Central hepatectomy: The golden mean for treating central liver tumors?

Charalabos Stratopoulos*, Zahir Soonawalla, Jens Brockmann, Kathrin Hoffmann, Peter J. Friend

Nuffield Department of Surgery, John Radcliffe Hospital, Headington, Oxford OX3 9DU, UK

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Abstract
The treatment of patients with central liver tumors involving segments 4, 5 and 8 is a difficult clinical problem. These tumors often straddle Cantlie’s line and involve parts of both lobes of the liver. The traditional management of such tumors is to perform either an extended right or an extended left hepatectomy. However, extended hepatectomies are associated with greater morbidity and mortality, mainly due to increased risk of postoperative liver failure. Central hepatectomy (or mesohepatectomy) may be superior to extended hepatectomy, because it conserves more liver parenchyma. However, the operation can be tedious and may result in increased blood loss, and was therefore infrequently used. Recommendations for its application for centrally located tumors are not clear. The aim of our study is to evaluate the evidence supporting central hepatectomy as a safe procedure for the management of central hepatic tumors, and to describe the effectiveness of central hepatectomy compared to extended hepatectomy. We present herein two patients who underwent central hepatectomy and systematically review the English literature until December 2006. We found 13 studies of multisegmental (≥2 segments) central liver resection that included at least four patients. Only three retrospective non-randomized studies have looked at central hepatectomy in comparison to lobar or extended hepatectomy, and no clear consensus emerges. To date, there is insufficient evidence to categorically state that central hepatectomy is superior to extended hepatectomy, thus the use of all approaches can be justified. However, if central hepatectomy can be performed without excessive blood loss, then it should be preferred, as it is less extensive and results in greater...
functional remnant liver. Additionally, it would clearly be superior in patients with cirrhosis.

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### Case reports

From March 2003 to July 2004, 50 consecutive patients with liver tumors were referred to our center for elective liver resection. During this period, two patients underwent central hepatectomy for central liver tumors. Our standard surgical approach is through a bilateral subcostal incision with midline extension. After mobilizing the liver, our usual practice is extrahepatic division of hepatic arterial and portal venous inflow, followed by extrahepatic division of the relevant hepatic veins. The patient is then positioned with a 5–15° head-up tilt, aiming to lower the central venous pressure (CVP) to 5 mmHg or less, while maintaining adequate blood pressure. Parenchymal transection is performed with the Cavitron ultrasonic surgical aspirator CUSA (Valleylab, Boulder, CO, USA) and Ultracision harmonic scalpel (Ethicon Endo-surgery Inc., Cincinnati, OH, USA). Hemostasis is achieved by argon beam coagulation. We did not perform a Pringle manoeuvre in either of these cases.

#### Case 1

A 61-year-old male was referred for surgical resection of a solitary hepatic metastasis. He had undergone a high anterior resection for a Dukes B (T3, N0, R0) sigmoid adenocarcinoma 3 months previously. Magnetic resonance imaging (MRI) disclosed a 2.6 cm lesion consistent with a metastasis in segment 4b of the liver (Fig. 1). The patient was advised surgical resection of this presumed solitary metastasis, rather than first undergoing neoadjuvant chemotherapy. At surgery, a 2.8 cm tumor was found close to the gallbladder involving segments 4b and 5, while two smaller lesions were found in segment 8 of the liver. Intraoperative ultrasound of the liver confirmed the above findings of open inspection and palpation. A mesophagectomy was performed (Fig. 2) including most of segments 4b, 5 and 8. The middle hepatic vein was divided intrahepatically with a vascular stapler. Surgical time was 210 min, while blood loss was 900 ml. The patient did not need any blood products and was discharged on the sixth postoperative day after an uneventful recovery. Histology confirmed three hepatic metastases from colorectal adenocarcinoma, with clear resection margins.

#### Case 2

A 71-year-old female was referred to our department for surgical treatment of a tumor in segment 8 of the liver. She had undergone a right hemicolectomy 6 months before for a Dukes B (T3, N0, R0) cecal adenocarcinoma. On MRI, a 3.2 cm lesion within segment 8 of the liver was identified (Fig. 3). The patient was advised surgical resection, with a plan to perform a segmental resection. At operation, the lesion was found to be closer to the middle hepatic vein than expected, and a central hepatectomy was performed with excision of segments 5 and 8, along with the middle hepatic vein, preserving all of segment 4b and part of segment 4a (Fig. 4). The duration of the operation was 200 min, the blood loss was 2000 ml and the patient received two units packed red cells. The patient was discharged on the eighth postoperative day after an uneventful course. Pathologic examination revealed a hepatocellular carcinoma (HCC), positive for HepPar1, alpha1 antitrypsin, focally for cyto-keratin (CK) 8 and CK18 and negative for CK7, CK20 and alpha-fetoprotein. The background liver showed no evidence of cirrhosis or other underlying liver disease, and postoperative tests for hepatitis viruses, hemochromatosis and primary biliary cirrhosis were negative.

In summary, both patients underwent uneventful central hepatectomy with acceptable blood loss and no postoperative liver failure. All tumors were removed with grossly negative margins. At a follow-up of 33 and 28 months, respectively, the patients are doing well with no signs of recurrence.
Review of the literature

Searching methodology and study selection

The aim of our review was to evaluate the evidence supporting central hepatectomy as a safe procedure for the management of central hepatic tumors and to compare central hepatectomy to extended hepatectomy. A systematic literature search was conducted on medline until December 2006. Database searches used the keywords central hepatectomy, central liver resection, mesohepatectomy, right anterior segmentectomy, central bisegmentectomy, central trisegmentectomy, segmental liver resection and segment oriented liver resection. There were restrictions regarding the language of publication (only English language) and the number of reported cases (more than 3). We used the oxford hierarchy for grading clinical studies according to the levels of evidence.

Anatomic basis and rationale for central hepatectomy

Surgery remains the only curative option for either primary or secondary liver tumors [1,2]. Surgical treatment of centrally located tumors (Couinaud’s segments 4a, 4b, 5 and 8) has always been a challenge. Traditionally, extended right or left hepatectomies have been used for the extirpation of central liver tumors. However, these methods remove 60–80% of liver parenchyma, and are associated with considerable risk of postoperative liver failure [3]. A non-anatomical resection is an alternative approach for parenchymal preservation, but hindered by intraoperative hemorrhage and higher rates of margin positivity between 19% and 35% [4]. For tumors limited to the left medial and right anterior sectors, central hepatectomy is an attractive option because it entirely removes the tumor-bearing segments while preserving the rest of the liver.

Ipsilateral portal vein embolization can be considered preoperatively to allow hypertrophy of the contralateral unaffected liver parenchyma, thereby facilitating extended resections. However, with centrally located tumors it is often difficult to determine which side of the portal vein should be embolized. Moreover, there is minimal evidence that this procedure affects the resectability rate or improves survival [5].

Terminology

The terminology that has been used for liver resections of the central part of the liver is inconsistent. Confusion may arise due to the use of the terms central hepatectomy [6], middle lobectomy [7], central bisegmentectomy [8] or...
central trisegmentectomy [9]. The scientific committee of the Hepato-Pancreatico-Biliary Association has created a rationale and anatomically correct nomenclature for liver resections [10]. According to that, the resection of segments 5 and 8 is named right anterior sectionectomy, while resection of segments 4a and 4b is named left medial sectionectomy. There is no proposed name for the resection of segments 4a, 4b, 5 and 8. This operation has now predominantly been termed mesohepatectomy or central hepatectomy [11].

Patient selection

The selection criteria in the literature for central hepatectomy include non-cirrhotic patients or Child-Pugh class A or B patients with indocyanine green 15-min retention rate (ICG R15) less than 20%, removal of all tumors with a 1-cm margin and preservation of venous drainage as well as vascular supply to the remaining segments [11–13].

Studies of multisegmental central liver resection

Most of the literature regarding central hepatectomy for liver tumors reports outcome data of a mixed patient population (cirrhotic and non-cirrhotic, primary and secondary tumors). Individual studies are difficult to compare because of differences in patient selection. However, a number of reports are available that demonstrate the feasibility of central liver resection with an acceptable mortality and morbidity. Table 1 summarizes several studies of multisegmental (≥2 segments) central liver resection. Non-randomized studies comparing central hepatectomy with lobar or extended hepatectomy are presented in Table 2.

Mortality and morbidity

The surgical mortality rate has been reported to be between 0% and 6.25%. The most frequent causes of perioperative death are liver failure and hemorrhage [4,8,9,11–20]. Postoperative early morbidity rates are as high as 55%, due to hemorrhage (5.6–6.2%) [8,12], bile leakage (5.6–12.5%) [8,9,11–13], liver failure (5.8–6.2%) [8,13], ascites (1.9–11.6%) [8,9,11–13,19], wound infection (1.7–6.2%)

![Fig. 3 MRI abdomen image in second patient: within segment 8 of the liver there was a 3.2 cm lesion (arrow). A simple cyst was located at segment 6.](image)

![Fig. 4 Liver transection plane after resection of right anterior segment with part of the middle hepatic vein (Couinaud’s segments 5 and 8), preserving all of segment 4b and most of segment 4a. FL indicates falciform ligament; LM, left medial segment (Couinaud’s segment 4); LL, left lateral segment (Couinaud’s segments 2 and 3) RP, right posterior sector (Couinaud’s segments 6 and 7).](image)
Impact of different techniques of vascular occlusion on operative blood loss

In most cases, total inflow occlusion (Pringle manoeuvre) [11–13,17,19,20], hemihepatic inflow occlusion [4,8,11–13,17], alternate partial hepatic vascular occlusion with preservation of caval flow [15,18] or total inflow occlusion with occlusion of the inferior vena cava below the liver [19] was used for controlling bleeding during transection of the parenchyma. These techniques can reduce the requirements for intraoperative blood transfusion [8,15]. Two prospective randomized trials have compared different techniques of vascular occlusion for central liver resections in patients with cirrhosis [17,19]. The first trial showed that operative blood loss during declamping was significantly greater in total inflow occlusion group than in hemihepatic inflow occlusion group [17]. The second trial demonstrated that operative blood loss during liver resection was significantly greater in total inflow occlusion group than in the group undergoing total inflow occlusion with occlusion of the inferior vena cava below the liver [19]. There were no significant differences in liver enzyme changes or post-operative morbidity and mortality between comparative groups.

Many centers nowadays perform liver resection without total inflow occlusion, and find that blood loss during surgery remains low due to the use of low-CVP anesthesia and modern techniques to transect liver parenchyma. In the present study, the Pringle manoeuvre was not used in either of the resections.

Comparison of central hepatectomy with lobar or extended hepatectomy

The question remains whether central hepatectomy or extended hepatectomy is the preferred operative approach for the management of centrally located liver tumors. Three retrospective studies investigated this question (Table 2) [9,11,12]. No difference in perioperative morbidity and mortality, or mean postoperative hospital stay could be demonstrated in these comparative studies.

Wu et al. [11] found that mesohepatectomy and extended hepatectomy performed equally well for centrally located HCCs. Mesohepatectomies required a significantly longer inflow occlusion time for liver parenchymal transection than did extended hepatectomies. Patients who underwent extended hepatectomy had worse 1-, 3- and 6-year disease-free survival rates, but this was not statistically significant and may have been because of different tumor stages.

In the study conducted by Hu et al. [9], the outcome was very similar in patients with centrally located HCCs of comparable size who underwent treatment with central hepatectomy and conventional major hepatectomy. It was noted that the volume of transfused blood was significantly greater in central hepatectomy group than in major hepatectomy group (1030 ml versus 445 ml).

The third retrospective study has compared the results of central hepatectomy and lobar or extended hepatectomy for centrally located primary or secondary liver tumors [12]. The groups had similar patient demographics by age, background liver disease and indications for resection. It was demonstrated that mesohepatectomy resulted in a significantly lower late morbidity rate than extended hepatectomy (5.6% versus 14%). In this study, the mean operative blood loss was lower in the mesohepatectomy group than in the extended hepatectomy group. The overall duration of mesohepatectomy was significantly shorter than extended resection. The mean volume of resected liver in the mesohepatectomy group was significantly smaller (560 cm$^3$) than in the lobar (900 cm$^3$) and extended hepatectomy (1500 cm$^3$) groups. Mesohepatectomies required a significantly longer inflow occlusion time for liver parenchymal transection than did lobar hepatectomies.

Discussion

The treatment of large or deep-seated tumors that are located at the central part of the liver remains problematic. In these cases, extensive liver resection or non-anatomic wedge resection is usually recommended. Extensive liver resection (extended right or left hepatectomy) bears a considerable risk of liver failure because of compromised liver functional reserve, particularly in patients with chronic liver disease [21]. Postoperative liver failure occurs after extensive resection, even in non-cirrhotic patients [21,22]. On the other hand, non-anatomic wedge resections are associated with higher rates of positive resection margin and shorter survival rates than anatomical resections [23].

Improvements in the understanding of liver structure, based on functional segmental anatomy, together with advances in imaging technology have contributed to the development of segment-orientated liver surgery [4]. Central hepatectomy removes part or all of the left medial sector (segments 4a and 4b) and part or all of the right anterior sector (segments 5 and 8). It represents an alternative option, for those patients with liver cirrhosis and patients with normal liver function. A surgeon who sees a patient with a centrally located hepatic tumor must evaluate whether an extended hepatectomy or a central hepatectomy should be performed. There is no evidence in the literature to support either approach or formulate guidelines for the use of one or the other.

The performance status of the patient must be considered. Routine preoperative assessment of hepatic functional reserve includes clinical assessment, liver biochemistry, coagulation profile, platelet count, and Child-Pugh classification. The use of Child-Pugh classification has been used to select cirrhotic patients for liver resection. The ICG R15 has been found to be useful in predicting the safe limit of liver resection and decreasing posthepatectomy liver failure. For patients undergoing major hepatectomy, computed tomography (CT) volumetry is helpful in evaluating whether the remnant liver volume is adequate. Patients with less than 25% of normal liver remaining after extended resections
<table>
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<tr>
<th>Study (year)*</th>
<th>LoE</th>
<th>Resected segments</th>
<th>No. of patients</th>
<th>Indication</th>
<th>Operative mortality (%)</th>
<th>Total early complication rate (%)</th>
<th>Median survival (month)</th>
<th>Mean operative time (h)</th>
<th>Mean blood loss (ml)</th>
<th>Postoperative hospital stay (day)</th>
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<td>NA</td>
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LoE, level of evidence; HCC, hepatocellular carcinoma; CRM, colorectal metastases; CC, cholangiocarcinoma; GM, gastric metastasis; GBC, gallbladder carcinoma; HS, hepatic sarcoma and NA, not assessed.

*Studies are ordered according to year of publication.

<sup>b</sup>Including 1 resection of segments 4, 5, 7 and 8.
<sup>c</sup>Including 4 resections of segments 5, 8 plus part of 4 and 1 resection of segments 5, 7 and 8.
<sup>d</sup>Including 1 right anterior sectionectomy (segments 5 and 8).
<sup>e</sup>Including 6 resections of segments 1 and 4 and 2 resections of segments 1, 5 and 8.
<sup>f</sup>Including 1 resection of segments 4 and 5.
<sup>g</sup>Including 11 right anterior sectionectomies (segments 5 and 8).
<sup>h</sup>Including 9 right anterior sectionectomies (segments 5 and 8); 6 resections of segments 4 and 5; 3 resections of segments 5, 7 and 8 and 2 resections of segments 4a and 8.
<sup>i</sup>Including 16 right anterior sectionectomies (segments 5 and 8).
<sup>j</sup>Including 2 resections of segments 4b and 5 and 1 resection of segments 4a and 8.
<sup>k</sup>Including 15 right anterior sectionectomies (segments 5 and 8).
have three times greater risk of hepatic dysfunction [24]. However, the permissible extent of hepatectomy is greatly restricted in cirrhotic livers. A combination of the triphasic CT volumetric measurements of the liver and the ICG R15 has been found to be useful to predict the safe limits of hepatectomy in patients with impaired liver function [25]. For patients with a diseased liver, only those with an ICG R15 less than 20% are selected for central hepatectomy because the residual liver parenchyma is approximately 50–60% of the total liver volume [11].

Three-dimensional CT reconstruction of the liver can help identify and map the variations of the intrahepatic vascular structures and their relationship to tumors. Areas at risk for either devascularization or venous congestion may be identified prior to liver resection [26]. This is particularly important for resections that involve the middle hepatic vein (extended and central liver resections). Though less extensive than extended hepatectomies, central liver resections are technically more demanding, since they require more extensive dissection of vascular pedicles and larger transection surfaces [18]. Hence, it is advisable that such resections are performed at major centers with sufficient experience of liver surgery. Several studies (see “Impact of different techniques of vascular occlusion on operative blood loss”) used vascular occlusion techniques to control bleeding from the two wide resection planes during parenchymal transection, although this can be accomplished without hepatic inflow occlusion [27]. In one study, central liver resections were defined as having high risk for the development of postoperative bile leakage [16]. They are less likely to develop postoperative liver dysfunction due to maximal preservation of functional parenchyma, and may also provide increased opportunity to perform repeated resections [4,18,27,28].

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There is sufficient evidence (see “Studies of multsegmental central liver resection”) to conclude that central hepatectomy is a safe, feasible and effective option for the treatment of centrally located liver tumors. Though the evidence supporting this recommendation is limited and of low quality, it seems reasonable to recommend a less-extensive procedure that is shown to be safe and equally effective at resecting the tumor. There are accumulating data that segment-oriented resection provides several advantages over extended hepatectomy for both cirrhotic and non-cirrhotic patients without compromising surgical radicality.

**Table 2** Non-randomized trials comparing central hepatectomy and lobar or extended hepatectomy.

<table>
<thead>
<tr>
<th>Study (year)</th>
<th>LoE</th>
<th>No. of patients</th>
<th>Indication</th>
<th>Operative mortality (%)</th>
<th>Total early complication rate (%)</th>
<th>Mean operative time (h)</th>
<th>Mean blood loss (ml)</th>
<th>Median survival (months)</th>
<th>Mean operative time (min)</th>
<th>Vascular occlusion time (min)</th>
<th>Post-operative hospital stay (day)</th>
<th>LoE, level of evidence; HCC, hepatocellular carcinoma; CRM, colorectal metastases; CC, cholangiocellular carcinoma; GBC, gallbladder carcinoma; BL, benign lesion and NA, not assessed.</th>
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LoE, level of evidence; HCC, hepatocellular carcinoma; CRM, colorectal metastases; CC, cholangiocellular carcinoma; GBC, gallbladder carcinoma; BL, benign lesion and NA, not assessed.

Statistics significant.

Central hepatectomy is an acceptable, safe surgical method for treatment of centrally located liver tumors in non-cirrhotic patients, and should be considered in favor of an extended hepatectomy. It is the procedure of choice in patients with compromised liver function.

**References**


