Central Hepatectomy Using the Hilar Approach for Removal of Tumors in the Paracaval Portion of the Caudate Lobe

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ABSTRACT

Safe hepatectomy for the paracaval portion of the caudate lobe is technically demanding. We propose central hepatectomy using the hilar approach for resection of the paracaval portion. The right liver with the caudate lobe was totally mobilized from the inferior vena cava. Central hepatectomy with or without middle hepatic vein (MHV) resection was performed by dividing the right anterior and left medial sections vertically toward the inferior vena cava. The bilateral Glissonian pedicles were widely exposed (hilar approach), and the liver parenchyma including the paracaval portion of the liver was removed with a good surgical view. This procedure was performed in four patients with hepatocellular carcinoma, one patient with intrahepatic cholangiocarcinoma, and one patient with colorectal liver metastasis. Combined resection of the MHV was performed in four patients, and removal of the tumor thrombus in the bile duct was performed in one patient. The median operation time was 439 minutes, and the median blood loss was 800 ml. The resected liver parenchyma was 12.0% (range, 4.7%–39.5%) of the total liver volume. No patients developed postoperative liver failure. Central hepatectomy using the hilar approach is a safe, parenchyma-preserving surgical procedure for removal of tumors located in the paracaval portion.

Key words: central hepatectomy, hilar approach, caudate lobe, paracaval tumor, parenchyma-preserving hepatectomy

Abbreviations:

MHV - middle hepatic vein
IVC - inferior vena cava
HCC - hepatocellular carcinoma
BDTT - bile duct tumor thrombus
RHV - right hepatic vein

INTRODUCTION

The caudate lobe is located deep within the liver and surrounded by the three major hepatic veins, the inferior vena cava (IVC), and the hepatic hilum (1,2). The caudate lobe of the liver consists of three portions: the Spiegel lobe, the caudate process, and the paracaval portion (3,4). Among the three portions of the caudate lobe, resection of tumors in the paracaval portion is most challenging. Resection of hepatocellular carcinoma (HCC) in the paracaval portion is reportedly associated with a longer operation time, larger blood loss

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volume, and smaller surgical margins than resection in other sites within the caudate lobe (5). Resection of the paracaval portion can be performed in combination with other resection techniques such as extended hemihepatectomy (6) or posterior sectionectomy in patients with enough functional reserve (7). However, isolated caudate lobectomy using a high dorsal approach (8) or anterior transhepatic approach (9) is required in patients with impaired liver function reserve, and the liver parenchyma should be preserved as much as possible to prevent postoperative liver failure. Although the high dorsal approach is ultimately an isolated caudate lobectomy procedure, it is technically demanding because of the strictly limited surgical field. The transhepatic approach is also a parenchyma-preserving alternative, but removal of tumors invading the middle hepatic vein (MHV) is difficult, and some ischemic or congested areas remain.

Therefore, we propose central hepatectomy using the hilar approach as a useful and safe alternative for removal of tumors located in the paracaval portion of the liver with a good surgical field.

CASE REPORTS

Central hepatectomy using the hilar approach was performed in six patients: four with HCCs in segment 1 [one of these patients had HCC with a bile duct tumor thrombus (BDTT) via the anterior bile duct (Patient #2)], one patient with intrahepatic cholangiocarcinoma, and one patient with multiple colorectal liver metastases in segments 4, 5, and 8 and the paracaval portion. The patients' characteristics are shown on *table 1*. We

calculated the future liver remnant from the pre-operative computed tomography images using three-dimensional simulation software (Synapse Vincent; Fujifilm, Tokyo, Japan) (10). The surgical indication was determined based on our resection criteria as represented by the indocyanine green retention rate at 15 min (11).

SURGICAL PROCEDURE

An inverted L-shaped skin incision was used to perform the laparotomy. In Patient #3, a thoracotomy was added at the ninth intercostal space because a sufficient surgical field was not obtained. The location of the tumor was confirmed by intraoperative ultrasonography. First, the right liver with the caudate lobe was totally mobilized from the IVC by ligating and dividing the short hepatic veins. The right hepatic vein (RHV) was taped as a landmark during liver transection. The IVC was also taped to control bleeding during resection of the liver parenchyma, if necessary. Second, liver transection lines were designed to remove the central part of the liver, including the paracaval portion. The left-side line was designed along the falciform ligament in case of combined resection of the MHV or Spiegel lobe. In contrast, the left-side line might course along the MHV if required according to the tumor location (*fig. 1 a–d*). To determine the right-side line, indigocarmine solution with indocyanine green was injected into the portal branch of the right anterior section or the ventral branch of segment 8, and the stained area was marked with electrocautery (12,13) (*fig. 2 a,b*). To determine the right-sided border of the

Table 1 - Characteristics and surgical outcomes of central hepatectomy using the hilar approach

No.	Age Sex	Diagnosis	Tumor size (cm)	ICG-R15 (%)	Procedure of central hepatectomy	Op time (min)	Blood loss (mL)	Transfusion	*Resected liver volume (mL) (/TLV)	Morbidity	Hospital stay (days)	Outcome
1	80's F	HCC	2.5	9.8	S4+S8vent+PC+SP with MHV resection	442	110	no	220 (25.7%)	None	14	No recurrence, alive (4y4m)
2	60's M	HBV, HCC with BDTT	3	22.8	Partial S5+S8vent+PC+CP with T-tube drainage	420	1100	no	63 (6.8%)	Bile leakage	33	No recurrence, alive (3y1m)
3	70's M	HCC	13	17	S4+S5+S8vent+PC with MHV resection	715	3380	no	87 (4.7%)	Ascites	19	Liver recurrence, alive (1y1m)
4	80's F	HCV, HCC	1.7	15.8	S8vent+PC	433	1115	yes	39 (5.2%)	Pulmonary effusion	13	No recurrence, alive (1y11m)
5	60's F	ICC	9.5	7.0	S4/5/8+PC with MHV resection	435	500	no	359 (39.5%)	Abdominal abscess	25	Liver recurrence, alive (1y5m)
6	30's M	CRLM	2.5	9.5	Partial S4/5/8 +PC with MHV resection	477	450	no	143 (17.2%)	None	14	Pelvis, liver recurrence, alive (3y0m)

F, female; M, male; HCC, hepatocellular carcinoma; BDTT, bile duct tumor thrombus; ICC, intrahepatic cholangiocarcinoma; CRLM, colorectal liver metastasis; ICG-R15, indocyanine green retention rate at 15 min; vent, ventral area; PC, paracaval portion; SP, Spiegel lobe; MHV, middle hepatic vein; CP, caudate process; TLV, total non-cancerous liver volume; LN, lymph node

*Resected liver volume = 'Resected volume of the specimen' – 'Tumor volume calculated by CT volumetry'

Figure 1 - Liver resection lines in central hepatectomy

a. The tumor of Patient #5 was large, requiring combined resection of the MHV. The left-side line was along the falciform ligament (arrows). The right-side line was marked between the right anterior section and the right posterior section (arrowheads). b. The caudal view of a three-dimensional simulation image of Patient #5 is shown. The tumor and the future liver remnant are colored red and yellow, respectively. c. The liver function of Patient #2 was impaired, requiring preservation of a large future liver remnant. The left-side line was marked along the MHV (arrows). The right-side line was determined by the location of the anterior Glissonian pedicle and the root of the RHV (arrowheads). d. The caudal view of a three-dimensional simulation image of Patient #2 is shown. The tumor and the future liver remnant are colored red and yellow, respectively. MHV, middle hepatic vein; RHV, right hepatic vein

paracaval portion, the paracaval branch was punctured when possible (*fig. 2 c,d*). Third, liver transection was started on the right side, dividing the portal branches associated with right anterior section or dividing the right anterior fissure, exposing the wall of the RHV. Liver transection was performed using the clamp–crush technique under the Pringle maneuver. The left hand of the operator was placed behind the right liver and in front of the IVC, pushing up and controlling the venous backflow from the RHV. The parenchyma belonging to the paracaval portion was easily divided with guidance provided by the left hand between the right liver and IVC or using the landmark of the taped RHV (*fig. 3 a,b*). The caudate branches originating from the hilar plate were meticulously ligated and divided, allowing dissection of the caudate lobe off the hilar plate (*fig. 4 a,b*). During these maneuvers, the bilateral Glissonian pedicles were taped and the hilar plate was widely exposed (hilar approach). Next, the left side of the liver was transected by dividing the portal pedicles supplying the left medial section (segment 4) toward

the root of the MHV. Arantius' ligament was divided, but removal of the Spiegel lobe was required in selected cases. Finally, the MHV was divided and the central liver with the caudate lobe was extracted. The stump of the MHV was sutured continuously. The cut surfaces after central hepatectomy and the resected specimen are shown in *fig. 5*.

RESULTS

The surgical outcomes of all six patients (three men, three women) are summarized in *table 1*. The patients' median age was 71 years (range, 34–83 years). The median tumor size was 2.8 cm. The median indocyanine green retention rate at 15 min was 12.8%. Combined resection with the MHV was performed in four patients, and the MHV was preserved in two patients. The median operation time was 439 min, and the median blood loss volume was 800 mL. The median occlusion time during the Pringle maneuver was 118 min (range, 60–143 min). The median resected volume

Figure 2 - An example of identification of the anatomical border (Patient #5)

a. The portal branch of the right anterior section was punctured, and indigocarmine solution with indocyanine green was injected (arrow). b. The area stained by indocyanine green appeared green by the fluorescence imaging system (PINPOINT; Novadaq, Mississauga, Ontario, Canada). c. Indigocarmine solution with indocyanine green was also injected into the portal branch of the paracaval portion. However, the border of the paracaval portion was obscure (arrowheads). d. The border of the paracaval portion was clearly visualized by the PINPOINT system (arrow heads).

was 12.0% (range, 4.7%–39.5%) of the total liver. No patients developed postoperative liver failure.

DISCUSSIONS

We modified the isolated caudate lobectomy procedure using an anterior approach and described central hepatectomy using the hilar approach,

Figure 3 - An example of the cut surface of the right side of central hepatectomy (Patient #5)

a. The root of the RHV and the common root of the MHV and LHV were taped by blue vessel loops. The right anterior section was divided vertically until the wall of the IVC was exposed. The portal branch of the paracaval portion was taped by a yellow vessel loop. The paracaval portion (asterisk) was included in the excision side. b. A schema of figure 3a is shown. IVC, inferior vena cava; RHV, right hepatic vein; MHV, middle hepatic vein; LHV, left hepatic vein

Figure 4 - Tips for central hepatectomy using the hilar approach (Patient #1)

a. The bilateral Glissonian pedicles were taped (arrows) and the hilar plate was pulled caudally for a good surgical view. The surgeon's left index finger (star) was placed on the ventral side of the IVC, the dorsal side of the paracaval portion (asterisk), the caudal side of the root of the RHV, and the cranial side of the hilar plate. This procedure facilitated bleeding control. b. A schema of figure 4a is shown. IVC, inferior vena cava; RHV, right hepatic vein

Figure 5.

a. The cut surfaces of central hepatectomy using the hilar approach are shown (Patient #1). The bilateral Glissonian pedicles (arrows) and the hepatoduodenal ligament (arrowhead) were taped. b. An example of the resected specimen is shown (Patient #6).

especially for removal of tumors located in the paracaval portion of the liver with preservation of the greatest amount of liver parenchyma possible. This technique has two main differences from the anterior approach: all or part of the anterior section and left medial section are sacrificed in a square shape, and the MHV is divided if necessary to obtain a good surgical field, especially behind the MHV.

Central hepatectomy using the hilar approach can maintain a good balance between establishment of a favorable surgical field and preservation of the remnant liver function. Longitudinal and straight transection lines can ensure technical ease and a good surgical field. Additionally, our case series included one patient (Patient #3) whose tumor was >10 cm in size and

another patient (Patient #2) who underwent bile duct-preserving surgery for HCC with BDDT (14). By taping the bilateral Glissonian pedicles, the tumor was safely detached from the right Glissonian pedicle and the BDDT was removed from the right hepatic duct. Shindoh et al. (15) reported a similar technique for central hepatectomy. They resected the central segments systematically (S8+S5 ventral area and S4), which required removal of 30% of the liver parenchyma. In contrast, the resected liver volume in our study was only 12% of the total liver volume, which could be indicated in patients with worse functional liver reserve. The transection line to the hepatic hilum can thus be chosen according to the patient's liver function (*fig. 1, table 1*).

The first key to this approach is complete mobilization of the caudate lobe from the IVC and insertion of the left hand behind the right liver during transection of the right anterior section. This provides the surgeon with a good surgical view and makes it easy to control the venous bleeding from the hepatic veins by lifting the left hand. If the adhesions are too severe to mobilize the caudate lobe because of repeated liver resections, transhepatic enucleation may be a feasible option (16). The second key is to approach the hilar plate. That is, the bilateral Glissonian pedicles are taped and the hilar plate is widely exposed. The portal pedicles branching from the hilar plate can then be confidently ligated and divided. The perihilar Glissonian approach, also called “the taping game,” is another effective method to achieve taping of the hilar plate (17). This approach was originally proposed by Takasaki et al. (18) and can enable taping of the hilar plate before liver transection (19). However, this Glissonian approach is not recommended when the paracaval tumor is suspected to invade the hepatic hilum or be accompanied by a tumor thrombus, as in Patient #2 of the present series.

The paracaval portion reaches the diaphragmatic surface in almost half of patients based on anatomical studies using casts (1,2,20) and three-dimensional computed tomography scans (21). Therefore, it would be reasonable to open the diaphragmatic surface of the right liver to completely remove the paracaval portion. Higaki et al. (7) reported the feasibility of combined resection of the paracaval portion together with segment 8, especially when the tumor is located beyond the caval portion. In the present study, the dorsal part of the segment 8 was preserved in 5 of 6 patients (83%). Surgeons can approach the paracaval portion even if they do not completely remove segment 8. Mesohepatectomy is another option for removal of tumors located at both the central bisectations (22-24). However, these previous mesohepatectomy procedures were rarely intended to remove tumors in the paracaval portion (25). Another possible procedure for paracaval tumors is the “liver tunnel” method (26,27), by which the tumor is hollowed through the liver parenchyma overlying the paracaval portion. However, the surgical field becomes deep and restricted by the surrounding liver parenchyma overlying the hepatic hilum. Tani et al. (28) reported resections of deeply located tumors in combination with adjacent segments, such as segment 6, 7, or 8, to preserve the liver parenchyma. This approach is very effective when the tumor does not invade the major hepatic veins or hepatic hilum. Our central hepatectomy

technique using the hilar approach is widely applicable among patients with centrally located tumors, even those that invade the MHV or hepatic hilum, and even in patients with poor functional reserve when a good surgical field is established by opening the central area of the liver using the pivot of the hepatic hilum.

Another issue regarding this procedure is the right-sided transection line of the paracaval portion. The right-sided boundary of the paracaval portion is not easy to confirm (29). However, three-dimensional imaging software recently revealed that a small branch from the RHV can be a landmark for the right-sided transection line in about half of patients (21).

CONCLUSIONS

Central hepatectomy using the hilar approach is a safe surgical procedure for paracaval tumors. Even for tumors that require MHV resection or tumor thrombectomy, our procedure can provide an adequately wide surgical view.

Conflict of Interest

The authors declare no conflict of interest.

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There is no financial support on this study.

Informed Consent

Informed consent was obtained from all participants to be included in the study.

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