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The technique and outcomes of central hepatectomy by the Glissonian suprahilar approach

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ABSTRACT

Introduction: Central hepatectomy (CH) is technically challenging and seldom-used to treat centrally located tumors. However, CH is a parenchyma-sparing resection that may decrease the risk of postoperative liver failure. This retrospective study presents our technique of CH and assesses the outcomes.
Methods: All CH performed in our department over two decades (1997–2017) were identified. Indications and short-term outcomes were compared between the two decades. Long-term outcomes were assessed.
Results: Sixty-four patients underwent CH using a suprahilar approach for hepatocellular carcinoma (HCC: n = 30), metastasis (n = 23), intrahepatic cholangiocarcinoma (IHCCA: n = 9) or other diseases (n = 2). CH represented 6% of 1004 major hepatectomies, (7.4% (n = 35) before 2007 vs 5.4% (n = 29) after 2007). The mean operating time was 219 ± 56 min. A perioperative blood transfusion was required in 14 patients (22%). Intraoperative bile duct injuries occurred in 5 patients (8%), and they were repaired. One patient died postoperatively (1,5%). Ten patients (16%) experienced a major complication. Nine patients (14%) suffered from bile leakage, of which 6 healed spontaneously. Only one patient had low grade liver failure. The R0-resection rate was 69%. After 2007, there were no bile duct injuries (0/29 vs 5/35, $p < 0.05$), and the average hospital stay was shorter but not significantly (11 vs 14 days). Actuarial 5-year survival was 56% for HCC patients and 34% for those with colorectal metastasis
Conclusions: CH is associated with significant biliary morbidity and may increase positive surgical margins. Nevertheless, it should be recommended in selected patients to avoid the risk of postoperative liver failure.

Introduction

Central hepatectomy (CH), that remove *en bloc* the Couinaud's segments 4, 5 and 8, were not described in the Brisbane 2000 system [1]. CH is the least used of the major hepatic resections, as it is deemed to be a challenging procedure [2–8]. The main difficulty of this technique lies in the identification and division of the right portal fissure, which is the right limit of resection. The hemostasis and biliostasis of the two parenchymal transection planes is also challenging. Moreover, the central location of tumors and their proximity to the hilum increases both the risk of biliary injuries and of positive surgical margins [3,5,9]. However, recent systematic reviews and/or meta-analyses [10–13] have shown that CH is an interesting parenchymal-sparing alternative to right or left trisectionectomy (TS) for the treatment of centrally located tumors, which (i) clearly reduces the risk of postoperative liver failure, (ii) facilitates repeat hepatectomy and (iii) offers comparable survival rates compared with conventional major hepatectomies. The Glissonian suprahilar control of the right anterior pedicle (RAP) seems a safe and effective way to simplify the CH technique whenever the hilar plate is not invaded. We hereafter present the basics of this

Abbreviations: CH, Central Hepatectomy; RAP, Right Anterior Pedicle; HCC, Hepatocellular Carcinoma; IHCCA, Intrahepatic Cholangiocarcinoma; BL, Bile Leakage; TS, Trisectionectomy; POD, PostOperative Day.

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surgical technique and review our experience with this unusual hepatic resection.

Methods

Surgical procedure

Glissonian suprahilar approach (Fig. 1) *(see* suppl video material).

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The key point of the technique is based on the first suprahilar approach of the RAP, as it was described by Couinaud [14], refined by Takasaki et al. [15] and later updated by Lazorthes et al. [16]. The section of the cystic pedicle exposes the thin posterior extremity of the cystic plate (Fig. 1a) that is inserted at the anterior margin of the hilar plate [17]. It must be divided to access to the underlying RAP, which is located on average, 1 cm to the right side of the cystic plate [18]. The pedicle should then be dissected using scissors or cold instruments in contact with the whitish, resistant Glissonian sheath. The RAP is remarkably consistent [17–19]; its direction is upward and vertical whereas the right posterior pedicle is horizontal and almost parallel to the inferior surface of the right liver. The left side of the RAP is easily accessible by detaching the hilar plate after an incision of the hepatic capsule on the posterior rim of segment 4. Its right side is reached by passing in front of the right posterior pedicle, which is well identified by the incisura dextra of Gans (Fig. 1b) that is present in 73% of cases [18]. After the RAP has been identified, clamping the RAP results in ischemia-induced color changes that identify the right portal fissure (Fig. 1d), whose position on the upper surface of the liver is highly variable [17]. By lowering the hilar plate, it is easy to individualize the left portal pedicle in order to clamp it later. Similarly, the inferior side of the right pedicle should be dissected to allow its selective clamping. It is useful to control the root of the right hepatic vein, which will be largely dissected during the transection of the right portal fissure (Fig. 2a), and of the middle hepatic vein that will be removed with the specimen. This control is particularly useful when tumors are located next to the hepatocaval confluence because of vascular risk (Fig. 2b).

Hepatic resection

A hepatic resection should be performed using alternate hemi-hepatic inflow occlusion [20,21]. The transection of the umbilical fissure is performed using selective left clamping, thus leaving the right posterior section vascularized. The parenchymal transection is performed by crush clamp technique or by ultrasonic dissection. The hilar plate is reached on its left end. After that, the left portal pedicle is unclamped, and the left lateral section is revascularized. The division of the right portal fissure is performed using selective

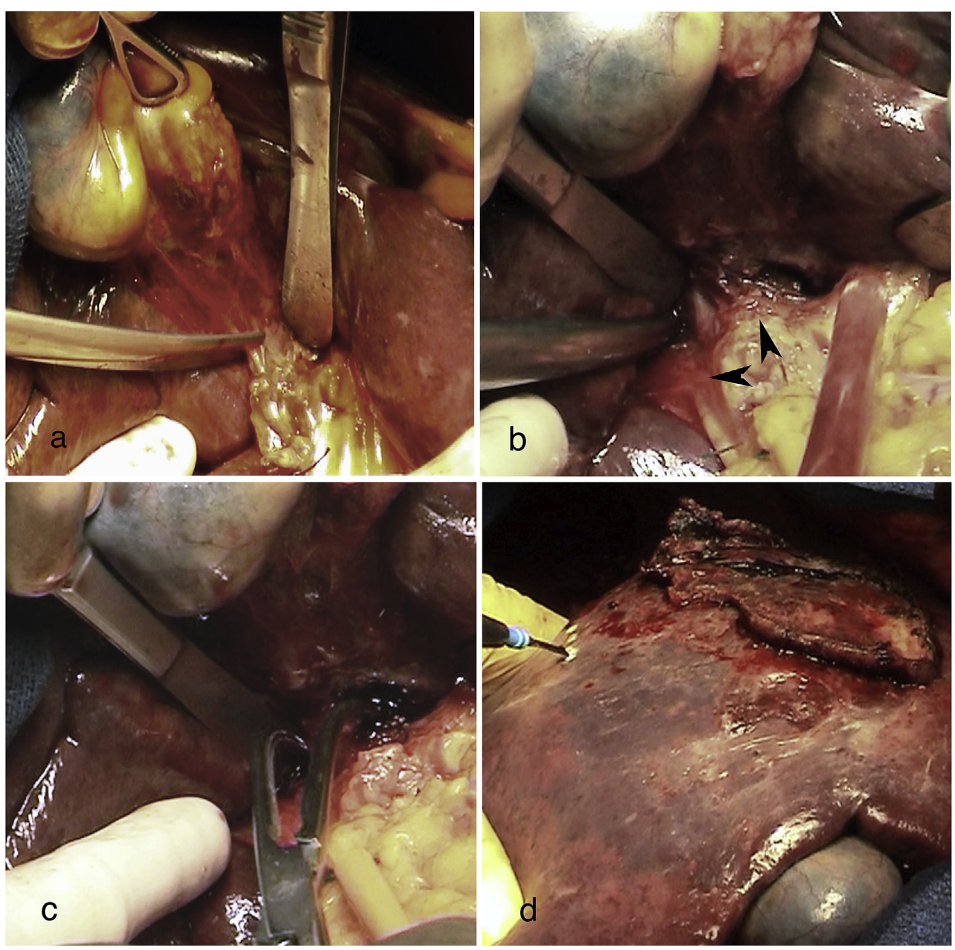

Fig. 1. The suprahilar approach. a: After division of the cystic duct (black tie) and cystic artery, the posterior extremity of the cystic plate must be divided. b: Then, after a short detachment of the hilar plate, the right side of the RAP is dissected using scissors in front of the incisura dextra of Gans. Black arrows indicate the right anterior and posterior pedicles. c: The RAP is clamped without taping it. d: This maneuver allows color demarcation of the parenchyma and indicates the exact position of the right portal fissure.

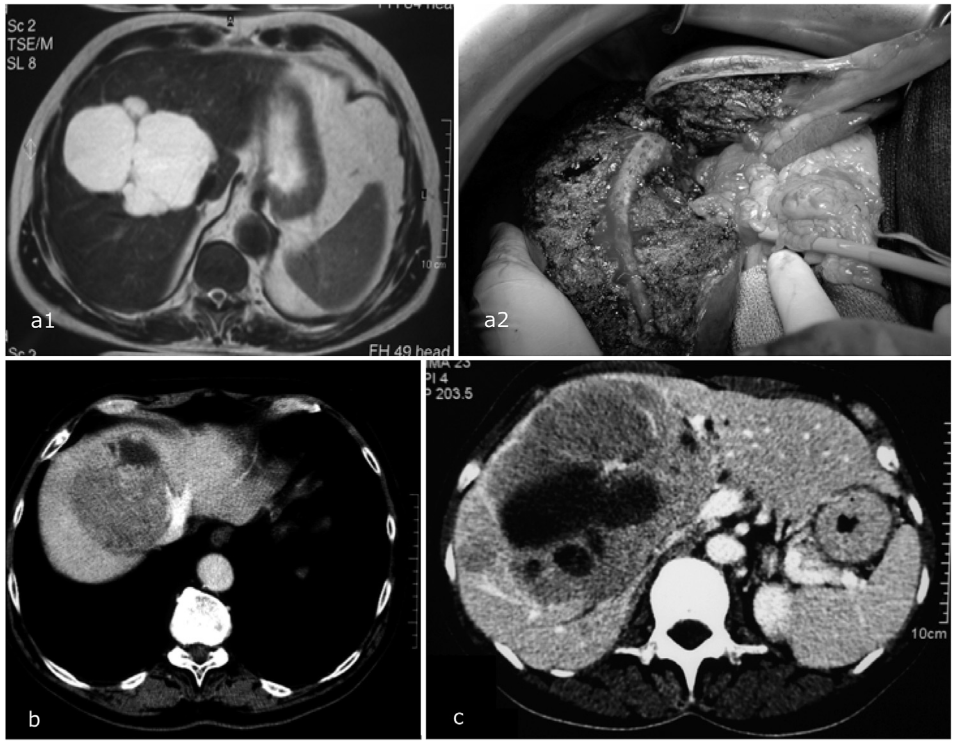

Fig. 2. a1: T2 weighted MRI showing a centrally located cystadenocarcinoma in a 70-year-old man. a2: operative view after CH. The limits of resection are clearly showed: umbilical fissure surrounded by the round ligament and right portal fissure showing the right hepatic vein. The patient is alive without disease 138 months after surgery. b: HCC on fibrotic HCV liver in a 78-year-old man. Axial CT scan showing a 10 cm tumor that compresses the hepatocaval confluence. A 6-min total vascular exclusion of the liver was needed at the end of resection to divide the middle hepatic vein. Operative specimen weighted 725 g. The patient presented late HCC recurrence and died 61 months after resection. c: Neuroendocrine metastasis with symptomatic hepatomegaly in a 50-year-old woman. Axial CT scan. The 18 cm-tumor closely squeezes the hilum and the right portal pedicle. CH was decided intraoperatively because of the small volume of the left lateral segment. Operative specimen weighted 1443 g. Tangential injury of the right posterior duct was repaired on T-tube, but persistent postoperative biliary fistula with biliary-bronchial fistula needed right posterior sectionectomy 3 months later. The patient died 8 months after operation from recurrent disease. Clearly, this case demonstrates the limits of this procedure.

right portal clamping. This step is much longer than the previous one because of the wider surface of the right portal fissure. Given the depth of the fissure, it is facilitated by the mobilization and elevation of the right liver. The course of the right hepatic vein is the landmark that guides the transection towards the inferior vena cava. At the hilum, the RAP is divided *en masse*, keeping enough of it above the clamp for suturing or stapling and to avoid injury to the right posterior bile duct. Indeed, in its usual supraportal type (85% of cases [22]), the right posterior bile duct runs cranially around the right anterior portal vein, drawing the Hjörstjö arch [19,22,23], where it can be injured during division or suture of the RAP stump. The specimen is then drawn forward (ventrally) and to the left to open widely the fissure and complete the posterior transection that is in contact with segment I; care must be taken to ensure a margin, and finally the middle hepatic vein near its root is cut. Bile leakage tests and/or cholangiography are used for checking the integrity of bile ducts on both sides of the remaining liver. The raw area of the liver is covered by the greater omentum, and drainage is systematically used.

Patient selection and analysis

The indications for CH were as follows: tumors located in both segments 4 and 8 at least, regardless of size or number but without tumor contact with the right or left hepatic veins or with the hilar plate (absence of jaundice). In such cases, CH was generally preferred to TS (±progenerative method) as a parenchyma-sparing resection. In addition, patients with cirrhosis should be classified as Pugh-Child A or B7, without portal hypertension, and should have an indocyanine green clearance of less than 15% at 15 min.

All demographic data, indications for resection, operative data, and postoperative follow-up of CH patients were retrospectively reviewed from a prospective database. Complications or death occurring during the same hospitalization or within 90 days were defined as morbidity and mortality, respectively. Complications were classified according to Dindo et al. [24]. Liver failure was defined using the 50-50 criteria [25]. Bile leakage (BL) was defined according to the ISGPS grade [26].

Statistics

Results were expressed as the mean ± SD (range). Comparisons were made using Chi-square test and Student's t-test, as appropriate. $P < 0.05$ was considered statistically significant. Survival rates were calculated using the Kaplan-Meier method.

Results

Patients series

From December 1997 to December 2017, 2099 liver resections were performed, of which 1004 were ≥3 segments, including 208 right TS and 30 left TS. During the same period, 64 (6%) patients underwent CH with a Glissonian suprahilar approach, whose characteristics are presented in Table 1.

Table 1
Patients characteristics (n = 64).

Age (mean ± SD, range)	64 ± 11	(37–84)
Age > 75 years	13	20%
Male sex	43	67%
Type of tumor		
Hepatocellular carcinoma	30	
Cholangiocarcinoma	9	
Metastasis from colorectal cancer	19	
Other metastasis	4	
Primary sarcoma	1	
Adenomatosis	1	
Liver parenchyma		
normal (F0)	38	
fibrotic (F1–F2)	9	
cirrhotic (F3–F4)	17	
Preoperative liver tests	mean ± SD	range
PT ratio (%)	93 ± 9	(74–100)
Bilirubin level (μmol/L)	11 ± 8	(4-27)
Albumin (g/L)	41 ± 6	(23–52)
ICG test (%) (25 pts)	13 ± 7	(5-36)

ICG: Indocyanine Green.

Table 2
Intraoperative data.

Additional procedures	35/64 patients	55%
Tumorectomy or RF ablation on the liver remnant		13
Diaphragmatic resection		7
Biliary tract repair for injury (T tube or Roux-en-Y)		5
Right posterior duct	3	
Left duct	1	
Bile duct confluence	1	
Hepatoduodenal lymph node resection		5
Resection of segment VI (en-bloc or not)		3
Resection of segment I		2
Extraction of tumor thrombus in the median hepatic vein		2
Pancreaticoduodenectomy		1
Left colectomy		1
Splenectomy for metastasis		1
Abdominal wall resection		1
Transdiaphragmatic en-bloc wedge pulmonary resection		1
Vascular inflow occlusion (intermittent)	60/64 patients	95%
Alternate hemihepatic (left then right) clamping		36
Total clamping (Pringle maneuver)		15
Combinations of total and selective clamping		9
No clamping		4
Duration of clamping for the left transection	20 ± 8 min	(10–45)
Duration of clamping for the right transection	37 ± 13 min	(19–80)
Operative duration	219 ± 56 min	(120–360)
Perioperative RBCs transfusion	14/64 patients median: 2	22% (2–5)

RF: radiofrequency; RBCs: red blood cells.

Intraoperative data (Table 2)

Surgical exposure was obtained via a right (±left) subcostal incision with upper midline extension in all patients. The suprahilar control of the RAP was successfully performed in 56 of 64 cases (87%). In the other 8 cases (13%), the control of the RAP was performed using a transhepatic approach from the left to the right because of the difficulties of achieving a suprahilar approach to the RAP. In 3 cases due to the absence of color changes despite RAP clamping, the fissure was found by spotting the right hepatic vein on ultrasonography. Intraoperative injuries of the bile ducts of the remaining liver occurred in 5 patients (8%) and were repaired by a Roux-en-Y cholangiojejunostomy (3 cases) or by direct suture on a T-tube (2 cases). Intermittent vascular inflow occlusion was used in all cases except 4. The mean operating time was 219 ± 56 min, including the additional procedures performed in more than half of CH patients.

Morbidity and mortality (see suppl table "detailed morbi-mortality")

Postoperative morbidity occurred in 19 patients (30%), of whom 10 (16%) experienced a major morbidity (Dindo III-V). One patient died one day after CH from cardiopulmonary causes (1/64 = 1,5%). For specific complications, 3 patients had transient ascites, one of whom had low grade liver failure (PT ratio 48% and total bilirubin 108 μmol/L at POD 5, discharged at POD 12). A peak in liver enzyme levels was noticed on the first POD (AST 589 ± 403 UI (143–2115)), but in the vast majority of cases, liver function tests returned to normal levels at one week. Thereby, the mean values at POD 7 were 67 ± 83 UI/L for AST, 81 ± 16% for PT ratio and 21 ± 15 μmol/L for bilirubin level. One patient had an acute hemorrhage from retro-pancreatic lymph node resection that required immediate reoperation and prolonged his ICU stay (40 days). Nine patients (14%) had BL, of whom 3 had biliary repair during surgery. Among these 9 patients, the BL healed spontaneously by the time of discharge for 3 patients or later for 3 patients (Grade A). Two patients had percutaneous drainage of bilioma (Grade B), and one patient had right posterior sectionectomy three months later for biliary-bronchial fistula after failure of endoscopic drainage (Grade C) (Fig. 2c). The mean postoperative stay was 13 ± 10 days (6-40).

Pathological data

The average specimen weighed 620 ± 225 g (250–1445). A single tumor was retrieved in 40 cases, The tumor was more likely to be solitary in cases of primary tumor (31/40) than in metastatic cases (9/23). The maximum tumor size was 7.4 ± 8 cm (1,5–18). The R0 and R1 resection-rates were 69% (n = 44) and 30% (n = 19) respectively. Only one patient had a R2-resection. R0 resection rate was obtained in 24/30 for hepatocellular carcinoma (HCC), 16/23 for metastasis, and only 2/7 for intrahepatic cholangiocarcinoma (IHCCA). Regardless of the margin status, 3 young patients had CH for highly symptomatic tumors (Fig. 2c) despite distant metastasis (lung, bones or lymph nodes).

Long-term outcomes (see suppl material)

For HCC patients, survival rates were 90%, 66% and 56% at 1, 3 and 5 years, respectively. Five-year survival rates were 34% for colorectal metastasis and 33% for IHCCA. In all, survival was not significantly different whether the resection was R0 or R1. Among the 15 patients who experienced an isolated hepatic recurrence, 11 had one or two repeat hepatectomies (n = 3), including 9 sectionectomies. Three of these 11 patients had an initial R1 resection, but none had margin-related recurrence (Table 3).

Comparison of the 2 decades of the study

The analysis of the series over time (2007–2017 vs 1997–2006) showed an increased scarcity of performing CBS (5.4% vs 7.4% of

Table 3
Repeat hepatectomy for recurrent disease (n = 14 among 11 patients).

Patient	Diagnosis	Resection margins	Type and delay	Status and delay
M, 59	HCC	R0	LLS, 11 mo	Dead, 21 mo
M, 49	CRM	R0	LLS, 26 mo	Dead, 45 mo
M, 66	HCC	R0	RPS, 31 mo	Dead, 39 mo
F, 78	CRM	R1	LLS, 28 mo	Alive, 111 mo
M, 61	CRM	R1	RPS + segment I, 11 mo	reoperation
= = =	= = =	R0	Segment III Tx, 24 mo	Dead, 53 mo
M, 70	HCC/cirrhosis	R0	Segment I Tx, 104 mo	Alive, 131 mo
F, 69	IHCCA	R1	LLS, 12 mo	reoperation
= = =	= = =	R0	Segment VII Tx, 18 mo	Alive, 126 mo
M, 68	HCC	R0	RPS, 53 mo	Dead, 68 mo
M, 55	HCC/cirrhosis	R0	Segment VI Tx, 28 mo	reoperation
= = =	= = =	R0	Liver Transplant, 35 mo	Alive, 60 mo
M, 74	HCC/cirrhosis	R0	RPS, 48 mo	Alive, 50 mo
M, 61	HCC/cirrhosis	R0	RPS, 22 mo	Alive, 24 mo

HCC = hepatocellular carcinoma, CRM = colorectal metastasis, IHCCA = intrahepatic cholangiocarcinoma, LLS = left lateral sectionectomy (segments II-III), RPS = right posterior sectionectomy (segments VI-VII), Tx = tumorectomy.

major hepatectomies). Recently, there have been more HCC patients (18/29 vs 12/35, p = 0.04), no intraoperative bile duct injuries (0/29 vs 5/35, p = 0.05), decreased BL (2/29 vs 7/35, p = 0.16), shorter hospital stay (11 ± 7 vs 14 ± 9 days, p = 0.13), unchanged tumor diameter (7.2 vs 7.6 cm, p = 0.79) and specimen weight (577 vs 610 g, p = 0.58).

Discussion

CH with a suprahilar Glissonian approach is a safe technique for the treatment of centrally located tumors with a low risk of postoperative liver failure. However, CH involves a high biliary morbidity and may increase the risk of positive margins. Although some series from China reported more than 100 ([27]) or 200 cases [28], this study reports a large Western series of CH.

Technically, the Glissonian approach precludes the numerous anatomical variations of the right pedicle [29], and many authors used it with a suprahilar or transhepatic approach [2,3,16,27,30–32]; however, the surgical technique was rarely detailed [33,34]. The suprahilar approach is easy to perform when dividing the posterior extremity of the cystic plate to reach the RAP, and clamping allows immediate identification of the right portal fissure. Moreover, this approach facilitates control of the right and left portal pedicles to allow alternate hemi-hepatic vascular occlusion in order to limit both ischemia of the remaining liver and splanchnic stasis [2–4,7,8,32,33]. Sometimes, the suprahilar approach may be difficult because of the volume and/or the location of the tumor. In our series, it was ineffective in only 8 cases (13%).

The postoperative mortality of CH is low: 1.5% in our series, 1.6% in a review of 859 CH [6], 2% in a recent meta-analysis of 1798 CH [12], and 1.4% in another study including 1380 CH (range 0–9%) [10]. Thus, mortality from CH appears much lower than mortality from TS in expert centers, which is approximately 8–9% [35,36], although several comparative studies have surprisingly shown no significant difference in mortality rates between CH and TS [11,12,27]. However, a recent comparative studies and meta-analysis showed reduced overall morbidity, reduced postoperative liver failure and shorter length of stay in the CH group compared to extended hepatectomy [10]. In all studies, CH has a significantly decreased rate of postoperative liver failure and might be the procedure of choice in cases of cirrhotic livers [10,13,27,28,32,37]. In those cases, patients are rarely amenable to TS because the remnant liver volume accounts for 15–40% of the total liver volume, as compared to 40–60% in CH cases [5]. Moreover, for central tumors, it is sometimes difficult to choose the side of the portal vein embolization [6,11].

The drawbacks of CH, including biliary complications and small surgical margins, are inherent to the central location of the tumor and its proximity to the hilum. BL remains a major issue after CH. In a recent study, more than half of the patients with BL had CH [38]. Postoperative BL was observed in 14% of CH in our series, which is twice as frequent as what was observed after major hepatectomy in our past experience (7%) [39]. BL rate was reported as high as 18% of cases after CH in a recent series [40]. CH has a relative risk for BL 5 times higher than other resections [41] and 2.75 time higher than TS [13]. Indeed, CH combines the recognized risk factors for BL: exposure of the hilar plate [42], exposure of the major Glissonian sheaths [41], and opening the right portal fissure [42,43]. It is disappointing that the Glissonian dissection technique did not reduce the rate of biliary complications, which should have constituted one of its putative advantages. The only randomized study that compared hilar dissection versus the Glissonian approach did not identify significant differences in BL (7.5% vs 10%), but there were no CH cases in this series [44]. However, no intraoperative bile duct injury was observed in the second period of our study, which was probably a result of the surgical experience. According the ISGLS classification [26], only one patient was classified with grade C BL. Regardless, we must be cautious when dividing the RAP, when exposing the hilar plate and as previously suggested [40], we must avoid the use of devices that generate heat (coagulation or thermofusion devices) in contact with the Glissonian sheaths, which is responsible for necrosis and secondary stenosis.

As for the surgical margins, a key prognostic factor in liver surgery [45] the 30% R1-resection rate in this study was unusually large, especially for IHCCA (7/9). However, the enlargement of surgical margins is weighed against the functional risk of TS. Many authors believe that CH is associated with smaller margins [2,3,5,6,11,13,37]. For HCC, which are often encapsulated, the question of the margin is less crucial than the anatomical nature of the resection since the tumor is large [45], and tumor exposure at the margins of the Glissonian sheaths or hepatic veins is allowed [37,46]. For metastases, small resection margins are not a contraindication for surgery [47,48]. Finally, for IHCCA, which are invasive tumors with biliary tropism and are often large at diagnosis [45], R0 resection is difficult to achieve [49]. Therefore, it seems clear that suprahilar CH is not a suitable treatment for large, mediohepatic IHCCA, which probably requires resection of the hilar plate with the bile duct confluence and/or TS.

As a retrospective study, this study has inherent selection limitations and the generalizability of these results might be restricted to specialized high-volume centers. The long period of time and the heterogeneity of the case series prevented us from further discussing the long-term results for each tumor type.

Conclusions

Contrary to widespread beliefs, CH is a feasible and safe technique for the treatment of centrally located tumors that are located a sufficient distance from the hilum. Jaundice and even hilum vicinity by the tumor are contraindications for the suprahilar approach. Careful control of the biliostasis should be provided. CH entails a very low risk of postoperative liver failure and mortality. Centrally located, large HCCs, including those on cirrhotic livers, are the ideal candidates that may benefit from the procedure.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ejso.2019.09.010.

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