Modified Liver Hanging Maneuver for *En-bloc* Right-sided Hepatectomy Combined with Total Caudate Lobectomy for Colon-Cancer Liver Metastasis and Hepatocellular Carcinoma

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Abstract. *Background: A right-sided hepatectomy with total caudate lobectomy is indicated for colorectal-cancer liver metastases (CLM) and hepatocellular carcinomas (HCC) located in the caudate lobe with extension to the right lobe of the liver. Caudate-lobe resection (i.e. segmentectomy 1 according to the Brisbane terminology) is one of the most difficult types of hepatectomy to carry out radically and safely. The deep portion of hepatic transection around the caudate lobe, hepatic veins and inferior vena cava is a critical source of massive bleeding. Prolonged transection can increase blood loss. Patients and Methods: We analyzed the outcome of 10 patients who underwent right-sided hepatectomy with caudate lobectomy using a modified liver hanging maneuver (mLHM) in comparison with 16 patients who underwent the operation without mLHM. Results: Blood loss during liver transection and blood loss per unit area of cut surface were significantly less in the mLHM group (p=0.014 and 0.015, respectively). In patients diagnosed pathologically with liver impairment, transection time was significantly shorter in the mLHM group (p=0.038), as were red blood cell transfusion volume (p=0.042) and blood loss (p=0.049) during transection. Conclusion: Use of mLHM can potentially improve surgical outcomes by reducing blood loss and transection time, which are especially important for patients with liver impairment.*

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Key Words: Hepatectomy, liver hanging maneuver, caudate lobectomy, colon cancer, metastasis, liver cancer.

A right-sided hepatectomy with total caudate lobectomy is indicated for colorectal liver metastases (CLM) and hepatocellular carcinoma-cancer (HCC) located in the caudate lobe with extension to the right lobe. Caudate lobe resection [*i.e.* segmentectomy 1 according to the Brisbane terminology (1)] is one of the most difficult types of hepatectomy to carry out radically and safely (2, 3). The deep portion of hepatic transection around the caudate lobe, hepatic veins and inferior vena cava (IVC) is a critical source of massive bleeding. Prolonged transection can increase blood loss. Such considerations require optimal procedures for liver transection around the caudate lobe. Previous studies have suggested that caudate-lobe resection using the anterior trans-hepatic approach or an additional tape-guided approach improves feasibility of isolated caudate lobectomy (2, 3).

In 2004, Belghiti and colleagues developed the liver hanging maneuver (LHM) for right hepatectomy with an anterior approach using a tape inserted between the anterior aspect of the vena cava and the liver (4). Subsequently, the LHM has been applied widely, not only to major hepatectomy, but also to various anatomic resections, and many reports have demonstrated the usefulness of this technique in improving surgical outcomes (5-11). LHM also has been reported to be useful in major hepatectomy with caudate lobe resection (6, 12). However, the utility of LHM has not been clearly demonstrated in en-bloc resection combining right-sided hepatectomy with total caudate lobectomy. In this study, we investigated the potential advantages of a modified LHM (mLHM) in this operation.

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Table I. *Characteristics of patients with colorectal-cancer liver metastases (CLM) and hepatocellular carcinoma (HCC) undergoing hepatectomy with or without the modified liver hanging maneuver (mLHM).*

Characteristic	mLHM (n=10)	Non-mLHM (n=16)	*p*-Value
Age (years)	68.9 ± 5.9	58.4 ± 10.6	0.009†
Gender: Male/female	5/5	9/7	1.0‡
Diagnosis: CLM/HCC	7/3	7/9	0.248‡
ICGR15 (%)	16.3	14.1	0.521†
Child-Pugh classification: A/B	10/0	16/0	–
Parenchymal liver disease: NL/CH/LC	7/2/1	10/3/3	0.834§
Number of tumors	4.67 ± 5.36	5.94 ± 5.49	0.458†
Maximum tumor size (mm)	45.3 ± 28.0	71.3 ± 48.6	0.074†
Procedure			0.992§
Post.+ Sg1	4	6	
Rt hemi.+ Sg1	3	5	
Ext. Rt hemi.+ Sg1	3	5	
IVC resection: Yes/no	5/5	5/11	0.425‡
Resection of extrahepatic bile duct: Yes/no	2/8	0/16	0.538‡

CGR15: Indocyanine green retention15; NL: normal liver; CH: chronic hepatitis; LC: liver cirrhosis; Sg1: segmentectomy 1; Rt hemi.: right hemi-hepatecomy; Ext. Rt hemi.: extended right hemi-hepatecomy; IVC: inferior vena cava. Values are the mean ± SD. †Student's *t*-test; ‡Fisher exact test; §χ^2 test.

Materials and Methods

Patients. A retrospective review of patients who underwent a right-sided hepatectomy with total caudate lobectomy for colorectal-cancer liver metastases (CLM) and hepatocellular carcinoma (HCC) at Yokohama City University Graduate School of Medicine and Teikyo University Chiba Medical Center between November 1985 and September 2014 was undertaken. Eligibility criteria were performance status less than 2, a non-occlusive primary tumor, at least two liver segments without tumor, no more than three resectable lung metastases, no other site of metastasis (including lymph nodes in the hepatic pedicle or coeliac region), and acceptance of the strategy by the patient. Data were collected prospectively from the time the first patient was included (Table I). All patients had abdominal and chest computed tomography (CT) and magnetic resonance imaging (MRI) of the liver.

Indications. A right-sided hepatectomy with total caudate lobectomy is indicated for CLM and HCC located in the caudate lobe with extension to the right lobe. To determine whether or not a hepatectomy procedure was acceptably safe for a given patient, we used a predictive score (PS) introduced by Yamanaka *et al*. (13, 14). The PS was calculated using the formula $PS = -84.6 + 0.933a + 1.11b + 0.999c$, where a is the percentage anticipated resection fraction calculated from computed tomographic (CT) volumetry; b, the percentage indocyanine green retention rate at 15 minutes; and c, the patient's age in years. A PS below 50 indicates that a given hepatectomy would be acceptable. Patients with a PS of 50 or more were considered for a two-stage approach with or without pre-hepatectomy portal vein embolization.

Surgical technique. After the liver was exposed through a J-shaped abdominal incision, the location of the tumor and its relation to vascular structures were evaluated by intra-operative ultrasonography. The coronary and right triangular ligaments were transected, and the superior surface of the liver exposed up to the anterior aspect of the suprahepatic inferior vena cava (IVC). At that point, the right liver was completely mobilized. The left lobe was displaced superiorly, and the *ligamentum venosum* (ligament of Arantius) was divided at its junction with the left hepatic vein and the Spiegel lobe. Our mLHM was then performed as follows: A tape (6F Penrose drain; Silascon, Kaneka Medical Products, Osaka, Japan) was placed upon the fossa *ductus venosi*. The cranial tip of the tape was passed to the right behind the common trunk of the left hepatic vein (LHV) and the middle hepatic vein (MHV), and the caudal tip was passed behind the left portal pedicle to the hepatic hilum (Figures 1, 2A and 2B). The cranial tip was repositioned between the LHV and MHV for extended right hemi-hepatectomy with total caudate lobectomy (Figure 1C). For posterior sectionectomy with total caudate lobectomy, the cranial tip was passed to the right behind the right hepatic vein (RHV) and repositioned between the anterior branch and the posterior branch of the right portal pedicle (Figure 1D). Before parenchymal transection, the right pedicle was divided, devascularizing the right liver. For extended right hemi-hepatectomy and posterior sectionectomy, the Pringle maneuver was performed additionally or substituted. Parenchymal transection was performed with a Cavitron Ultrasonic Surgical Aspirator (CUSA; AMCO., Tokyo, Japan). Vessel coagulation was performed using a soft-coagulation system (TissueLink; TissueLink Medical, Dover, NH, USA). During parenchymal division, upward traction on the tape in the hanging maneuver led to the shortest transection line, facilitating exposure and hemostasis of the deeper parenchymal plane.

Statistical analysis. This study was a retrospective observational study of a cohort of patients who underwent hepatic surgery for CLM and HCC. The primary endpoint of this study was surgical outcomes. Secondary endpoints included overall survival (OS) and relapse-free survival (RFS). Statistical analysis was performed with the chi-square and Fisher's exact tests for comparing categorical variables. The two-tailed Student *t*-test was used to compare

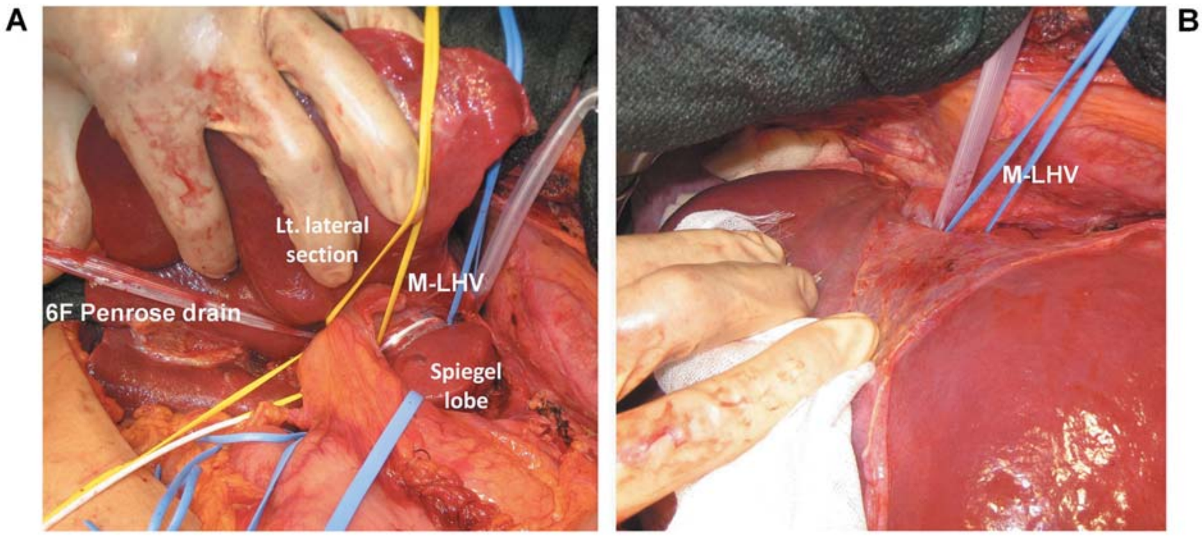

Figure 1. *Intra-operative images of the modified liver hanging maneuver for right hemi-hepatectomy with total-caudate lobectomy. A tape is placed upon the fossa ductus venosi. Then the cranial tip is passed behind the common trunk of the left and middle hepatic veins (LHV and MHV), while the caudal tip is passed right behind the left portal pedicle to the hepatic hilum (A and B).*

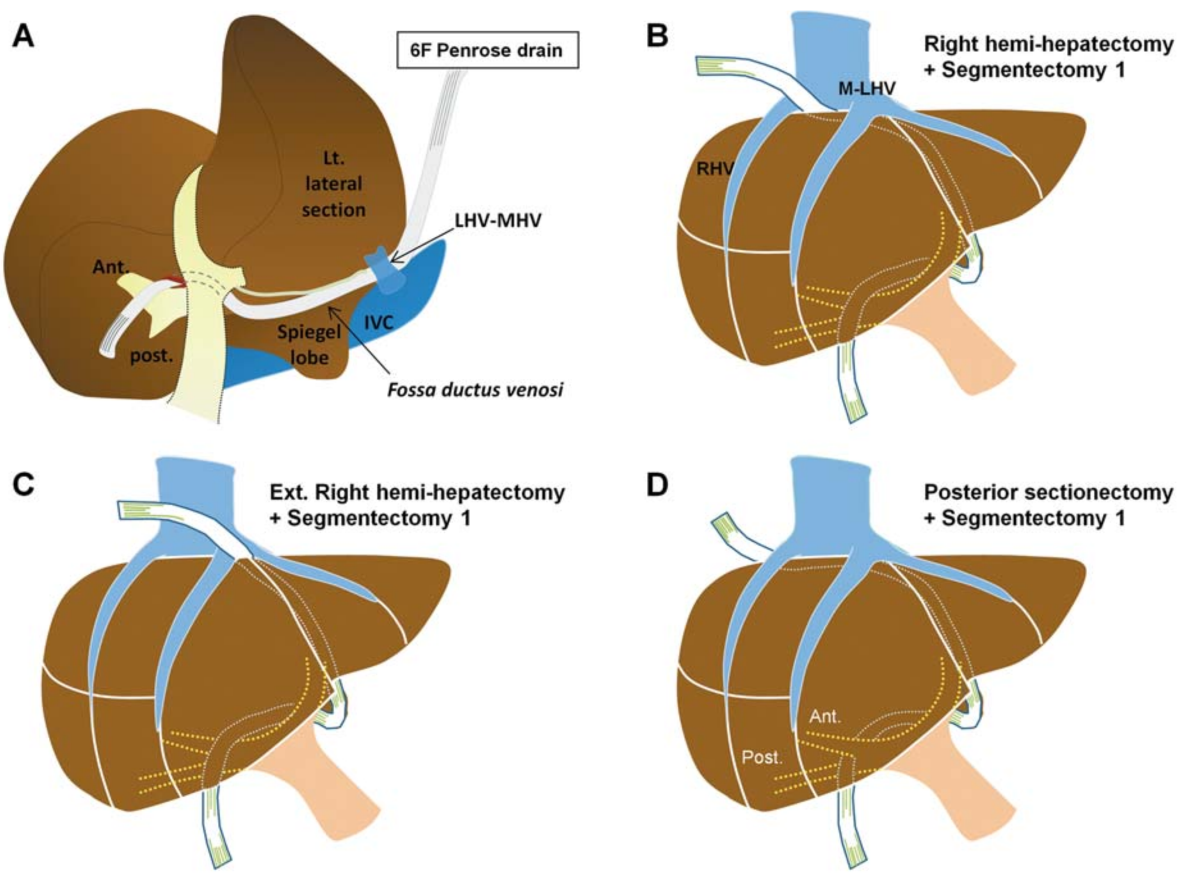

Figure 2. *Scheme of the modified liver hanging maneuver for right-sided hepatectomy with total-caudate lobectomy (A). The cranial tip of a tape is passed behind the common trunk of the left and middle hepatic veins (LHV and MHV) for right hemi-hepatectomy with total-caudate lobectomy (B). The cranial tip is repositioned between the LHV and the MHV for extended right hemi-hepatectomy with total caudate lobectomy (C). For posterior sectionectomy with total caudate lobectomy, the cranial tip is passed to right behind the right hepatic vein (RHV) and the caudal tip is repositioned between the anterior branch and the posterior branch of the right portal pedicle (D).*

Table II. *Surgical outcomes in patients with colorectal-cancer liver metastases (CLM) and hepatocellular carcinoma (HCC) undergoing hepatectomy with or without the modified liver hanging maneuver (mLHM).*

Characteristic	mLHM (n=10)	Non-mLHM (n=16)	*p*-Value
Surgical margin: Negative/positive	8/2	10/6	0.420‡
Resected liver weight (g)	490±203	806±717	0.114†
Duration of operation (min)	511±133	611±177	0.14†
Blood loss (ml)	858±391	3251±3737	0.022†
RBC transfusion (ml)	48±103	1188±1381	0.005†
Time for liver transection (min)	118±58	165±64	0.073†
Blood loss during transection (ml)	500±305	2002±2145	0.014†
Area of cut surface (cm^2)	77±22	82±29	0.609†
Transection blood loss/cut surface (ml/cm^2)	7.47±6.87	25.3±25.0	0.015†
Hospital stay (days)	15±13	24±14	0.114†
Complications			
Uncontrolled ascites: No/yes	9/1	14/2	1.0‡
Hepatic failure: No/yes	9/1	16/0	0.385‡

RBC: Red blood cell. Values are mean ± SD. †Student *t*-test; ‡Fisher exact test.

continuous variables among the treatment groups. Kaplan–Meier survival curves were used to assess patient survival. SPSS statistical software (SPSS 20.0; IBM, Chicago, IL, USA) was used for statistical analyses. Statistical significance was defined as $p<0.05$. All analyses in this study were performed in accordance with the ethical guidelines of the Institutional Ethical Committee, Yokohama City University and Teikyo University, Japan.

Results

We assessed relevant cases among 1168 consecutive hepatectomies performed for CLM and HCC at Yokohama City University Graduate School of Medicine and Teikyo University Chiba Medical Center between November 1985 and September 2014. Right-sided hepatectomies with total caudate lobectomy were performed in 26 patients (2.2%). Of these, 10 patients underwent posterior sectionectomy, eight underwent right hemi-hepatectomy, and eight underwent extended right hemi-hepatectomy. Among these 26 patients, 10 underwent hepatectomy using the mLHM as described above (Figure 1). All patients were treated successfully using conventional techniques. No specific complication was associated with use of an mLHM in the present series.

Table I compares the patient characteristics between mLHM and non-mLHM groups. No significant differences in age, gender, diagnosis (CLM *vs*. HCC), liver function, or non-neoplastic liver disease were noted between the two groups. The mean number of tumors was also similar for both groups. However, the maximum tumor diameter tended to be smaller in the mLHM group than in the non-mLHM group ($p=0.074$). No significant difference was evident in the type of hepatectomy, inclusion of IVC resection, or resection of extrahepatic bile ducts.

Table II displays the operative variables and post-operative outcomes for the 26 patients in this study. No significant difference was noted for surgical margin, resected liver weight, cut-surface area between the mLHM and non-mLHM groups. Volumes for blood loss ($p=0.022$), red blood cell (RBC) transfusion ($p=0.005$), blood loss during liver transection ($p=0.014$), and transection blood loss per unit area of cut surface ($p=0.015$) were all significantly smaller in the mLHM group than in the non-mLHM group. No significant difference in total operative time was noted between the two groups ($p=0.14$), but time required for liver transection tended to be shorter in the mLHM group ($p=0.073$). Post-operative outcome, length of hospital stay and morbidity rate were not significantly different between the two groups. The mean follow-up duration was 572 days (19.1 months; 53 to 1471 days) in the mLHM group and 1812 days (60.4 months; 172 to 4716 days) in the non-mLHM group. No significant difference between groups was apparent in overall survival (OS) (40 months for mLHM *vs*. 68.8 months for non-mLHM, $p=0.945$) and relapse-free survival (RFS) (21.7 months for mLHM *vs*. 27.4 months for non-mLHM, $p=0.940$, log-rank test). Local metastatic recurrence was observed in 4/10 remnant livers in the mLHM group, and in 13/16 remnant livers in the non-mHM group.

The operative data presented in Table II likely reflect more than simply the outcomes related to hepatectomy with and without mLHM, because the function of the uninvolved liver has a great effect. To address this point, we assembled a subgroup of 14 patients diagnosed pathologically with liver impairment (*i.e*. chronic hepatitis, cirrhosis, or steatohepatitis from chemotherapy) from among the 26 patients studied overall, and compared surgical outcomes between mLHM

Table III. *Characteristics of patients with colorectal-cancer liver metastases (CLM) and hepatocellular carcinoma (HCC) with pathological liver impairment undergoing hepatectomy with or without the modified liver hanging maneuver (mLHM).*

Characteristic	mLHM (n=6)	Non-mLHM (n=8)	*p*-Value
Age (years)	69.2±5.1	60.0±13.4	0.108†
Gender: Male/female	4/2	5/3	1.0‡
Diagnosis: CLM/HCC	3/3	2/6	
Parenchymal liver disease: CH/LC/steatohepatitis	2/1/3	3/3/2	0.580‡
Number of tumors	5.17±6.71	5.13±5.51	
Maximum tumor size (mm)	46.7±31.7	65.5±37.5	0.566§
Procedure			
Post.+ Sg1	2	4	0.99†
Rt hemi.+ Sg1	3	2	0.342†
Ext. Rt hemi.+ Sg1	1	2	0.627§
IVC resection: Yes/no	3/3	3/5	1.0‡

CH: Chronic hepatitis; LC: liver cirrhosis; Sg1: segmentectomy 1; Rt hemi.: right hemi-hepatecomy; Ext. Rt hemi.: extended right hemi-hepatecomy; IVC: inferior vena cava. Values are mean ± SD. †Student *t*-test; ‡Fisher exact test; §χ^2 test.

Table IV. Surgical outcomes in patients with colorectal-cancer liver metastases (CLM) and hepatocellular carcinoma (HCC) with pathological liver impairment undergoing hepatectomy with or without the modified liver hanging maneuver (mLHM).

	mLHM (n=6)	Non-mLHM (n=8)	*p*-Value
Surgical margin: Negative/positive	5/1	6/2	1.0‡
Resected liver weight (g)	563±234	692±541	0.598†
Duration of operation (min)	511±86	646±166	0.097†
Blood loss (ml)	875±404	3624±3320	0.052†
RBC transfusion (ml)	80±126	1436±1543	0.042†
Time for liver transection (min)	101±40	178±72	0.038†
Blood loss during transection (ml)	536±319	2819±2713	0.049†
Area of cut surface (cm^2)	74±28	80±34	0.715†
Transection blood loss/cut surface (ml/cm^2)	8.51±8.16	37.3±30.8	0.035†
Hospital stay (days)	17±18	25±19	0.426†
Complications			
Uncontrolled ascites: No/yes	5/1	7/1	1.0‡
Hepatic failure: No/yes	5/1	8/0	0.429‡

RBC: Red blood cell. Values are mean ± SD. †Student *t*-test; ‡Fisher exact test.

and non-mLHM patients for this subgroup. Severity of steatohepatitis was evaluated semi-quantitatively according to Brunt's necro-inflammatory grade (15). Steatohepatitis of grade 1 or more was included in the liver-impairment subgroup. Patient characteristics within this subgroup are summarized in Table III. No significant difference in age, gender, diagnosis (CLM *vs*. HCC), non-neoplastic liver status, average number of tumors, maximum diameter of tumors, type of hepatectomy, or inclusion of IVC resection was evident between mLHM and non-mLHM patients.

Operative data and postoperative outcomes for these 14 patients are shown in Table IV. No significant difference was noted for surgical margin, resected liver weight, or cut-surface area between the two groups. Amount of blood loss and total operative time tended to be lower in the mLHM group, but the difference was not significant. Volume of RBC transfusion (p=0.042), amount of blood loss during transaction (p=0.049), transectional blood loss per unit area of cut surface (p=0.035) were significantly smaller in the mLHM group, as was time for liver transection (p=0.038). No significant difference in OS or RFS was evident between patients treated with mLHM and non-mLHM within the liver-impairment subgroup (mean OS: 41.2 *vs*. 65.8 months, p=0.698; mean RFS, 18.9 *vs*. 37.2 months, p=0.617, log-rank test).

Discussion

The LHM is a useful technique enabling safer, faster, and relatively bloodless hepatic parenchymal transection during right hepatectomy, right anterior sectionectomy, or central bisectionectomy (4, 7, 9). When performing anatomic resection for hepatic tumors located in the caudate lobe with extension to the right hemi-liver, surgical outcome and morbidity are influenced by transection around the caudate lobe. The mLHM procedure can facilitate resection in this critical region, since the greatest advantage of the mLHM is the more reliable confirmation of the appropriate plane for transection permitted by traction on the hanging tape from the opposite side of the cut plane (16). In the present study, mLHM reduced the amount of blood loss and RBC transfusion volume compared to the non-mLHM group. The time required for liver partition also tended to be shorter in the mLHM group. Since a previous report identified increased blood loss as a risk factor for post-hepatectomy morbidity and reduced patient survival (17), reduction of blood loss, by using the mLHM in performing right-sided hepatectomy with total caudate lobectomy was expected to improve post-operative outcomes. In this study, however, the length of hospital stay and morbidity rate did not significantly differ between the groups with and without mLHM.

With regard to possible oncological benefit from the LHM, some reports demonstrated improved outcomes with anterior approaches using the LHM, because such an anterior approach avoids mobilization of the remnant liver and liver rotation, eliminating inadvertent cancer-cell dissemination (18, 19). A recent study by Nanashima *et al*. found that patients with HCC who had distant metastases tended to be more common in the non-LHM group and OS in the LHM group tended to be longer than in the non-LHM group. In patients with CLM, rates of tumor recurrence and distant metastasis were lower in the LHM group, but this did not influence the OS (16). Shindoh *et al*. reported similar outcomes after hepatectomy in patients with and without LHM (20).

We performed liver transection *via* an anterior approach after the right lobe was completely mobilized, given that the most important advantages of the LHM are control of bleeding while transecting the deeper liver parenchyma and improved visibility facilitating a straight transection line. Considering these findings, however, complete liver mobilization before transection might have contributed to the similarity of long-term outcomes for the mLHM group and the non-mHM group.

The state of the liver is likely to influence the surgical outcome. In a study of patients undergoing major hepatectomy, those with steatosis had increased blood loss, more postoperative complications, and longer mean intensive-care-unit stays than did matched control patients with healthy livers (21-23). Other reports indicated that patients with cirrhosis are at increased risk of developing significant peri-operative complications, including intraoperative hemorrhage because of primary hemostatic dysfunction (24, 25). In our study, 14 patients whose liver specimens showed chronic hepatitis, cirrhosis, or steatohepatitis were placed in a subgroup in which to compare surgical outcomes between those undergoing and those not undergoing mLHM. Among these 14 patients, blood loss during liver transection and loss per unit area of cut surface were significantly smaller, and transection time was significantly shorter, in the mLHM group, suggesting potential for improvement of surgical outcomes in such patients. However, post-operative outcome, length of hospital stay, morbidity rate, OS, and RFS showed no significant difference between mLHM and non-mLHM patients with pathologically-evident hepatic compromise.

A cautionary note is that our studies in mouse tumor models have indicated that large liver resection can enhance metastasis (26).

Conclusion

We examined the suitability of a mLHM to right-sided hepatectomy with total caudate lobectomy. Use of mLHM can improve surgical outcomes by reducing blood loss and transection time, especially for patients with liver impairment. To more fully determine the oncological role and significance of mLHM, larger numbers of patients should be examined in prospective randomized controlled studies or in investigations using propensity-score matching. Further development of mLHM techniques may lead to greater OS and RFS since the improvement in all the other parameters indicate mLHM has important potential to increase survival.

Conflict of Interest

None of the Authors have any conflict of interest in regard to this study.

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References

1 Strasberg SM: Nomenclature of hepatic anatomy and resections: a review of the Brisbane 2000 system. J Hepatobiliary Pancreat Surg *12*: 351-355, 2005.
2 Philips P, Farmer RW, Scoggins CR, McMasters KM and Martin RC 2nd: Caudate lobe resections: a single-center experience and evaluation of factors predictive of outcomes. World J Surg Oncol *11*: 220, 2013.
3 Yamamoto J, Kosuge T, Shimada K, Yamasaki S, Takayama T and Makuuchi M: Anterior transhepatic approach for isolated resection of the caudate lobe of the liver. World J Surg *23*: 97-101, 1999.

4 Belghiti J, Guevara OA, Noun R, Saldinger PF and Kianmanesh R: Liver hanging maneuver: a safe approach to right hepatectomy without liver mobilization. J Am Coll Surg *193*: 109-111, 2001.
5 Gaujoux S, Douard R, Ettorre GM, Delmas V, Chevallier JM and Cugnenc PH: Liver hanging maneuver: an anatomic and clinical review. Am J Surg *193*: 488-492, 2007.
6 Hwang S, Lee SG, Lee YJ, Kim KH, Ahn CS, Kim KW, Ko KH and Choi NK: Modified liver hanging maneuver to facilitate left hepatectomy and caudate lobe resection for hilar bile duct cancer. J Gastrointest Surg *12*: 1288-1292, 2008.
7 Kim SH, Park SJ, Lee SA, Lee WJ, Park JW, Hong EK and Kim CW: Various liver resections using hanging maneuver by three glisson's pedicles and three hepatic veins. Ann Surg *245*: 201-205, 2007.
8 Nanashima A, Sumida Y, Abo T, Nagayasu T and Sawai T: Usefulness and application of the liver hanging maneuver for anatomical liver resections. World J Surg *32*: 2070-2076, 2008.
9 Ogata S, Belghiti J, Varma D, Sommacale D, Maeda A, Dondero F and Sauvanet A: Two hundred liver hanging maneuvers for major hepatectomy: a single-center experience. Ann Surg *245*: 31-35, 2007.
10 Kokudo N, Imamura H, Sano K, Zhang K, Hasegawa K, Sugawara Y and Makuuchi M: Ultrasonically assisted retrohepatic dissection for a liver hanging maneuver. Ann Surg *242*: 651-654, 2005.
11 Kokudo N, Sugawara Y, Imamura H, Sano K and Makuuchi M: Sling suspension of the liver in donor operation: a gradual tape-repositioning technique. Transplantation *76*: 803-807, 2003.
12 Endo I, Matsuyama R, Taniguchi K, Sugita M, Takeda K, Tanaka K and Shimada H: Right hepatectomy with resection of caudate lobe and extrahepatic bile duct for hilar cholangiocarcinoma. J Hepatobiliary Pancreat Sci *19*: 216-224, 2012.
13 Yamanaka N, Okamoto E, Kuwata K and Tanaka N: A multiple regression equation for prediction of posthepatectomy liver failure. Ann Surg *200*: 658-663, 1984.
14 Yamanaka N, Okamoto E, Oriyama T, Fujimoto J, Furukawa K, Kawamura E, Tanaka T and Tomoda F: A prediction scoring system to select the surgical treatment of liver cancer. Further refinement based on 10 years of use. Ann Surg *219*: 342-346, 1994.
15 Brunt EM, Janney CG, Di Bisceglie AM, Neuschwander-Tetri BA and Bacon BR: Nonalcoholic steatohepatitis: a proposal for grading and staging the histological lesions. Am J Gastroenterol *94*: 2467-2474, 1999.
16 Nanashima A, Abo T, Takagi K, Arai J, To K, Kunizaki M, Hidaka S, Takeshita H, Sawai T and Nagayasu T: Prognostic influence of the liver hanging maneuver for patients with hepatobiliary malignancies who underwent hepatic resections. Eur J Surg Oncol *40*: 1540-1549, 2014.
17 Katz SC, Shia J, Liau KH, Gonen M, Ruo L, Jarnagin WR, Fong Y, D'Angelica MI, Blumgart LH and Dematteo RP: Operative blood loss independently predicts recurrence and survival after resection of hepatocellular carcinoma. Ann Surg *249*: 617-623, 2009.
18 Capussotti L, Ferrero A, Russolillo N, Langella S, Lo Tesoriere R and Vigano L: Routine anterior approach during right hepatectomy: results of a prospective randomised controlled trial. J Gastrointest Surg *16*: 1324-1332, 2012.
19 Liu CL, Fan ST, Cheung ST, Lo CM, Ng IO and Wong J: Anterior approach *versus* conventional approach right hepatic resection for large hepatocellular carcinoma: a prospective randomized controlled study. Ann Surg *244*: 194-203, 2006.
20 Shindoh J, Hasegawa K, Aoki T, Beck Y, Sugawara Y, Makuuchi M and Kokudo N: Significance of liver hanging maneuvers for invasive liver lesions in no-routine anterior approach policy. J Gastrointest Surg *15*: 988-995, 2011.
21 Maor Y, Malnick S: Liver injury induced by anticancer chemotherapy and radiation therapy. Int J Hepatol *2013*: 815105, 2013.
22 McCormack L, Petrowsky H, Jochum W, Furrer K, Clavien PA: Hepatic steatosis is a risk factor for postoperative complications after major hepatectomy: a matched case-control study. Ann Surg *245*: 923-930, 2007.
23 Karoui M, Penna C, Amin-Hashem M, Mitry E, Benoist S, Franc B, Rougier P and Nordlinger B: Influence of preoperative chemotherapy on the risk of major hepatectomy for colorectal liver metastases. Ann Surg *243*: 1-7, 2006.
24 Grazia Scuderi M, Magro G, Cataldo AD, Pesce A, Scalora L, Vecchio GM, Portale R, Benedetto VD and Puleo S: Evaluation of neoadjuvant chemotherapy effects on liver parenchyma in resected pediatric malignancies. Pediatr Hematol Oncol *30*: 392-399, 2013.
25 Violi F, Leo R, Vezza E, Basili S, Cordova C and Balsano F: Bleeding time in patients with cirrhosis: relation with degree of liver failure and clotting abnormalities. C.A.L.C. Group. Coagulation Abnormalities in Cirrhosis Study Group. J Hepatol *20*: 531-536, 1994.
26 Momiyama M, Kumamoto T, Suetsugu A, Kishimoto H, Chishima T, Tanaka K, Akiyama H, Ichikawa Y, Bouvet M, Endo I and Hoffman RM: Major liver resection stimulates stromal recruitment and metastasis compared with repeated minor resection. J Surg Res *178*: 280-287, 2012.

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