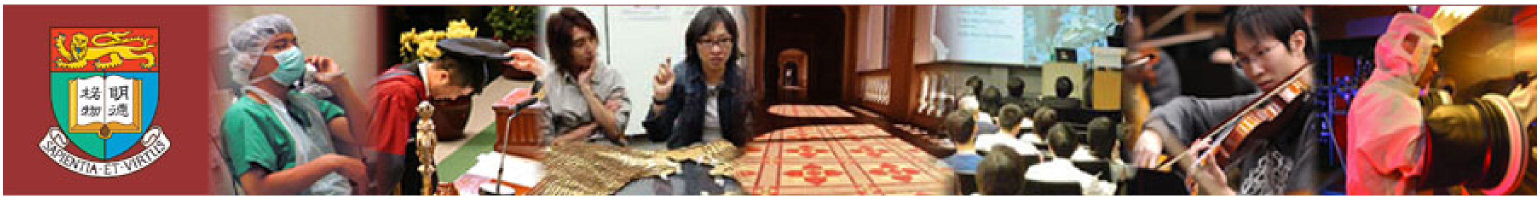

Title	Resection of T4 hepatocellular carcinomas with adjacent structures, is it justified?
Author(s)	Chok, KSH; Ng, KK; Cheung, TT; Chan, ACY; Chan, SC; Lo, CM
Citation	Hepatobiliary & Pancreatic Diseases International, 2017, v. 16 n. 1, p. 52-57
Issued Date	2017
URL	http://hdl.handle.net/10722/243853
Rights	

Resection of T4 hepatocellular carcinomas with adjacent structures, is it justified?

Running title: **Resect T4 HCCs with adjacent structures**

Abstract

Background: T4 hepatocellular carcinoma (HCC) with invasion to adjacent structure(s) may require resection of not only the tumor but also the invaded structure(s).

Method: Adult patients with T4 HCC were divided into groups. Patients whose tumors and invaded adjacent structures were resected together in combined resection were assigned to Group 1 if they had histopathologically confirmed tumor invasion or Group 2 if they had histopathologically confirmed tumor adhesion. Group 3 consisted of patients who received tumor resection only. Group comparisons were made.

Results: Totally 144 patients were included in the study. There were 71, 14 and 59 patients in Group 1, 2 and 3 respectively. The groups were comparable in demographics, complication and survival. Ten hospital deaths occurred (5, 0 and 5 in Group 1, 2 and 3 respectively; p=0.533.) The 5-year overall survival (hospital mortality excluded) was 17.8% in Group 1, 14.3% in Group 2, and 28.9% in Group 3 (p=0.191). The 5-year disease-free survival was 10.4% in Group 1 and 14.5% in Group 3 (no data for Group 2 yet) (p=0.565). On multivariate analysis, combined resection was not a risk factor for survival whereas macrovascular invasion and poor differentiation were.

Conclusions: Combined resection achieved survival outcomes similar to mere tumor resection, with an acceptably but not significantly higher risk. Patients with tumor invasion and patients with tumor adhesion had comparable survival after combined resection. At centers with the required expertise, combined resection should be attempted to treat T4 HCCs with clinically suspected invasion of adjacent structures.

Introduction

The outcomes of hepatic resection for hepatocellular carcinoma (HCC) have improved significantly in recent years because of better surgical techniques and perioperative care[1]. HCC is a common malignancy in many Asian countries where hepatitis B virus infection is prevalent. It is the fourth most common cancer and the third cause of cancer-related deaths in Hong Kong[2]. A rising trend in HCC has also been observed recently in developed countries such as the United States and the United Kingdom[3]. Locally advanced T4 HCC carries a poor prognosis if left untreated, and only 10-37% of the patients are suitable for surgery because of the advanced stage at presentation and limited hepatic functional reserve from underlying chronic liver disease[1, 4-5].

Complete surgical resection of T4 HCCs provides the best chance of a cure[6]. HCCs with direct invasion of adjacent organs or structures require resection of not only the tumors but also the invaded organs or structures, but there are few reports documenting the safety profile and outcomes of such combined resection[7-11]. Most of the time, the 'invasion' is actually a dense desmoplastic reaction which cannot be differentiated on the operative field. This study assessed whether such combined resection for T4 HCC is justifiable. It also compared combined resection for tumor invasion, combined resection for tumor adhesion and mere tumor resection (for tumors not adhering to any surrounding structure) in terms of survival outcomes.

Patients and Methods

This retrospective study reviewed the prospectively collected data of the 1387 patients who underwent liver resection for HCC at our hospital during the period from December 1989 to December 2010. The study period was divided into Era 1 (1989-1999) and Era 2

(2000-2010) in order to reflect the effect of technical advancement on the survival outcomes. Patients with extrahepatic disease were excluded. A total of 144 adult patients with T4 HCC were divided into 3 groups. Patients whose tumors and invaded adjacent organs or structures were resected together in combined resection were assigned to Group 1 if they had histopathologically confirmed tumor invasion or Group 2 if they had histopathologically confirmed tumor adhesion. Group 3 consisted of patients who received only resection of tumors as the tumors breached the visceral peritoneum only and did not adhere to any surrounding organ or structure.

Diagnosis and Preoperative Assessment

Diagnosis of HCC was based on typical imaging findings (i.e. early arterial enhancement with early portovenous washout) on computed tomography (CT) or magnetic resonance imaging and/or a serum α-fetoprotein level of >400 ng/mL. Percutaneous needle biopsy was not routinely performed on patients with resectable tumors to avoid needle-tract seeding of tumor cells.

A patient was eligible for resection if he or she had adequate hepatic functional reserve and no extrahepatic disease, and if the tumor was anatomically resectable as evaluated by imaging studies. Hepatic function assessment in terms of Child-Pugh classification[12] and indocyanine green clearance test was performed routinely. During the period from 1989 to 1993, the decision for laparotomy was based mainly on Child-Pugh classification. Child-Pugh class C was regarded as a contraindication to hepatectomy. After the indocyanine green clearance safety limit for major hepatectomy was determined in 1995[13], patients' suitability for surgery was based largely on their results of indocyanine green clearance tests rather than their Child-Pugh classes. Patients with an indocyanine green retention rate ≤14% at 15 minutes were eligible for major hepatectomy[14]. Since 2010, dual-tracer positron emission tomography was performed when extrahepatic metastasis was suspected.

Surgical Management

Our techniques of hepatic resection have been standardized over the years[1]. Briefly, the operation started with a bilateral subcostal incision or a right subcostal incision with an upward midline extension. Assessment of resectability by intraoperative ultrasonography was routinely done to detect any major vascular invasion in the contralateral lobe and undetected tumor in the future liver remnant and to mark the plane of transection. The anterior approach was adopted for patients with large tumors to minimize tumor manipulation before division of all vascular attachments. Parenchymal transection was performed using the finger-fracture technique from 1989 to 1992, and thereafter using an ultrasonic dissector. Central venous pressure was kept below 5 mmHg as far as possible. Hemostasis during hepatic transection was achieved by diathermy coagulation, argon beam coagulation or fine suturing. Intermittent hepatic inflow occlusion was applied during hepatic transection only if excessive bleeding was encountered. Routine bile leakage test was performed by methylene blue injection via a cannula placed inside the common bile duct through the cystic duct after transection. If tumor involvement with an adjacent organ or structure was suspected, the organ or structure was resected together. Since 2002, intra-abdominal drain was not used[15]. Since 2009, patients with chronic active hepatitis B were given antivirals. No medical therapy was given to patients with chronic hepatitis C.

Postoperative Management

All patients were admitted to the intensive care unit or the high dependency unit during the early postoperative period and received broad-spectrum antibiotics for 5 days. For patients with cirrhosis, parenteral nutrition in the form of branched-chain amino-acid-enriched solution, low-dose dextrose and medium- and long-chain triglycerides was provided via a surgically placed central line until oral feeding could be well tolerated.

All patients were followed up monthly in the first year and quarterly afterwards, with regular monitoring for recurrence by serum α-fetoprotein level check and CT of the liver. CT of the liver was done one month after hepatectomy and then every two to four months. Diagnosis of recurrence was based on typical imaging findings; percutaneous find-needle aspiration cytology was also performed if necessary. Since 2010, dual-tracer positron emission tomography was performed when indefinite recurrences were encountered[16]. A standardized aggressive management protocol as described in a previous report was adopted to treat recurrences[17].

Definitions

The American Joint Committee on Cancer tumor-node-metastasis system for staging of primary liver cancer (7th edition) was used. An HCC was defined as T4 if there was direct invasion of adjacent organs other than the gallbladder, or perforation of the visceral peritoneum. A hepatic resection was classified as a major resection if three or more segments (according to the Couinaud classification) were resected[18]. If fewer than three segments were resected, it was a minor resection. Hospital mortality was defined as death occurring during the hospital stay for primary operation. Complication was defined as any deviation from the normal postoperative course with the need for pharmacological, surgical, endoscopic or radiological intervention. All complications were prospectively documented and graded according to the Clavien-Dino classification[19].

Statistical Analysis

Pearson's chi-squared test or Fisher's exact test was used where appropriate to compare categorical variables. Patients were matched according to T4 tumor status, tumor size, tumor number and age, and were divided into three groups. The Kruskal-Wallis test was used to compare the continuous variables of the three groups of patients. Univariate analyses of possible risk factors associated with overall survival and disease-free survival respectively were performed with a logistic regression model, and factors with $p \leq 0.1$ were put into the Cox regression hazard model to determine independent risk factors associated with overall survival and disease-free survival respectively. The Kaplan-Meier method was used for survival analyses, and the log-rank test was used to compare variables. $P<0.05$ denoted statistical significance and all p values were two-tailed.

Results

One hundred and forty-four patients were included in the study. There were 71, 14 and 59 patients in Group 1, 2 and 3 respectively. It turned out that about 16.5% (14/85) of the patients who received combined resection had tumor adhesion rather than tumor invasion.

As shown in Table 1, the three groups had comparable demographic data and preoperative clinical characteristics. Table 2 shows the operative data and tumor characteristics and Table 3 shows the postoperative data, complication details and recurrence patterns in the three groups. They were all comparable. The most commonly resected organ or structure was the diaphragm (56 in Group 1 and 11 in Group 2), followed by the colon (8 in Group 1 and 1 in Group 2) and the stomach (3 in Group 1 and 3 in Group 2). Six out of the 71 patients in Group 1 had tumor rupture causing invasion of the diaphragm.

In the search for risk factors for overall survival, presence of macrovascular invasion, higher serum α-fetoprotein level, longer prothrombin time, bigger operative blood loss amount, poorer tumor grading, and presence of postoperative complication were identified in univariate analysis, whereas presence of macrovascular invasion, poorer tumor grading, and presence of postoperative complication were identified in multivariate analysis. In the search for risk factors for disease-free survival, higher serum α-fetoprotein level, higher serum total bilirubin level, higher serum aspartate transaminase level, bigger operative blood loss amount, bigger tumor size, and poorer tumor grading were identified in univariate analysis, whereas higher serum total bilirubin level, bigger tumor size, and poorer tumor grading were identified in multivariate analysis.

Both Groups 1 and 3 had five hospital deaths, whereas no death occurred in Group 2 (Table 3). Figure 1 compares the three groups of patients in terms of overall survival and disease-free survival with hospital deaths excluded. No survival differences were found. Subgroup analyses in terms of overall survival and disease-free survival were conducted to compare patients who had their diaphragms resected with patients who had other organs or structures resected. Again, no differences were found.

Discussion

There is a spectrum of locally advanced HCCs, ranging from those breaching only the visceral peritoneum to those invading other organs or structures. Those with invasion of surrounding organs or structures carry a poor prognosis. A previous study by our center found that patients with such disease had a median post-resection survival duration of 15.1 months only[20], which is similar to what was found in the present study – a median of around

17 months – despite advances in surgical treatment over the years. Patients with such disease also have a high incidence of recurrence because there is no effective adjuvant treatment for them. A randomized controlled trial in China reported a significantly higher disease-free survival rate in patients with postoperative transarterial chemoembolization and portal vein chemotherapy[21]. However, such postoperative treatment is not widely practiced; more randomized controlled trials are needed to validate the usefulness of adjuvant therapy for locally advanced HCCs.

Tumor extension to an adjacent organ or structure does not necessarily indicate tumor invasion. According to various reports, only 7-43% of such extensions found during operation had final histological proof of direct invasion[7,8,22,23]. In the present study, it was 16.5%. Any attempt to separate a tumor from an adjacent organ or structure should be prohibited since it might cause torrential bleeding and tumor seeding. Although combined resection is technically challenging, it would not cause more blood loss or more major complications.

In this study, the most commonly resected organ or structure was the diaphragm. Six patients had tumor rupture that caused direct invasion of the diaphragm. The study echoes the report by Lau et al.[24] that diaphragm removal could result in curative resection and did not cause more significant morbidities.

There were more bilobar tumors in Group 2, which had the worst overall survival and disease-free survival, but univariate analysis did not demonstrate a significant impact of bilobar disease on overall survival. However, there were only 14 patients in this group, making it impossible to conduct a meaningful further analysis or draw any conclusion.

Multivariate analysis showed that combined resection and era were not risk factors for overall or disease-free survival. Macrovascular invasion, poor tumor cell differentiation and postoperative complication were found to be risk factors for overall survival. Among these risk factors, the last one is the only one that can be attenuated or removed by a surgeon with good surgical skills. Previous study from our center already demonstrated that the presence of postoperative complication could affect survival outcomes[25]. As combined resection itself does not cause more hospital deaths or postoperative morbidities but provides the only chance of a cure, it should be attempted as far as possible.

This study is a single-center one and has a retrospective nature, which means selection bias is inevitable. It also covers a long period, which has made data intrepretation difficult since different surgical techniques and management protocols were employed over the years. However, imaging modalities were more or less the same over the years, and surgical exploration was carried out in case of doubt. If invasion was suspected, combined resection was performed whenever possible. Although there has been advancement in multidisciplinary input in the management of T4 HCC, resection is still by far the most promising treatment provided that it can remove the tumor bulk and eradicate associated symptoms (gastrointestinal bleeding in case of colon invasion if left untouched).

Ideally, patients with T4 HCCs without surgery should have been studied too, but these patients were under the care of oncologists rather than surgeons, and had these patients been included, the patient profile would have been totally different (e.g. there would be significant comorbidities making surgery unsafe). Hence, they were not included in the present study. However, the study has by far the largest series reported. Hopefully it can shed light on the management of patients with such difficult disease. Before a more appealing treatment is available, combined resection should be the treatment of choice for these patients at centers with the required expertise.

In conclusion, combined resection achieved survival outcomes similar to mere tumor resection, with an acceptably but not significantly higher risk. Patients with tumor invasion and patients with tumor adhesion had comparable survival after combined resection. At centers with the required expertise, combined resection should be attempted to treat T4 HCCs with clinically suspected invasion of adjacent organs or structures.

References

1. Fan ST, Lo CM, Liu CL, Lam CM, Yuen WK, Yeung C, et al. Hepatectomy for hepatocellular carcinoma: toward zero hospital deaths. Ann Surg 1999;229:322-330. PMID: 10077043
2. Hong Kong Cancer Registry. Hospital Authority 2011. http://www3.ha.org.hk/cancereg
3. El-Serag HB, Mason AC. Rising incidence of hepatocellular carcinoma in the United States. N Eng J Med 1999;340:745-750. PMID: 10072408
4. Colella G, Bottelli R, De Carlis L, Sansalone CV, Rondinara GF, Alberti A, et al. Hepatocellular carcinoma: comparison between liver transplantation, resective surgery, ethanol injection and chemoembolization. Transplant Int 1998;11 Suppl 1:S193-S196. PMID: 9664977
5. Fong Y, Sun RL, Jarnagin W, Blumgart LH. An analysis of 412 cases of hepatocellular carcinoma at a Western center. Ann Surg 1999;229:790-800. PMID: 10363892
6. Song TJ, Ip EW, Fong Y. Hepatocellular carcinoma: current surgical management. Gastroenterology 2004;127:S248-S260. PMID: 15508091
7. Wu CC, Ho WL, Liu TJ. Hepatocellular carcinoma with adjacent organ extension: the enhancement of preoperative transcatheter arterial embolization and the results of surgical resection. Surg Today 1994;24:882-888. PMID: 7894185
8. Lau WY, Leung KL, Leung WT, Liew CT, Chan M, Li AK. Resection of hepatocellular carcinoma with diaphragmatic invasion. Br J Surg 1995;82:264-266. PMID: 7749707
9. Leung KF, Chui AK, Leung K, Lai PB, Liew CT, Lau WY. Clinicopathological study of hepatocellular carcinoma with diaphragmatic involvement. Br J Surg 2001;88:681-682. PMID: 11350440
10. Zhou YM, Sui CJ, Li B, Xu F, Kan T, Yang JM. Results of en bloc resection for hepatocellular carcinoma extending to adjacent organs. Can J Surg 2012;55:222-226. PMID: 22617536

11. Nanashima A, Abo T, Takeshita H, Yamasaki N, Sawai T, Nagayasu T. Safety of hepatectomy accompanying combined resection of other organs. Hepatogastroenterology 2012;59:1915-1920. PMID: 22369742
12. Pugh RN, Murray-Lyon IM, Dawson JL, Pietroni MC, Williams R. Transection of the oesophagus for bleeding varices. Br J Surg 1973;60:646-649. PMID: 4541913
13. Fan ST, Lai EC, Lo CM, Ng IO, Wong J. Hospital mortality of major hepatectomy for hepatocellular carcinoma associated with cirrhosis. Arch Surg 1995;130:198-203. PMID: 7848092
14. Lau H, Man K, Fan ST, Yu WC, Lo CM, Wong J. Evaluation of preoperative hepatic function in patients with hepatocellular carcinoma undergoing hepatectomy. Br J Surg 1997;84:1255-1259. PMID: 9313707
15. Liu CL, Fan ST, Lo CM, Wong Y, Ng IO, Lam CM, et al. Abdominal drainage after hepatic resection is contraindicated in patients with chronic liver diseases. Ann Surg 2004;239:194-201. PMID: 14745327
16. Cheung TT, Chan SC, Ho CL, Chok KS, Chan AC, Sharr WW, et al. Can positron emission tomography with the dual tracers [11 C]acetate and [18 F]fludeoxyglucose predict microvascular invasion in hepatocellular carcinoma? Liver Transpl 2011;17:1218-1225. PMID: 21688383
17. Poon RT, Fan ST, Lo CM, Liu CL, Wong J. Intrahepatic recurrence after curative resection of hepatocellular carcinoma: long-term results of treatment and prognostic factors. Ann Surg 1999;229:216-222. PMID: 10024103
18. Couinaud C, Le Foi. Etudes anatomiques et chirugicales. Paris: Masson Publishers; 1957: 400-409.
19. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new

proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 2004;240:205-213. PMID: 15273542

20. Poon RT, Fan ST, Ng IO, Wong J. Prognosis after hepatic resection for stage IVA hepatocellular carcinoma. Ann Surg 2003;237:376-383. PMID: 12616122
21. Li Q, Wang J, Sun Y, Cui YL, Juzi JT, Li HX, et al. Efficacy of postoperative transarterial chemoembolization and portal vein chemotherapy for patients with hepatocellular carcinoma complicated by portal vein tumor thrombosis--a randomized study. World J Surg 2006;30:2004-2011. PMID: 17058027
22. Tung WY, Chau GY, Loong CC, Wu JC, Tsay SH, King KL, et al. Surgical resection of primary hepatocellular carcinoma extending to adjacent organs. Eur J Surg Oncol 1996;22:516-520. PMID: 8903496
23. Jeng KS, Chen BF, Lin HJ. En bloc resection for extensive hepatocellular carcinoma: is it advisable? World J Surg 1994;18:834-839. PMID: 7846905
24. Lau WY, Leung KL, Leung WT, Liew CT, Chan M, Li AK. Resection of hepatocellular carcinoma with diaphragmatic invasion. Br J Surg 1995;82:264-266. PMID: 7749707
25. Chok KS, Ng KK, Poon RT, Lo CM, Fan ST. Impact of postoperative complications on long-term outcome of curative resection for hepatocellular carcinoma. Br J Surg 2009;96:81-87. PMID: 19065644

Table 1. Demographic data and preoperative clinical characteristics in the three groups

	Group 1 (n=71)	Group 2 (n=14)	Group 3 (n=59)	P
Age (years)	55 (35-80)	57 (39-76)	52 (30-79)	0.884
Sex (male : female)	9 (12.7%)	3 (21.4%)	8 (13.6%)	0.685
HBV infection				0.296
Not known	1 (1.4%)	0 (0%)	2 (3.4%)	
Negative	15 (21.1%)	0 (0%)	9 (15.3%)	
Positive	55 (77.5%)	14 (100%)	48 (81.4%)	
HCV infection				0.251
Not known	26 (36.6%)	2(14.3%)	22 (37.3%)	
Negative	43 (60.6%)	12 (85.7%)	33 (55.9%)	
Positive	2 (2.8%)	0 (0%)	4 (6.8%)	
Comorbidity	19 (26.8%)	3 (21.4%)	16 (27.1%)	0.905
Cardiovascular	12 (16.9%)	2 (14.3%)	9 (15.3%)	0.952
Pulmonary	4 (5.6%)	1 (7.1%)	5 (8.5%)	0.817
Renal	2 (2.8%)	0 (0%)	2 (3.4%)	0.786
Diabetes mellitus	7 (9.9%)	1 (7.1%)	3 (5.1%)	0.593
Gastrointestinal	5 (7%)	1 (7.1%)	4 (6.8%)	0.998
AFP (ng/mL)	926 (2-1335900)	4681 (5-236790)	250.5 (2-481000)	0.323
Creatinine (umol/L)	85.5 (52-152)	85 (66 -110)	87 (57-1710	0.580
Platelet (×10^9/L)	207 (66-554)	211 (137-813)	209 (78-621)	0.809
Total bilirubin (umol/L)	13 (5-38)	11 (6-19)	13 (4-42)	0.465
Albumin (g/L)	39 (29-49)	38 (26-46)	39 (26-46)	0.492
AST (U/L)	66.5 (22-248)	72.5 (42-1324)	54 (17-268)	0.224
ALT (U/L)	47.5 (9-376)	53.5(25-248)	43(7-144)	0.370
INR	1 (0.8-1.4)	1 (0.9-1.2)	1.1 (0.9-1.4)	0.594
ICG15	10.9 (2-32.1)	9.85 (1.7-19.4)	9.7 (2.4-39.2)	0.522
Child-Pugh class				0.022
A	70 (98.6%)	14 (100%)	52 (88.1%)	
B	1 (1.4%)	0 (0%)	7 (11.9%)	

Data are presented in median with range or number with percentage.
HBV = hepatitis B virus
HCV = hepatitis C virus
AFP = α-fetoprotein
AST = aspartate transaminase
ALT = alanine transaminase
INR = international normalized ratio
ICG15 = indocyanine green retention rate at 15 minutes

Table 2. Operative data and tumor characteristics in the three groups

	Group 1 (n=71)	Group 2 (n=14)	Group 3 (n=59)	P
Blood loss (L)	1.6 (0.1-8.0)	1.6 (0.7-7.13)	1.6 (0.1-8.9)	0.483
Blood replacement (L)	0 (0-3.5)	0 (0-2.36)	0.6 (0-6.27)	0.227
Lymph node metastasis	1 (1.4%)	0 (0%)	0 (0%)	0.596
Microvascular permeation	55 (77.5%)	10 (71.4%)	34 (57.6%)	0.051
Macrovascular invasion	12 (16.9%)	1 (7.1%)	7 (11.9%)	0.529
Size of tumor (cm)	11 (3.5-27)	11.5 (5-16)	10 (2-22)	0.073
No. of tumor nodule	1 (1-multiple)	1 (1-multiple)	1 (1-multiple)	0.472
No. of tumor nodule				0.272
One	45 (63.4%)	11 (78.6%)	33 (55.9%)	
More than one	26 (36.6%)	3 (21.4%)	26 (44.1%)	
Bilobar disease	6 (8.5%)	5 (35.7%)	12 (20.3%)	0.019
Invasion of adjacent organ or structure other than the gallbladder	71 (100%)	0 (0%)	0 (0%)	<0.0001

Data are presented in median with range or number with percentage.

Table 3. Postoperative data, complication details and recurrence patterns in the three groups

	Group 1 (n=71)	Group 2 (n=14)	Group 3 (n=59)	P
Hospital stay (days)	14 (5-89)	16 (6-22)	11 (6-87)	0.362
Hospital death	5 (7%)	0 (0%)	5 (8.5%)	0.533
With complication	30 (42.3%)	7 (50%)	20 (33.9)	0.440
Chest infection	6 (8.5%)	1 (7.1%)	4 (6.8%)	0.936
Chest infection requiring bronchoscopy	3 (4.2%)	0 (0%)	2 (3.4%)	0.732
Chest infection requiring tracheostomy	2 (2.8%)	0 (0%)	1 (1.7%)	0.768
Pleural effusion requiring drainage	4 (5.6%)	2 (14.3%)	6 (10.2%)	0.378
Wound infection	6 (8.5%)	1 (7.1%)	2 (3.4%)	0.489
Wound dehiscence	1 (1.4%)	0 (0%)	1 (1.7%)	0.888
Subphrenic abscess	1 (1.4%)	0 (0%)	2 (3.4%)	0.622
Intra-abdominal bleeding	4 (5.6%)	0(0%)	2 (3.4%)	0.583
Urinary tract infection	0 (0%)	0 (0%)	1 (1.7%)	0.484
Cardiac arrhythmia	6 (8.5%)	1 (7.1%)	1 (1.7%)	0.237
Heart failure	1 (1.4%)	0 (0%)	0 (0%)	0.596
Biliary fistula or leakage	3 (4.2%)	0 (0%)	1 (1.7%)	0.547
Infected ascites	1 (1.4%)	0 (0%)	0 (0%)	0.596
Pneumothorax	3 (4.2%)	1 (7.1%)	0 (0%)	0.199
Liver failure	5 (7%)	0 (0%)	4 (6.8%)	0.595
Renal failure	4 (5.6%)	0 (0%)	3 (5.1%)	0.666
Subphrenic collection requiring drainage	0 (0%)	0 (0%)	1 (1.7%)	0.484
With complication of Clavien 3a or above	20 (28.2%)	6 (42.9%)	16 (27.1%)	0.491
Clavien 3a	14 (19.7%)	6 (42.9%)	9 (15.3%)	0.068
Clavien 3b	1 (1.4%)	0 (0%)	2 (3.4%)	0.622
Clavien 4a	0 (0%)	0 (0%)	5 (2.2%)	0.317
Clavien 4b	-	-	-	-
Clavien 5	5 (7%)	0 (0%)	5 (8.5%)	0.533
Pattern of recurrence				0.498
No recurrence	17 (23.9%)	1 (7.1%)	14 (23.7%)	
Intrahepatic recurrence	15 (21.1%)	3 (21.4%)	18 (30.5%)	
Extrahepatic recurrence	18 (25.4%)	4 (28.6%)	9 (15.3%)	
Both	21 (29.6%)	6 (42.9%)	18 (30.5%)	
Median follow-up period (months)	12.9 (0.26-184.88)	19.06 (5.03-96.81)	25.3 (0.26-199.7)	0.437

Data are presented in median with range or number with percentage.

Figure 1. Survival Comparison