Liver Hanging Maneuver Decrease Blood Loss and operative time in a Right-Side Hepatectomy

RUNNING TITLE: Liver hanging maneuver for right hepatectomy

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ABBREVIATIONS: Liver hanging maneuver (LHM), inferior vena cava (IVC), modified LHM (mLHM), fresh frozen plasma (FFP), acute respiratory distress syndrome (ARDS)

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ABSTRACT

BACKGROUND/AIMS: To clarify the clinical benefits of the maneuver in right-side hepatectomy.

METHODOLOGY: Eighty-one patients with liver tumor (54 hepatocellular carcinoma, 17 metastatic liver tumor, and 10 other tumors) treated with a right-side hepatectomy were prospectively analyzed. The patients were divided into the following three groups: a conventional approach (group A, n = 21); a liver dissection under the hanging maneuver after a liver mobilization (group B, n = 19); and a liver dissection under the hanging maneuver prior to a liver mobilization (group C, n = 41).

RESULTS: The liver hanging maneuver was safely performed in all the patients in groups B and C. The tumor size had a significantly positive correlation with the amount of intraoperative blood loss (R=0.52, P<0.05) in group A only. The patients in groups B and C had a significantly lower intraoperative use of blood loss (both, P<0.01), operation time (P<0.05 and P<0.01), and the frequency of blood product (both, P<0.05), in comparison to the group A, respectively. The postoperative morbidity and the mortality rates were similar the three groups.

CONCLUSIONS: Liver hanging maneuver is a safe procedure, which can decrease the intraoperative blood loss and the administration of blood product in a right-side hepatectomy.

INTRODUCTION

In a right-side hepatectomy, including a right and extended right hepatectomy, and a right tri-sectionectomy, the complete mobilization of the right liver prior to a parenchymal transection is considered a standard procedure (1). For the treatment of a large tumor and/or an invasion to the diaphragm, an anterior approach was developed with a parenchymal transection from the anterior surface down to the inferior vena cava (IVC) without liver mobilization (2).

Liver hanging maneuver (LHM), introduced by Belghiti and coworkers in 2001, is a new technique of anterior approach for right hepatectomy (3, 4), which was later applied to other types of hepatic resections (5-9). The hanging tape was required to pass between the anterior surface of the inferior vena cava (IVC) and the liver parenchyma. This procedure was recommended prior to liver mobilization, but a few patients experienced bleeding during the retrohepatic dissection due to injury of the hepatic capsule, the caudate vein, and the short hepatic vein (3, 4). Therefore, we started the modified LHM (mLHM) after the mobilization of the liver, and then switched to the original LHM that was introduced by Belghiti and coworkers (3).

Even in a large tumor, LHM allows for the dissection of liver without initial liver mobilization. The absence of rotation or compression of the liver has many advantages in a hepatic resection, especially for the malignant liver tumors. LHM can prevent the spillage of cancer cells into the intrahepatic vessels, the iatrogenic rupture of tumor capsule, and the maintenance of the hepatic flow of the remnant liver during hepatic transection. Moreover, hanging the liver with a tape along the retrohepatic avascular space has several advantages as follows: it facilitates the control of the bleeding at the deeper parenchymal plane; and, it guides the direction of anatomic parenchymal transection (3, 4). However, the impact of LHM has not been fully investigated in patients with liver tumors.   In order to evaluate the potential benefits of LHM, a comparative study of the patients with liver tumors treated with a right-side hepatectomy.

METHODOLOGY

Patients

From January 2000 to August 2007, a total of 479 hepatectomies were performed at the Department of Gastroenterological Surgery, Graduate School of Medical Sciences, Kumamoto University. Eighty-one patients (54 patients with liver tumor hepatocellular carcinoma, 17 patients with metastatic liver tumor, and 10 patients with other tumors)

who were considered for right-side hepatectomy were prospectively analyzed. A right-side hepatectomy was excluded in the patients without the liver tumor and the donor's operation of liver transplantation. The right-side hepatectomy included 41 right hepatectomies, 26 extended right hepatectomies, and 14 right tri-sectionectomies. The patients were divided into three groups; a conventional approach group (group A, n = 21, from 2000 to 2005), a modified LHM group (group B, n = 19, from 2003 to 2005), and a LHM group (group C, n = 41, from 2005 to 2007). LHM was indicated if the tumors did not infiltrate the anterior surface of the retrohepatic IVC. The HCC patients with compression of the IVC or of the major hepatic veins were not considered as contraindications to perform LHM.

The surgical techniques used in liver hanging maneuver

The liver was exposed through an abdominal J-shaped incision. A thoracotomy was added if the tumor was too large to manipulate or if it invaded the diaphragm. An intraoperative ultrasound was performed and special attention was paid to confirm the absence of tumor infiltration at the 10 to 11 o'clock position of the anterior surface of the retrohepatic IVC (3). The liver hilar dissection was achieved mainly by using the Glissonean approach (10), but, in the patients with a huge tumor compressing hilar vascular system, an individual dissection of the vessels was selected. The hepatic inflow of the resected liver was completely interrupted before the liver was isolated. In group A (conventional approach), after the complete mobilization of the right liver from the posterior abdominal wall to allow separation of the liver from the IVC, the liver transection was performed with an ultrasonic dissector and bipolar forceps without LHM. In group B (mLHM), a complete right liver mobilization was performed until a condition of safe taping was achieved for LHM. The liver transection was performed under LHM, using the same devices employed in group A. Inititally, in group C (LHM), without mobilization of the right liver including the tumor, the LHM was completed in a blind

manner. The ultrasonic parenchymal transection with precoagulation was performed under an anterior approach using LHM followed by the mobilization of the right liver. The parenchymal transection in all the groups was achieved with an ultrasonic dissector. The precoagulation technique with a dissecting sealer (Valley Lab, Boulder, Colorado, USA) 11) or the VIO soft coagulation system (ERBE, Elektromedizin GmbH, Germany) was used only in group C. The LHM technique was described previously (3). A blind retrohepatic dissection was performed at first. A cranial point was defined as the anterior surface of the suprahepatic IVC between RHV and MHV, and the caudal point was defined as an anterior surface of the infrahepatic IVC located at the back of the borderline of the right-and-left caudate lobe. The long clamp was inserted from a caudal to a cranial point through an avascular space, of approximately 1 cm in width, located at the anterior surface of the retrohepatic IVC. A 6- or 10-mm-wide soft, silicon multitubular drain was then seized with the clamp and pulled through the retrohepatic space, and was switched from the caudal side to the cranial side of the right portal pedicle. The hepatic transection was performed from the anterior surface of the liver to the right liver hilum, and down to the anterior surface of the IVC. After transection, the short hepatic, inferior right and right hepatic veins were then isolated, divided, and either ligated or sutured. Some of the large hepatic veins and the Glissonean sheaths were cut and closed with automatic suturing devices. An interruption of the hepatic flow was not performed. A minimal hemihepatic vascular occlusion (30 min of clamping and 5 min of release) (12) or the Pringle's maneuver (15 min of clamping and 5 min of release) was applied only in patients who had a tendency to bleed. In addition, the recommended low central venous blood pressure, that was controlled by the anesthesia team during the hepatectomy, helped to reduce the blood loss in the hepatic vein injury.

Outcome measures

In the three groups, the preoperative mean age, the Child-Pugh classification, the

diagnosis of liver tumor, the tumor size, the resected liver weight, the operative time, the intraoperative blood loss, and the frequency of RBC transfusion and the administration of fresh frozen plasma (FFP) were analyzed. The correlation between the tumor size and the amount of intraoperative blood loss in the three groups were evaluated. The operative morbidity and the hospital mortality were prospectively recorded. The postoperative events that required any surgical intervention or any of the events that extended the hospital stay to longer than one month were defined as complications. Hyperbilirubinemia was defined as the maximum total bilirubin level greater than 5 mg/dl.

Statistical analysis

The data were expressed as the mean ± standard deviation. The analysis of variance (ANOVA) and the t-test of independent means were used to determine the differences between multiple and two groups, respectively. A p-value less than 0.05 was considered significant.

RESULTS

The clinical characteristics of the patients are summarized in Table 1. In groups A, B, and C, the mean age was 55 ± 10.7, 59 ± 8.8, and 66 ±1 0.7 years, and the mean tumor size was 64.5 ± 48.2, 75 ±3 9.4, and 89.3 ± 48.3 mm, respectively. Group C had significantly older patients (p<0.05), had a significantly larger proportion of females (p<0.05), and had patients with larger tumors (p<0.01). There were no significant differences in the Child-pugh classification, the diagnosis of the liver tumor, and the resected liver weight. In group C, including the 15 of the 41 (36.6%) patients with the tumor compressing IVC, all the patients achieved LHM without any complication. A partial dissection of the IVC was needed in one patient with direct invasion to the side wall of the IVC.

The operative outcome is listed in Table 2. In groups A, B, and C, the mean surgical time was 562 ± 111, 472 ± 128, and 465 ± 104 minutes, the mean intraoperative blood

loss was 1771 ±1213 g, 805 ± 484g, and 671 ± 622g, the frequency of red blood cell transfusion was 33%, 21%, and 17%, and the frequency of fresh frozen plasma administration was 48%, 21%, and 11%, respectively. The operative blood loss and the operating time were significantly lower in group B (P <0.01, P <0.05) and group C (P<0.01, P <0.01) in comparison to group A, respectively. A massive operative blood loss of larger than 2 L occurred less frequently in groups B and C in comparison to group A (33% vs. 5.2%, and 4.9%, P < 0.01). The frequency of RBC transfusion was significantly lower in group C in comparison to group A (P <0.01), but groups A and B were similar. The frequency of the FFP administration was significantly lower in group C in comparison to groups A and B (P <0.0001, P <0.0001), and the rate was significantly reduced in group C in comparison to group B. The tumor size had a significantly positive correlation with the amount of intraoperative blood loss (R=0.52, P<0.05) in group A, but no significant relationships were found in groups B and C (Fig. 1). The postoperative morbidity rates were 33.3%, 15.8%, and 16.7% in groups A, B, and C, respectively. In group A there were 3 patients with hyperbilirubinemia, 2 patients with biliary fistula, 1 patient with hepatic failure, and 1 patient with a single wound infection. In group B there was one patient with biliary fistula, hemorrage and portal t thrombus, and all one portal thrombus, acute respiratory distress syndrome (ARDS) and biliary stricture. Hospital deaths occurred in 1 patient from the A and B groups, and 2 patients from group C. The causes of deaths were a hepatic failure due to postoperative rapid growth of the HCC in group A, a portal vein thrombosis after the removal of the portal tumor thrombosis in group B, and an ARDS following wound infection and an infection by the multidrug-resistant strains of Staphylococcus aureus in group C. The postoperative morbidity and the hospital mortality rates were similar in all three groups.

DISCUSSION

LHM was initially developed for the right hepatectomy and it was later modified for

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the left hepatectomy, the living donor hepatectomy, the caudate lobectomy, and for other anatomic liver resections (3-9). The key to LHM was the retrohepatic avascular tunnel that was anterior anatomically to the surface of the IVC. A clamp progression was possible in a channel free from any vascular injury risk in 85% to 93% of the patients reported in the anatomical studies (13,16). Consequently, 7% to 15% presence of a passage that is not truly avascular but that is vascularized by a lower density of veins, was reported regardless of whether the study was cadaveric or in vivo (16).

The intraoperative ultrasonography-guided and the endoscopic-assisted dissections of the retrohepatic tunnel were considered (17, 18). LHM was reported to be successfully performed in 201 patients with an overall feasibility of 88%, and the feasibility has increased significantly in recent years in comparison to the earlier years (94% from 2003–2005 vs. 76% from 2000–2002, P < 0.0001) (4). The bleeding risks during the retrohepatic dissection decreased to a range of 0% to 6% (6,7,16,17). Bleeding, when it occurred, was frequently minor, and few cases required the conversion to an anterior approach (3). The feasibility is increasing in parallel with the growing experience of the surgical team. . In this study, the LHM procedure reported by Belghiti and coworkers was successfully applied without the occurrence bleeding in all of the 41 patients, including the 15 patients with the tumor compressing IVC in the diagnostic imaging before surgery. In one patient with liver metastases, the simultaneous resection of the right wall of the IVC was needed, but the LHM was safely performed. During the same period, only 3 patients were preoperatively determined to be contraindications of LHM. If the tumor invasion was not observed on the anteromedian surface of the IVC, then the LHM was not necessarily contraindicative. Fourteen (6%) patients of the 242 patients were considered to have contraindication for LHM preoperatively because of the tumor infiltration to the anterior surface of the retrohepatic IVC (4).

The hanging tape used in this procedure performed two important roles, one was a

guide to the transection plane and the second was a means of retracting the liver. A pulling and aiming at the tape surrounding the transection plane facilitated the exposure and the bleeding control of the deep part of the parenchyma, and protected the retrohepatic IVC, the main Glissonean pedicle, and the hepatic vein of the remaining liver; Hence, the liver parenchyma can be safely divided without any compression or retraction of the other parts of the liver. In the current study, the patients in group C were significantly older (average; 66 years, P<0.05) than the patients in group A and had a larger tumor (89 mm, P <0.01 and P <0.05) in comparison to the other two groups. Nevertheless, the patients in groups B and C had a significantly shorter surgical time (472 minutes and 451 minutes, P<0.05 and P<0.01), intraoperative blood loss (805 g, and 671 g, both P <0.01) and shorter surgical time (472 minute and 465 minute, P <0.05 and P <0.01), in comparison group A (562 minute). The tumor size had significantly positive correlation with the amount of intraoperative blood loss (R=0.52, P <0.05) only in group A. Both before and after the mobilization of the liver, LHM can result in a stable hepatic resection regardless of a large tumor size in group B and C. The frequencies of the RBC transfusion in groups B and C were 21% and 24%, respectively. These frequencies were significantly lower than that of group A (33%, P <0.05). The frequencies of the FFP administration in groups B and C were 21% and 15%, respectively, and were significantly lower than that of group A (48%, both P <0.05). Furthermore, the rate was significantly lower in group C in comparison to group B. In group B, the hanging tape was inserted after the mobilization of the right liver. LHM also can reduce the frequency of the FFP administration. LHM before right liver mobilization may be useful in reducing the amount of FFP. The different results observed between groups B and C may be due to the precoagulation technique with dissecting or to the VIO soft coagulation system. Another study reported that LHM had no impact on the intraoperative bleeding, the blood transfusion, and the operating time in the patients with 71 anatomical liver resections, including those with 35 right-side hepatectomies (19).

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With respect to avoiding the intravenous tumor cell seeding in the operation, LHM must be performed, prior to the mobilization of the right liver with the viable tumor. With the Belghiti's LHM procedure used in group C, the liver mobilization was performed after a complete dissection of the right portal pedicle, and the short, inferior right, and the right hepatic vein. A limited remnant liver mobilization might reduce the risk of malignant dissemination in the operative period. The anterior approach without the LHM can result in better operative and survival outcomes in comparison to the conventional approach used in a major right hepatic resection for large hepatocellular carcinoma (20). Further investigation is required to evaluate the impact of LHM on the recurrence and the long survival of malignant liver tumors. The rate of morbidity was lower in the LHM group and the hospital mortality rate was similar in all three groups. In addition, no intra- and post-operative complications related to LHM was observed. The lower morbidity rate in the LHM group might correlate with a stable blood flow and a lower   congestion of the remnant liver during the whole operative steps. In conclusion, LHM is a safe and very useful method to reduce the surgical insults incurred as a result of a right-side hepatectomy.

REFERENCES

1 Schwartz SI: Hepatic resection. Ann Surg 1990; 211: 1–8.

2 Lai EC, Fan ST, Lo CM, Chu KM, Liu CI: Anterior approach for difficult major right hepatectomy. World J Surg 1996; 20: 314–317.

3 Belghiti J, Guevara OA, Noun R, Saldinger PF, Kianmanesh R: Liver hanging maneuver: a safe approach to right hepatectomy without liver mobilization. J Am Coll Surg 2001;193:109–111.

4 Ogata S, Belghiti J, Varma D, Sommacale D, Maeda A, Dondero F, Sauvanet A: Two hundred liver hanging maneuvers for major hepatectomy: a single-center experience. Ann Surg 2007;245:31-5.

5 Wen Y, Miao X, Xiong L, Xiong G, Hu J, Zhong D, Li Q, Liu W; Application of

hemihepatic vascular occlusion with hanging maneuver in hepatectomy. Hepatogastroenterol 2009; 56: 442-6.

6 Suh KS, Lee HJ, Kim SH, Kim SB, Lee KU: Hanging maneuver in left hepatectomy. Hepatogastroenterol 2004; 51: 1464-6.

7 Kokudo N, Sugawara Y, Imamura H, Sano K, Makuuchi M: Sling suspension of the liver in donor operation: a gradual tape-repositioning technique. Transplantation 2003;76:803–807.

8 Tanaka H, Takemura S, Ohba K, Hai S, Ichikawa T, Kodai S, Shinkawa H, Shuto T, Hirohashi K, Kubo S: Convenience of a tape-guiding technique in different types of hepatectomy. Hepatogastroenterol 2008; 55: 160-3.

9 Kim SH, Park SJ, Lee SA, Lee WJ, Park JW, Hong EK, Kim CM: Various liver resections using hanging maneuver by three glisson's pedicles and three hepatic veins. Ann Surg 2007 245:201-5.

10 Takasaki K: Glissonean pedicle transection method for hepatic resection: a new concept of liver segmentation. J Hepatobiliary Pancreat Surg 1998;5:286-91.

11 Fioole B, van der Bilt JD, Elias SG, de Hoog J, Borel Rinkes IH: Precoagulation minimizes blood loss during standardized hepatic resection in an experimental model. Br J Surg 2005; 92:1409-16.

12 Makuuchi M, Mori T, Gunvén P, Yamazaki S, Hasegawa H: Safety of hemihepatic vascular occlusion during resection of the liver. Surg Gynecol Obstet 198;164:155-8.

13 Sato TJ, Hirai I, Murakami G, Kanamura T, Hata F, Hirata K: An anatomical study of short hepatic veins, with special reference to delineation of the caudate lobe for hanging maneuver of the liver without the usual mobilization. J Hepatobiliary Pancreat Surg 2002; 9: 55–60.

14 Hirai I, Murakami G, Kimura W, Kanamura T, Sato I: How should we treat short hepatic veins and paracaval branches in anterior hepatectomy using the hanging maneuver without mobilization of the liver? An anatomical and experimental study. Clin

Anat 2003; 16 : 224–232

15 Meng WC, Shao CX, Mak KL, Lau PY, Yeung YP, Yip AW: Anatomical justification of Belghiti's 'liver hanging manoeuvre' in right hepatectomy with anterior approach. ANZ J Surg 2003; 73: 407–409.

16 Ettorre GM, Douard R, Corazza V, Santoro R, Vennarecci G, Santoro E: Anatomical basis of liver hanging maneuver: a clinical and anatomical in vivo study. Am Surg 2007; 73:1193-6.

17 Kokudo N, Imamura H, Sano K, Zhang K, Hasegawa K, Sugawara Y, Makuuchi M: Ultrasonically assisted retrohepatic dissection for a liver hanging maneuver. Ann Surg 2005; 242:651-4.

18 Lai PB, Wong J, Ng WW, Lee WL, Cheung YS, Tsang YY, Lee KF: Safe modification of the liver-hanging maneuver by endoscopic-assisted dissection of the retrohepatic tunnel. Surg Today 2007;37:915-7.

19 Nanashima A, Sumida Y, Abo T, Nagayasu T, Sawai T: Usefulness and application of the liver hanging maneuver for anatomical liver resections. World J Surg 2008 32:2070-6.

20 Liu CL, Fan ST, Cheung ST, Lo CM, Ng IO, Wong J: Anterior approach versus conventional approach right hepatic resection for large hepatocellular carcinoma: a prospective randomized controlled study. Ann Surg 2006; 244:194-203.

FIGURE LEGENDS

Fig. 1 The correlations between the tumor size and the amount of intraoperative blood loss in the three groups.

The tumor size has a significantly positive correlation with the amount of intraoperative blood loss only in group A (R=0.52, P<0.05).