1960;48:1048–1060.
- Takasaki K. Glissonean pedicle transection method for hepatic resection: a new concept of liver segmentation. *J Hepatobiliary Pancreat Surg*. 1998;5(3):286–291. doi:10.1007/s005340050047
- Orcutt ST, Anaya DA. Liver resection and surgical strategies for management of primary liver cancer. *Cancer Control*. 2018;25(1):1073274817744621. doi:10.1177/1073274817744621
- Fong Y, Sun RL, Jarnagin W, Blumgart LH. An analysis of 412 cases of hepatocellular carcinoma at a Western center. *Ann Surg*. 1999;229(6):790–799;discussion 799–800. doi:10.1097/0000658-199906000-00005
- Makuuchi M, Takayama T, Gunven P, Kosuge T, Yamazaki S, Hasegawa H. Restrictive versus liberal blood transfusion policy for hepatectomies in cirrhotic patients. *World J Surg*. 1989;13(5):644–648. doi:10.1007/BF01658893
- Shirabe K, Shimada M, Gion T, et al. Postoperative liver failure after major hepatic resection for hepatocellular carcinoma in the modern era with special reference to remnant liver volume. *J Am Coll Surg*. 1999;188(3):304–309. doi:10.1016/S1072-7515(98)00301-9
- Wei AC, Tung-Ping Poon R, Fan ST, Wong J. Risk factors for perioperative morbidity and mortality after extended hepatectomy for hepatocellular carcinoma. *Br J Surg*. 2003;90(1):33–41. doi:10.1002/bjs.4018
- European Association for Study of L, European Organisation for R. Treatment of C. EASL-EORTC clinical practice guidelines: management of hepatocellular carcinoma. *Eur J Cancer*. 2012;48(5):599–641.
- Bruix J, Sherman M, American Association for the Study of Liver D. Management of hepatocellular carcinoma: an update. *Hepatology*. 2011;53(3):1020–1022. doi:10.1002/hep.24199
- Matsumata T, Kanematsu T, Takenaka K, Yoshida Y, Nishizaki T, Sugimachi K. Patterns of intrahepatic recurrence after curative resection of hepatocellular carcinoma. *Hepatology*. 1989;9(3):457–460. doi:10.1002/hep.1840090320

Clinical and Experimental Gastroenterology**Dovepress****Publish your work in this journal**

Clinical and Experimental Gastroenterology is an international, peer-reviewed, open access, online journal publishing original research, reports, editorials, reviews and commentaries on all aspects of gastroenterology in the clinic and laboratory. This journal is indexed on American Chemical Society's Chemical Abstracts Service (CAS).

The manuscript management system is completely online and includes a very quick and fair peer-review system, which is all easy to use. Visit <http://www.dovepress.com/testimonials.php> to read real quotes from published authors.

Submit your manuscript here: <https://www.dovepress.com/clinical-and-experimental-gastroenterology-journal>