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ORIGINAL ARTICLE

Extra-Glissonian approach in liver resection

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Abstract

Background: In this study we analyzed our most recent experience in the use of the extraglissonian approach to the hilar structures in two circumstances: pedicle transection during major liver resections, and selective clamping in minor hepatectomies.

Methods: The major liver resections study group consisted of 89 cases. Extraglissonian approach and stapler transection of hilar structures was used in 61 (69%). The study group of minor liver resections consisted of 103 cases. Extraglissonian approach and selective clamping was used in 27 cases (26%).

Results: In major hepatectomies pedicle stapling and hilar dissection demonstrated a similar operative time (240 vs. 260 min; $P = 0.230$); no differences were observed in the amount of haemorrhage (800 ml vs. 730 ml; $P = 0.699$), number of patients transfused (16 vs. 6; $P = 0.418$) and volume of blood transfused (4 PRC vs. 4 PRC; $P = 0.521$). Duration of vascular pedicle occlusion was 35 vs. 30 min respectively ($P = 0.293$). Major complications (grade $\geq$3a) occurred in 18 (20%) patients and mortality rates (4.9% vs. 3.5%; $P = 0.882$) were similar for both group. In minor liver resections there were no differences between Pringle and selective clamping in operative time (240 vs. 240 min; $P = 0.321$), haemorrhage (435 ml vs. 310 ml; $P = 0.575$), number of patients transfused (18 vs. 7; $P = 0.505$) and volume blood transfused (4 PRC vs. 3 PRC; $P = 0.423$). Major complications (grade $\geq$3a) occurred in 14 (14%) patients, and mortality (2.6% vs. 3.7%; $P = 0.719$) were similar for both groups. However, the duration of pedicle clamping was significantly longer in the selective clamping group (26 $\pm$ 21 minutes vs. 44 $\pm$ 18 minutes) ($P = 0.001$).

Conclusions: The extraglissonian approach can be extremely useful in liver surgery. Selective clamping with extraglissonian approach avoids ischemia to the other hemiliver. Selective clamping it is also important from the haemodynamic point of view because there is no splanchnic stasis and low fluid replacement.

Keywords

liver resection, liver surgery, hepatectomy, extra-Glissonian approach, selective clamping

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Introduction

Liver resection is the accepted treatment strategy for resectable malignant primary and secondary tumours of the liver.[1–5] Indications of hepatectomy and the criteria for resectability are expanding. However, morbidity and mortality after liver resection remain problematic and may occur as a result of either hepatic insufficiency or surgical complications.[2,5] During the last 20 years surgical techniques for hepatectomy have changed dramatically.[3–7] However, the results of surgical series depend mostly on hospital volume and surgeon expertise. Few randomized and well-designed control studies have been reported.[8–12]

In 1952, Lortat-Jacob and Robert[13] described the first right hepatectomy. In their report, the hilar structures (hepatic artery, biliary duct and portal vein) were isolated and ligated separately and extrahepatically within the pedicle before parenchymal transection. Subsequently, Takasaki *et al.* described the Glissonian sheath that envelopes the hilar structures inside the liver.[14] The

hilar structures can be approached together without dissecting Glisson's sheath in order to transect the hilar structures, for selective clamping in minor hepatectomies, or for surgical stapling of the biliary confluence in malignant tumours or bile duct injuries.[8,9]

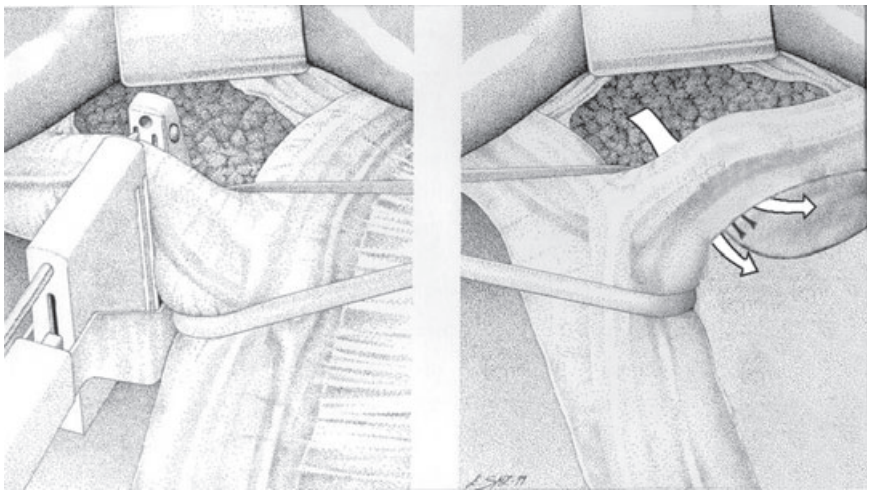
Controlled reports of the use of these different techniques and approaches in the surgical literature are lacking. This study aimed to analyse the feasibility, safety, efficiency and usefulness of the extra-Glissonian approach to hilar structures in a recent series of hepatectomies carried out in a tertiary referral centre.

Materials and methods

Between January 2005 and April 2008, 251 liver resections were performed in 232 patients for various benign and malignant hepatic diseases at the Department of Hepato-Biliary and Pancreatic Surgery, Josep Trueta Hospital, Girona (Spain). The protocol received the approval of the research review board of our hospital, and informed written consent was obtained from each patient before surgery. Patient demographic data, primary tumour-related factors, details of surgical techniques, perioperative and postoperative course, hospital stay, results of histopathological study and complications were entered prospectively into a computer database. Liver resections were defined according to International Hepato-Pancreato-Biliary Association terminology[15] derived from Couinaud's classification.[16] Minor liver resection was defined as resection of one or two segments, whereas resection of three or more segments was classified as a major hepatectomy. The amount of blood lost was measured by the volume of blood collected in the aspirator container and the ultrasonic dissector and by the weight of the soaked gauzes.

Surgical techniques

The surgical technique has been extensively described previously.[8–10] Briefly, both general and epidural anaesthesia were used. Central venous pressure (CPV) was maintained at 0–4 mmHg to help reduce blood loss during parenchymal transection.[17] The operation was divided into four steps: (i) the hepatic mobilization phase, including laparotomy, ultrasonographic exploration and liver mobilization; (ii) the hilar dissection phase, including cholecystectomy, transection of the vascular and biliary structures of the pedicle in major hepatectomies or preparation for hilar clamping in minor hepatectomies; (iii) the parenchymal transection phase, and (iv) haemostasis of the liver cut surface, including biliary dye injection and abdominal closure. All procedures were performed by or under the direct supervision of the same surgeon. In patients undergoing major hepatectomies the extra-Glissonian approach was the preferred technique for transection of the hilar structures. This approach was contraindicated in those patients in whom the proximity of the tumour to pedicular structures prevented safe dissection or when hilar lymphadenectomy or resection was indicated (hilar cholangiocarcinoma or gall bladder carcinoma); thus these patients were excluded from the study. The technique has been described extensively.[8] Briefly, a TA-30 vascular stapler, white type (United States Surgical Corp., Norwalk, CT, USA) was introduced to transect en-bloc the right or left portal triad (Fig. 1). During pedicle transection it is necessary to perform countertraction of the loop to avoid injury to the bile duct confluence[8] (Fig. 2). When hilar dissection was necessary, the portal vein, hepatic artery and biliary duct were isolated in the pedicle by opening Glisson's sheath. Vascular and biliary structures were ligated and transected



(A) (B)

Figure 1 (A) Right hepatectomy. A TA-30 vascular stapler, white type, is introduced to transect the right or left portal triad en-bloc. During pedicle transection, countertraction of the loop is necessary to avoid injury to the bile duct confluence. (B) Left hepatectomy. In order to preserve the vascularization of the caudate lobe, the vessels to segment I should be preserved. White arrows indicate alternative ways to introduce the stapler when it is necessary to perform left hepatectomy without caudate lobe

individually, before liver transection. In major hepatectomies the Pringle manoeuvre was used to minimize bleeding.[18] Briefly, the entire pedicle was isolated and surrounded with a tourniquet.

In order to minimize bleeding in minor hepatectomies, selective clamping was used as the preferred method of inflow occlusion, particularly in patients with underlying chronic liver disease. Details of the techniques have been extensively described elsewhere.[9] Briefly, control of the intrahepatic portal triad is achieved by a hepatotomy near the corresponding portal pedicle using the Glissonian approach (Fig. 3). During the hepatotomy, a short period of Pringle manoeuvre is sometimes necessary to minimize blood loss. Afterwards, the right or left portal pedicle en-bloc is isolated and encircled with a rubber tape and the hemiliver clamped with a tourniquet.

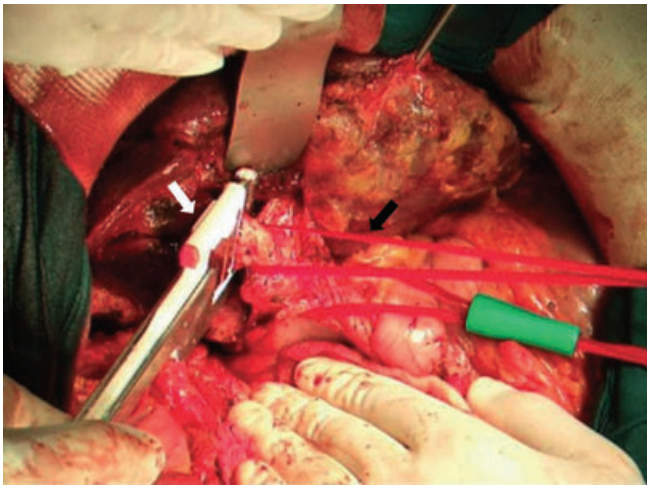


Figure 2 Right hepatectomy. Operative field during pedicle transection; when the stapler surrounds the right or left portal triad countertraction of the loop is necessary to avoid injury to the contralateral pedicle

Liver transection was initiated without pedicle clamping, but if parenchymal bleeding started to occur, 15 min of intermittent hepatic inflow occlusion with a 5-min rest period was applied.[11] Parenchymal transection was carried out using an ultrasonic dissector[19,20] (Cavitron Ultrasonic Surgical Aspirator [CUSA] System; Valleylab Inc., Boulder, CO, USA). In major hepatectomies, the right, middle or left hepatic vein was isolated and divided extrahepatically with a surgical stapler (EndoGIA 30; US Surgical Corp.) when liver transection was concluded.[21,22] If concomitant caudate lobectomy was performed, the entire caudate lobe was completely mobilized from the inferior vena cava and retracted towards the right side to be resected together with the right or left liver. Intraparenchymal vascular structures were ligated and cut between interrupted ligatures and metal clips.

At the end of the resection, haemostasis was achieved using monopolar irrigated electrocautery[23] (TissueLink Medical Inc., Dover, NH, USA) or argon beam coagulation (Valleylab Inc.).[24,25] Confirmation of biliary integrity was achieved by injecting methylene-blue and normal saline into a catheter introduced into the cystic duct. The resection surface was sealed using fleece-bound sealing (TachoSil; Nycomed ApS, Roskilde, Denmark).[26] Abdominal drainage was rarely placed. Morbidity was classified according to Clavien.[27] Nineteen re-hepatectomies were excluded from the analysis.[28]

Statistical analysis

Data were analysed using the Mann–Whitney *U*-test or the chi-squared test. $P < 0.05$ was considered statistically significant. All data analysis was performed on an IBM-compatible PC using SPSS Version 10.0 for Windows (SPSS Inc., Chicago, IL, USA).

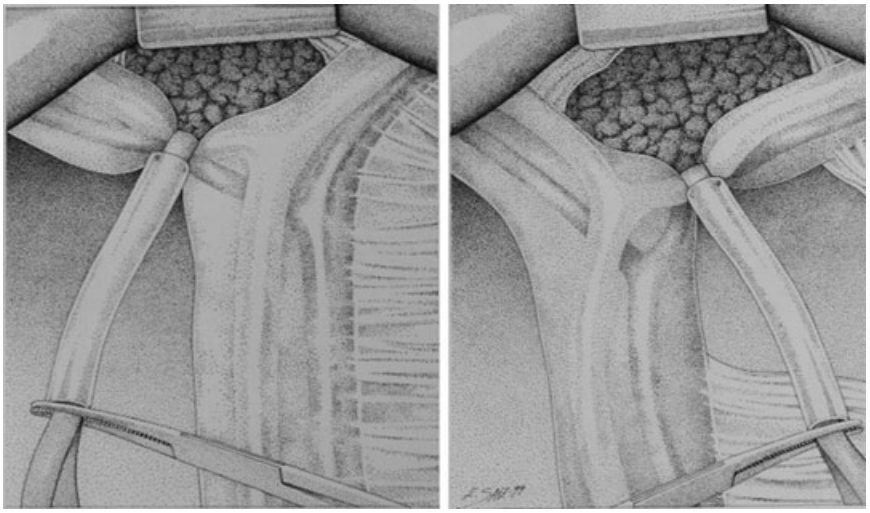


Figure 3 In minor hepatectomy selective clamping is our preferred method of inflow occlusion, particularly in patients with underlying chronic liver disease. When the extra-Glissonian approach has been made, the right or left pedicle is occluded selectively en-bloc with a tourniquet

Results

Our patients included 163 (70%) men and 69 (30%) women, with a median age of 62 years (range 29–86 years). Diagnoses and indications for hepatectomies were colorectal liver metastases (CRC LM) in 156 (67%), non-colorectal liver metastases (non-CRC LM) in 19 (8%), benign tumours in 19 (8%), hepatocellular carcinoma (HCC) in 15 (6%), Klatskin's tumours in nine (4%), intrahepatic cholangiocarcinoma in eight (4%), and gall bladder carcinoma in six (3%) patients. A total of 24 patients (10%) were excluded as they required hilar dissection and biliary duct resection. A further 16 patients (7%) undergoing minor hepatectomies failed to meet inclusion criteria and were excluded. Thus a total of 89 patients undergoing major hepatectomy and 103 patients undergoing minor hepatectomy were included for further analysis. The extra-Glissonian approach and stapler transection of hilar structures were possible in 61 (69%) of the 89 patients undergoing major hepatectomy. An extra-Glissonian approach and selective clamping were possible in 27 (26%) of the 103 patients undergoing minor hepatectomy. Patient demographics and preoperative data for all patients are shown in Table 1. Intraoperative data for those patients undergoing major and minor hepatectomy are provided in Tables 2 and 3, respectively.

Additional procedures performed at the same time as major hepatectomy in 14 patients included segmental bowel resection ($n = 5$), intrahepatic caval resection with prosthesis replacement ($n = 4$), inter-aorto-cava lymphadenectomy ($n = 4$), placement of a T-tube biliary drainage ($n = 4$), partial resection of the diaphragm ($n = 3$) and partial peritonectomy ($n = 1$). In the minor hepatectomy group, 18 patients underwent additional procedures including hilar lymphadenectomy ($n = 7$), duodenal resection ($n = 2$), partial bowel resection ($n = 1$), placement of a T-tube biliary drainage ($n = 1$), partial gastric resection ($n = 1$), peritonectomy ($n = 1$), partial resection of the diaphragm ($n = 1$), and other procedures ($n = 4$).

In the major hepatectomy group six patients underwent re-operation; three of these procedures were carried out for intestinal occlusion, two for haemoperitoneum and one for kinking of the hepatic vein. In the minor hepatectomy group nine patients underwent re-operation; four of these procedures were performed for intestinal obstruction, four for haemoperitoneum and one for acute incisional hernia.

Discussion

This study describes our experiences with the extra-Glissonian approach to hilar structures in two circumstances: pedicle transection during major liver resection, and selective ischaemic clamping in minor hepatectomy. The most important finding of the current study is that extra-Glissonian dissection and stapling could only be performed in 69% of major hepatectomies. Thus a hepatic surgeon needs to be competent in both techniques. Importantly, both techniques would seem to be equally efficacious. This observation has been previously demonstrated in a randomized study.[8] It is of particular interest that there was no significant difference in the incidence of margin-positive resections among patients in the extra-Glissonian group; however, given the low incidence of margin-positive resections, it is possible that an underlying type II error explains this. Based on these results, we would recommend that when the tumour lies near to the portal bifurcation, hilar dissection of the pedicle should be performed because the posterior sheaths of the pedicle may contribute to increasing the oncological safety margin. Alternatively, the extra-Glissonian approach is particularly useful for transection of the pedicle in major hepatecto-

Table 1 Clinical characteristics of patients included in the study

Characteristics	Major resections ($n = 89$)		P	Minor resections ($n = 103$)		P
	Extra-Glissonian	Hilar dissection		Pedicle clamp	Selective clamp	
n	61	28		76	27	
Age, years, median (range)	57 (37–80)	64 (34–80)	0.709	63 (29–85)	67 (43–86)	0.871
Male, n (%)	41 (67)	21	0.893	48 (63)	18	0.979
Indications for resection, n (%)			0.596			0.955
Metastasis of colorectal cancer	53 (86)	19		50 (66)	17	
Hepatocellular carcinoma	1 (2)	1		5 (7)	7	
Non-colorectal metastasis	4 (7)	2		9 (12)	1	
Benign tumour	3 (5)	6		8 (10)	0	
Peripheral cholangiocarcinoma				0	2	
Gall bladder carcinoma				4 (5)	0	
Simultaneous surgery, n (%)	4 of 53 (8)	2 of 26	0.720	14 of 50 (28)	4 of 17 (24)	0.948
Portal vein embolization, n (%)	9 (15)	2	0.577	4 (5)		0.550
Total vascular exclusion, n (%)	4 (7)	3	0.841	6 (8)		0.337

Peripheral cholangiocarcinoma, Klatskin tumours and gall bladder carcinoma were excluded from major resections
Patients with mainly open radiofrequency ablation or without Pringle manoeuvre of selective clamping were excluded from the minor hepatectomy group

Table 2 Operative and postoperative characteristics of patients in the major hepatectomy group

Characteristics	Major resections		*P*-value
	Extra-Glissonian (*n* = 61)	Hilar dissection (*n* = 28)	
Type of liver resection, *n* (%)			0.166
Right hepatectomy	35 (57)	11	
Left hepatectomy	11 (18)	12	
Mesohepatectomy	2 (3)	1	
Extended right hepatectomy	7 (11.5)	1	
Extended left hepatectomy	6 (10.5)	3	
Re-hepatectomy, *n* (%)	8 (13)	2	0.378
Resection of caudate lobe, *n* (%)	4 (6)	2	0.720
Minor resection of contralateral lobe, *n* (%)	17 (28)	6	0.806
Associated surgical procedures, *n* (%)	14 (23)	7	0.925
Median size of tumour, cm (range)	3.7 (0.4–19)	3.8 (0.5–14)	0.503
No. of nodular tumours, median (range)	5 (1–40)	3 (1–12)	0.964
Resection R1, *n* (%)	3 (5)	5	0.278
Operative time, min, median (range)	240 (160–600)	260 (160–540)	0.230
Median haemorrhage, ml (range)	800 (100–4900)[a]	730 (200–910)	0.699
Ischaemic duration, min, mean ± SD	35 ± 20	30 ± 16	0.293
Patients transfused, *n* (%)	16 (26)[a]	6	0.418
Median packed red cell units (range)	4 (2–12)[a]	4 (2–12)	0.521
Total morbidity, *n* (%)	30 (49)	15	0.403
Clavien's classification ≥3a[27]	10 (16)	8	0.262
Mortality rate within 30 days	3 (4.9)	1	0.882
Median postoperative stay, days (range)	9 (5–96)	9 (5–73)	0.973

[a]Four associated caval resection with prosthesis replacement
SD, standard deviation

mies in previously multi-operated patients in whom the pedicle has already been dissected.[8] In this situation the intrahepatic extra-Glissonian approach allows dissection into a previously untouched plane, making en-bloc dissection much easier.

There are, however, a number of technical considerations which need to be addressed. The main concern is the risk of bleeding when performing the hepatotomy to surround the right or left pedicle. In the early period of the current study a Pringle manoeuvre was used routinely in order to minimize bleeding during hepatotomy. Today, with more experience and the use of the CUSA ultrasonic dissector, pedicle clamping is almost always avoided. There is a 'safe' plane between the sheaths that surround the pedicular structures and the hepatic parenchyma. Careful dissection into this 'safe' plane avoids breaching the boundaries of the liver parenchyma and bleeding is almost non-existent. Maintaining this plane allows dissection to be continued out to dissect the secondary branches of the pedicle, if necessary. On occasion it may be necessary to ligate the very small branches that go to segments IV and I and the gall bladder. En-bloc transection using staplers reduces portal triad transection time and eliminates the risk of incidental damage to anomalous vessels or the contralateral biliary duct, as has been previously reported.[29]

Nakai *et al.*[30] described the extra-Glissonian approach as being associated with an increased rate of biliary fistula, but this observation may be related to lesions of ducts from the caudate lobe, which frequently drain into the left bile duct. These ducts may be injured if the stapler is introduced roughly, and if all the branches of the caudate are not preserved, especially in left hepatectomy. When a left hepatectomy without caudate lobe resection is performed, the stapler must be placed obliquely in order to preserve the biliary ducts of the posterior face of the left pedicle. By contrast, when the caudate lobe is to be resected, the stapler must be placed vertically in order to include the posterior ducts of segment I (Fig. 1). Alternatively, the branches of segment I can be ligated separately before introducing the stapler in order to avoid damage.

Over the last 20 years, several techniques have been reported to reduce blood loss during liver transection. Although some minor liver resections may be carried out without vascular clamping, there are five ways to block vascular inflow: pedicle clamping;[18] selective clamping with hilar dissection or the extra-Glissonian approach;[14,31] intraparenchimal clamping with an intraportal balloon,[32] and total vascular exclusion.[33] The current study shows that in a homogeneous group of 103 patients with small primary and secondary tumours of the liver, selective pedicle clamping was

Table 3 Operative and postoperative characteristics of patients in the minor hepatectomy group

Characteristics	Minor resections		*P*-value
	Pedicle clamp (*n* = 76)	Selective clamp (*n* = 27)	
Type of liver resection, *n* (%)			0.728
Uni- or bi-segmentectomy	27 (36)	9 (33)	
Limited resection	49 (64)	18 (77)	
Re-hepatectomy, *n* (%)	4 (5)	2 (7)	0.383
Minor resection of contralateral lobe, *n* (%)	1 (1)		0.582
Associated surgical procedures, *n* (%)	16 (21)	2 (7)	0.278
Median size of tumour, cm (range)	3 (0.3–14)	2.4 (0.7–9)	0.655
No. of nodular tumours, median (range)	2 (1–20)	1.5 (1–15)	0.938
Resection R1, *n* (%)	2 (3)	1 (4)	0.698
Operative time, min, median (range)	240 (70–520)	240 (150–450)	0.321
Median haemorrhage, ml (range)	435 (20–1390)	310 (100–1880)	0.575
Ischaemic duration, min, mean ± SD	26 ± 21	44 ± 18	0.001
Patients transfused, *n* (%)	18 (24)	7 (25)	0.505
Median packed red cell units (range)	4 (1–14)	3 (1–6)	0.423
Total morbidity, *n* (%)	28 (37)	11 (40)	0.728
Clavien's classification ≥3a[27]	6 (8)	8 (29)	0.363
Mortality rate within 30 days	2 (2.6)	1 (3.7)	0.719
Median postoperative stay, days (range)	7 (3–58)	7 (4–47)	0.893

SD, standard deviation

required in only 27 patients. A previous randomized study[9] demonstrated that the clinical advantages of selective clamping are more significant in patients with chronic liver disease, particularly in very difficult resections in patients in whom lengthy pedicular clamping is anticipated as a result of portal hypertension or in whom very large areas of transection are necessary. Not surprisingly, in the current study selective clamping was used more frequently in patients with HCC because the majority of these tumours occur in patients with cirrhosis. The median time of clamping was longer in the selective clamp group than in the group who underwent a Pringle manoeuvre (median 40 min, range 0–64 min vs. median 24 min, range 0–44 min; $P = 0.001$). This circumstance reflects the confidence of the surgeon in the procedure, and the extension of the duration of clamping until bleeding had completely stopped. The Pringle manoeuvre is efficient in haemorrhage control but has two adverse effects:[9,34] (i) it induces hepatic ischaemia and the subsequent reperfusion may cause hepatocellular injury, and (ii) it promotes splanchnic venous stasis, portal hypertension and lactic acidosis that is counterproductive, especially in cases of simultaneous colorectal surgery, and can produce haemodynamic instability.

By contrast, selective clamping or hemihepatic vascular occlusion, as described by Makuuchi *et al.*[31] does not increase venous portal pressure or cause fluid overload or a consequent increase in CVP.[9] In this group, selective clamping and pedicle clamping had similar operative durations, blood loss and perioperative courses. Gotoh *et al.* reported the possibility of damage to the perichole-dochal collateral vessels with subsequent biliary complications when selective clamping with arterial and portal dissection is applied.[35] In the current study, because the pedicle was dissected en-bloc with the Glissonian sheath, there were no biliary complications related to surgical technique (Fig. 1). Selective clamping in the extra-Glissonian approach reduces ischaemic injury and may be beneficial in cirrhotic patients and during mesohepatectomy.[36,37]

In conclusion, the extra-Glissonian approach is a very important technique that can be extremely useful in particular circumstances during liver surgery, such as in multi-operated patients or in patients with anomalous vascular and biliary variations. It is as safe as hilar dissection for transection of the portal triad in major hepatectomy and can be useful in nearly 70% of patients. The extra-Glissonian approach can be used for selective clamping of the hemiliver. Selective clamping can be beneficial in patients with chronic liver disease because it avoids causing ischaemia in the other hemiliver.

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Conflicts of interest

None declared.

References

1. Hemming AW, Reed AI, Fujita S, Foley DP, Howard RJ. (2005) Surgical management of hilar cholangiocarcinoma. *Ann Surg* 241:693–702.

2. Kondo S, Takada T, Miyazaki M, Miyakawa S, Tsukada K, Nagino M *et al.* (2008) Guidelines for the management of biliary tract and ampullary carcinomas: surgical treatment. *J Hepatobiliary Pancreat Surg* 15:41–54.
3. Chirica M, Scatton O, Massault PP, Aloia T, Randone B, Dousset B *et al.* (2008) Treatment of stage IVA hepatocellular carcinoma: should we reappraise the role of surgery? *Arch Surg* 143:538–543; discussion 543.
4. Pawlik TM, Schulick RD, Choti MA. (2008) Expanding criteria for resectability of colorectal liver metastases. *Oncologist* 13:51–64.
5. González HD, Figueras J. (2007) Practical questions in liver metastases of colorectal cancer: general principles of treatment. *HPB (Oxford)* 9:251–258.
6. Minagawa M, Yamamoto J, Miwa S, Sakamoto Y, Kokudo N, Kosuge T *et al.* (2006) Selection criteria for simultaneous resection in patients with synchronous liver metastasis. *Arch Surg* 141:1006–1012; discussion 1013.
7. Nuzzo G, Giuliante F, Ardito F, Vellone M, Pozzo C, Cassano A *et al.* (2007) Liver resection for primarily unresectable colorectal metastases downsized by chemotherapy. *J Gastrointest Surg* 11:318–324.
8. Figueras J, Lopez-Ben S, Lladó L, Rafecas A, Torras J, Ramos E *et al.* (2003) Hilar dissection versus the 'Glissonian' approach and stapling of the pedicle for major hepatectomies: a prospective, randomized trial. *Ann Surg* 238:111–119.
9. Figueras J, Llado L, Ruiz D, Ramos E, Busquets J, Rafecas A *et al.* (2005) Complete versus selective portal triad clamping for minor liver resections. A prospective randomized trial. *Ann Surg* 241:582–590.
10. Figueras J, Llado L, Miro M, Ramos E, Torras J, Fabregat J *et al.* (2007) Application of fibrin glue sealant after hepatectomy does not seem justified: results of a randomized study in 300 patients. *Ann Surg* 245:536–542.
11. Belghiti J, Noun R, Malafosse R, Jagot P, Sauvanet A, Pierangeli F *et al.* (1999) Continuous versus intermittent portal triad clamping for liver resection. A controlled study. *Ann Surg* 229:369–375.
12. Belghiti J, Noun R, Zante E, Ballet T, Sauvanet A. (1996) Portal triad clamping or hepatic vascular exclusion for major liver resection. A controlled study. *Ann Surg* 224:155–161.
13. Lortat-Jacob JL, Robert HG. (1952) Hepatectomie droite reglé. *Press Med* 60:549–551.
14. Takasaki K, Kobayashi S, Tanaka S. (1986) *Highly systematized hepatic resection by Glissonian sheath transection method*. Proceedings of the 9th College Internationale Chirurgie Digestivae (CICD) World Congress. Tel Aviv. (Int Surg 1990 75 (2):73–77).
15. Strasberg SM, Belghiti J, Clavien PA, Gadzijev E, Garden JO, Lau WY *et al.* (2000) The Brisbane 2000 terminology of liver anatomy and resections. Terminology committee of the International Hepato-Pancreato-Biliary Association. *HPB* 2:333–339.
16. Couinaud C. (1957) *Le Foie: Études Anatomiques et Chirugicales*. Paris: Masson & Cie, pp. 9–12.
17. Wang WD, Liang LJ, Huang XQ, Yin XY. (2006) Low central venous pressure reduces blood loss in hepatectomy. *World J Gastroenterol* 12:935–939.
18. Pringle JH. (1908) Notes on the arrest of hepatic haemorrhage due to trauma. *Ann Surg* 48:541–549.
19. Lesurtel M, Selzner M, Petrowsky H, McCormack L, Clavien PA. (2005) How should transection of the liver be performed? A prospective randomized study in 100 consecutive patients: comparing four different transection strategies. *Ann Surg* 242:814–823.
20. Fasulo F, Giori A, Fissi S, Bozzetti F, Doci R, Gennari L. (1992) Cavitron Ultrasonic Surgical Aspirator (CUSA) in liver resection. *Int Surg* 77:64–66.
21. Bismuth H. (1968) Les hépatectomies. Techniques chirurgicales. In: *Encycl Med Chir*. Paris: Elsevier, pp. 40–762.
22. Fong Y, Blumgart L. (1997) Useful stapling techniques in liver surgery. *J Am Coll Surg* 185:93–100.
23. Gruttadauria S, Doria C, Vitale CH, Mandala L, Magnone M, Fung JJ *et al.* (2004) New techniques in hepatic parenchymal transection for living related liver donor and liver neoplasms. *HPB Surg* 6:106–109.
24. Adam R, Laurent A, Azoulay D, Castaing D, Bismuth H. (2000) Two-stage hepatectomy: a planned strategy to treat irresectable liver tumours. *Ann Surg* 232:777–785.
25. Jaeck D, Oussoultzoglou E, Rosso E, Greget M, Weber JC, Bachellier P. (2004) A two-stage hepatectomy procedure combined with portal vein embolization to achieve curative resection for initially unresectable multiple and bilobar colorectal liver metastases. *Ann Surg* 240:1037–1049; discussion 1049–1051.
26. Figueras J, Burdio F, Ramos E, Torras J, Llado L, Lopez-Ben S *et al.* (2007) Effect of subcentimeter nonpositive resection margin on hepatic recurrence in patients undergoing hepatectomy for colorectal liver metastases. Evidences from 663 liver resections. *Ann Oncol* 18:1190–1195.
27. Dindo D, Demartines N, Clavien PA. (2004) Classification of surgical complications. A new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg* 240:205–213.
28. Adam R, Bismuth H, Castaing D, Waechter F, Navarro F, Abascal A *et al.* (1997) Repeat hepatectomy for colorectal liver metastases. *Ann Surg* 225:51–62.
29. Ramaciato G, Aurello P, D'Angelo F, Caramitti A, Barillari P, Fornasari V. (1998) Effective vascular endostapler techniques in hepatic resection. *Int Surg* 83:317–323.
30. Nakai T, Koh K, Fuani S, Kawabe T, Okuno K, Yasutomi M. (1999) Comparison of controlled and Glisson's pedicle transections of hepatic hilum occlusion for hepatic resection. *J Am Coll Surg* 189:300–304.
31. Makuuchi M, Mori T, Gunvén P, Yamazaki S, Hasegawa H. (1987) Safety of hemihepatic vascular occlusion during resection of the liver. *Surg Gynecol Obstet* 164:155–158.
32. Castaing D, Garden J, Bismuth H. (1989) Segmental liver resection using ultrasound-guided selective portal venous occlusion. *Ann Surg* 210:20–23.
33. Heaney JP, Stanton WK, Halbert DS, Seidel J, Vice T. (1966) An improved technique for vascular isolation of the liver: experimental study and case reports. *Ann Surg* 163:237–241.
34. Chouker A, Schachtner T, Schauer R, Dugas M, Löhe F, Martignoni A *et al.* (2004) Effects of Pringle manoeuvre and ischaemic preconditioning on haemodynamic stability in patients undergoing elective hepatectomy: a randomized trial. *Br J Anaesth* 93:204–211.
35. Gotoh M, Monden M, Sakon M, Kanai T, Umeshita K, Nagano H *et al.* (1994) Hilar lobar vascular occlusion for hepatic resection. *J Am Coll Surg* 178:6–10.
36. Machado MAC, Herman P, Machado MCC. (2007) Intrahepatic Glissonian approach for pedicle control during anatomic mesohepatectomy. *Surgery* 141:533–537.
37. Giuliante F, Nuzzo G, Ardito F, Vellone M, De Cosmo G, Giovannini I. (2008) Extraparenchymal control of hepatic veins during mesohepatectomy. *J Am Coll Surg* 206:496–502.