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ORIGINAL ARTICLE

Basic Study

7347 Reabsorption of iron into acutely damaged rat liver: A role for ferritins
Malik IA, Wilting J, Ramadori G, Naz N

7359 Region-dependent effects of diabetes and insulin-replacement on neuronal nitric oxide synthase- and heme oxygenase-immunoreactive submucous neurons
Bódi N, Szalai Z, Chandrakumar L, Bagyánszki M

7369 Parallel mRNA, proteomics and miRNA expression analysis in cell line models of the intestine
O'Sullivan F, Keenan J, Aherne S, O'Neill F, Clarke C, Henry M, Meleady P, Breen L, Barron N, Clynes M, Horgan K, Doolan P, Murphy R

Retrospective Cohort Study

7387 Fecal calprotectin measurement is a marker of short-term clinical outcome and presence of mucosal healing in patients with inflammatory bowel disease
Kostas A, Siakavellas SI, Kosmidis C, Takou A, Nikou J, Maropoulos G, Vlachogiannakos J, Papatheodoridis GV, Papaconstantinou I, Bamias G

Retrospective Study

7397 Endoscopic balloon dilation of crohn's disease strictures-safety, efficacy and clinical impact
Lopes S, Rodrigues-Pinto E, Andrade P, Afonso J, Baron TH, Magro F, Macedo G

7407 Survival analysis based on human epidermal growth factor 2 status in stage Ⅱ-Ⅲ gastric cancer
Cho JH, Lim JY, Cho JY

7415 Efficacy of postoperative adjuvant transcatheter arterial chemoembolization in hepatocellular carcinoma patients with microvascular invasion
Ye JZ, Chen JZ, Li ZH, Bai T, Chen J, Zhu SL, Li LQ, Wu FX

7425 Value of gamma-glutamyltranspeptidase-to-platelet ratio in diagnosis of hepatic fibrosis in patients with chronic hepatitis B
Hu YC, Liu H, Liu XY, Ma LN, Guan YH, Luo X, Ding XC

Observational Study

7433 Anatomic isolated caudate lobectomy: Is it possible to establish a standard surgical flow?
Jin Y, Wang L, Yu YQ, Zhou DE, Liu DR, Yang JJ, Peng SY, Li JT

7440 Circulating miRNAs as biomarkers for severe acute pancreatitis associated with acute lung injury
Lu XG, Kang X, Zhan LB, Kang LM, Fan ZW, Bai LZ

Prospective Study

7450 Scoring systems for peptic ulcer bleeding: which one to use?
Budimir I, Stojsavljević S, Baršić N, Bišćanin A, Mirošević G, Bohnec S, Kirigin LS, Pavić T, Ljubičić N

Randomized Controlled Trial

7459 Tenofovir *vs* lamivudine plus adefovir in chronic hepatitis B: TENOSIMP-B study
Rodríguez M, Pascasio JM, Fraga E, Fuentes J, Prieto M, Sánchez-Antolín G, Calleja JL, Molina E, García-Buey LM, Blanco MÁ, Salmerón J, Bonet ML, Pons JA, González JM, Casado MA, Jorquera F; the TENOSIMP-B Research Group

7470 Clinical outcomes of transcatheter selective superior mesenteric artery urokinase infusion therapy *vs* transjugular intrahepatic portosystemic shunt in patients with cirrhosis and acute portal vein thrombosis
Jiang TT, Luo XP, Sun JM, Gao J

CASE REPORT

7478 Extraordinary response of metastatic pancreatic cancer to apatinib after failed chemotherapy: A case report and literature review
Li CM, Liu ZC, Bao YT, Sun XD, Wang LL

7489 3D-printed "fistula stent" designed for management of enterocutaneous fistula: An advanced strategy
Huang JJ, Ren JA, Wang GF, Li ZA, Wu XW, Ren HJ, Liu S

World Journal of Gastroenterology
Volume 23 Number 36 November 7, 2017

Contents

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World Journal of Gastroenterology (*World J Gastroenterol*, *WJG*, print ISSN 1007-9327, online ISSN 2219-2840, DOI: 10.3748) is a peer-reviewed open access journal. *WJG* was established on October 1, 1995. It is published weekly on the 7th, 14th, 21st, and 28th each month. The *WJG* Editorial Board consists of 1375 experts in gastroenterology and hepatology from 68 countries.

The primary task of *WJG* is to rapidly publish high-quality original articles, reviews, and commentaries in the fields of gastroenterology, hepatology, gastrointestinal endoscopy, gastrointestinal surgery, hepatobiliary surgery, gastrointestinal oncology, gastrointestinal radiation oncology, gastrointestinal imaging, gastrointestinal interventional therapy, gastrointestinal infectious diseases, gastrointestinal pharmacology, gastrointestinal pathophysiology, gastrointestinal pathology, evidence-based medicine in gastroenterology, pancreatology, gastrointestinal laboratory medicine, gastrointestinal molecular biology, gastrointestinal immunology, gastrointestinal microbiology, gastrointestinal genetics, gastrointestinal translational medicine, gastrointestinal diagnostics, and gastrointestinal therapeutics. *WJG* is dedicated to become an influential and prestigious journal in gastroenterology and hepatology, to promote the development of above disciplines, and to improve the diagnostic and therapeutic skill and expertise of clinicians.

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ORIGINAL ARTICLE

Observational Study

Anatomic isolated caudate lobectomy: Is it possible to establish a standard surgical flow?

Yun Jin, Liang Wang, Yuan-Quan Yu, Dong-Er Zhou, Da-Ren Liu, Jun-Jie Yang, Shu-You Peng, Jiang-Tao Li

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Author contributions: Peng SY and Li JT conceived and designed the study; Jin Y, Wang L, Yu YQ and Yang JJ performed the study; Jin Y and Yang JJ wrote the paper; Zhou DE, Liu DR, Peng SY and Li JT reviewed and edited the manuscript; All authors read and approved the manuscript.

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Abstract

AIM

To establish the surgical flow for anatomic isolated caudate lobe resection.

METHODS

The study was approved by the ethics committee of the Second Affiliated Hospital Zhejiang University School of Medicine (SAHZU). From April 2004 to July 2014, 20 patients were enrolled who underwent anatomic isolated caudate lobectomy at SAHZU. Clinical and postoperative pathological data were analyzed.

RESULTS

Of the total 20 cases, 4 received isolated complete caudate lobectomy (20%) and 16 received isolated partial caudate lobectomy (80%). There were 4 cases

with the left approach (4/20, 20%), 6 cases with the right approach (6/20, 30%), 7 cases with the bilateral combined approach (7/20, 35%), 3 cases with the anterior approach (3/20, 15%), and the hanging maneuver was also combined in 2 cases. The median tumor size was 5.5 cm (2-12 cm). The median intra-operative blood loss was 600 mL (200-5700 mL). The median intra-operative blood transfusion volume was 250 mL (0-2400 mL). The median operation time was 255 min (110-510 min). The median post-operative hospital stay was 14 d (7-30 d). The 1- and 3-year survival rates for malignant tumor were 88.9% and 49.4%, respectively.

CONCLUSION

Caudate lobectomy was a challenging procedure. It was demonstrated that anatomic isolated caudate lobectomy can be done safely and effectively.

Key words: Caudate lobectomy; Surgical flow; Anatomic liver resection

Core tip: Caudate lobe resection is still a challenging procedure for the vast majority of surgeons because of the difficult anatomical location and intraoperative bleeding. According to prior experience, six steps were established and validated on the patient. Anatomic isolated caudate lobectomy can be done safely and effectively following the surgical flow.

Jin Y, Wang L, Yu YQ, Zhou DE, Liu DR, Yang JJ, Peng SY, Li JT. Anatomic isolated caudate lobectomy: Is it possible to establish a standard surgical flow? *World J Gastroenterol* 2017; 23(41): 7433-7439 Available from: URL: http://www.wjgnet.com/1007-9327/full/v23/i41/7433.htm DOI: http://dx.doi.org/10.3748/wjg.v23.i41.7433

INTRODUCTION

The caudate lobe (CL), situated in a tricky location, lies deep in the liver and is adjacent to major blood vessels. CL consists of a Spiegel lobe on the left, a caudate process on the right, and a paracaval portion between them[1]. Surgical resection is the most suitable strategy to eradicate hepatic malignant lesions in this area. In recent years, the number of caudate lobectomies has increased with the improvement of imaging[2-5]. However, CL resection remains a challenging procedure for the vast majority of surgeons because of the difficult anatomical location and intraoperative bleeding.

Overall survival (OS) can be achieved by anatomic liver resection for hepatocellular carcinoma (HCC) patients[6,7]. However, reports of anatomic resection usually refer to segment Ⅱ to segment Ⅷ, excepting CL. The implement of more CL resection is limited due to a lack of standard flow. Therefore, the aim of this study was to establish the surgical flow for anatomic isolated CL resection.

MATERIALS AND METHODS

Patients

The study was approved by the ethics committee of the Second Affiliated Hospital Zhejiang University School of Medicine. Twenty patients who underwent anatomic isolated caudate lobectomy between April 2004 to July 2014, performed by our group, were enrolled in this study, including 13 males (13/20, 65%) and 7 females (7/20, 35%). The median age of patients was 55.5 years, ranging from 24-72 years. Postoperative pathological examinations included 14 cases of HCC (14/20, 70%), 2 cases of adenocarcinoma (2/20, 10%), 1 case of hepatic hemangioma (1/20, 5%), 1 case of hepatosarcoma (1/20, 5%), 1 case of angioleiomyoma (1/20, 5%), and 1 case of adenoma (1/20, 5%) (Table 1).

Surgical approach

The procedures were performed according to the results of computed tomography (CT) or magnetic resonance imaging (MRI) before surgery (Figure 1). Based on the location of the tumor, four different flows were planned before surgery (Figure 2).

Step 1: Mobilization of the liver. For all patients, a reversed L-shaped incision was adopted from xiphoid to the tip of 12th rib. For resection of the caudate process, the right ligamentum teres, falciform ligament, coronary ligament and triangular ligament were divided (Figure 3A). The hepatorenal ligament was dissected and the right adrenal gland was separated from the right liver with a right approach. For resection of the Spiegel lobe, usually, the ligaments of the left liver were dissected, Arantius ligament was divided until the tip of the CL and the Spiegel lobe was exposed completely with a left approach (Figure 4). For complete CL resection, usually, both left and right liver were mobilized. For giant CL tumors or the paracaval portion, sometimes, the transection of the liver parenchyma along Cantilie's line were conducted.

Step 2: Ligation of short hepatic veins. For a right approach, liver was turned to the left and the inferior vena cava (IVC) was exposed. The inferior right hepatic vein was divided firstly and short hepatic veins were ligated gradually along the IVC (Figure 3B). The caudate process was exposed and dissociated from the IVC. For a left approach, the liver was turned to the right and short hepatic veins were isolated as well as divided until the Spiegel lobe was separated from the

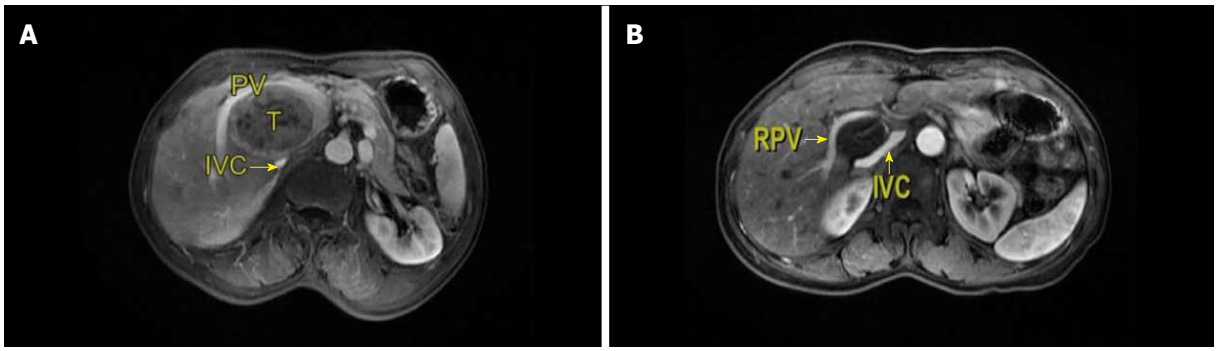

Figure 1 Magnetic resonance images for caudate lesions. A: T located between PV and IVC; B: Hepatic hemangioma located between RPV and IVC. IVC: Inferior vena cava; PV: Portal vein; RPV: Right portal vein; T: Tumor.

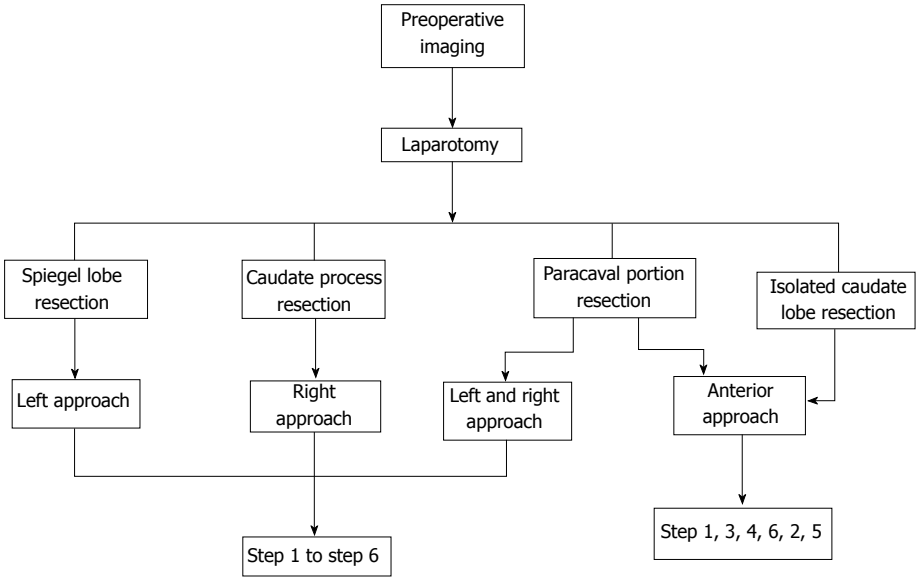

Figure 2 Surgical flow.

Table 1 Clinical data for all 20 patients with isolated caudate lobectomy

n = 20	Data
Sex	
Female	7 (35)
Male	13 (65)
Age in yr	55.5 (24-72)
Pathological examinations	
Hepatocellular carcinoma	14 (70)
Intrahepatic cholangia carcinoma	2 (10)
Hepatic hemangioma	1 (5)
Hepatosarcoma	1 (5)
Angiomyolipoma	1 (5)
Adenoma	1 (5)
Tumor size in cm	5.5 (2-12)

Data are presented as *n* (%) or median (range).

IVC completely.

Step 3: Isolation and taping of three major hepatic veins. The liver was pushed down medially, and the fossa was exposed between the right hepatic vein (RHV) and the middle hepatic vein (MHV) (Figure 3C). A tape was positioned around the common trunk of the MHV and the left hepatic vein (LHV). The hepatocaval ligament (Makuuchi ligament[8]) was extra-hepatically dissected from the right side and another tape was positioned around the RHV carefully.

Step 4: Controlling the inflow blood supply. The hepatoduodenal ligament was exposed and a tape was encircled around the hepatic hilum to control hepatic blood inflow if necessary. The occlusion time was usually 5 min, 8 min and 10 min during the first three times and then 10 min with 2 min interruption every time. The branch of portal triads to the CL was divided and ligated. Afterwards, ischemia landmarks could be found easily (Figure 3D).

Step 5: Identification of the CL boundary. The left boundary was established as the Arantius ligament, the right boundary was described as Peng's line from the CL tip to the caudate process[9] (Figure 5). The tip

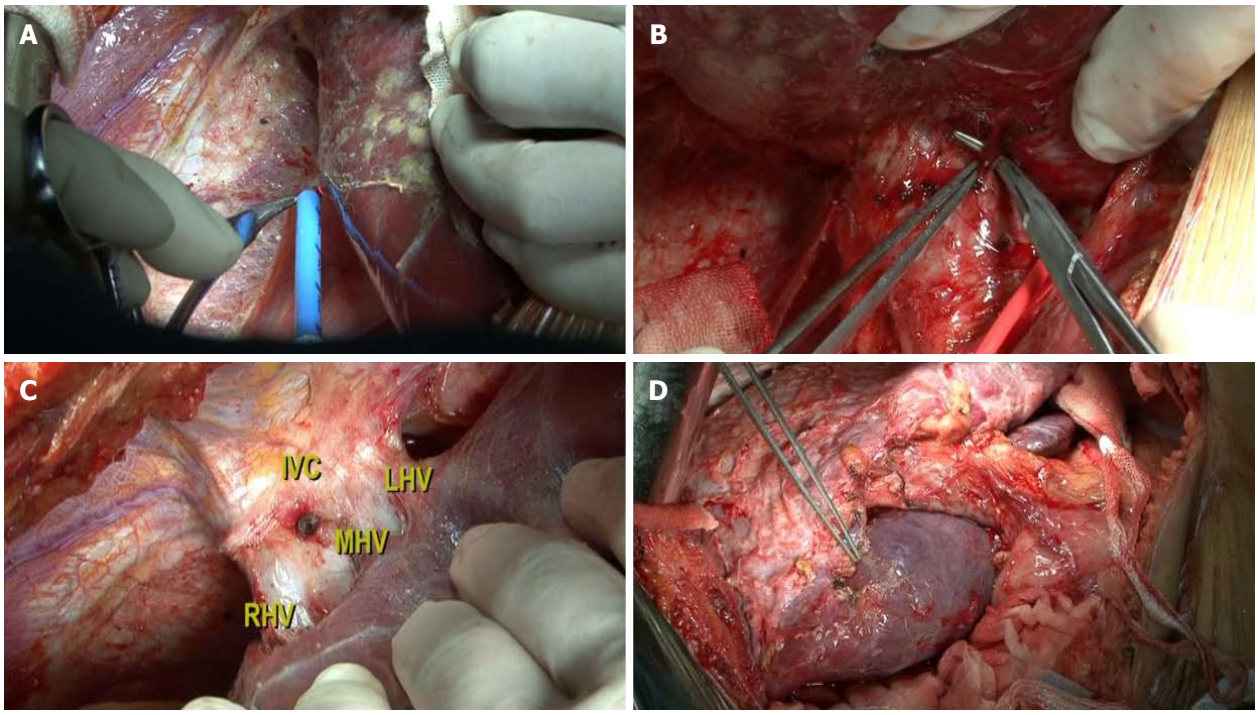

Figure 3 Flow of the caudate lobectomy. A: Liver mobilization; B: Short hepatic veins isolated and divided; C: Three hepatic veins isolated; D: Ischemia landmark of the caudate lobe is shown.

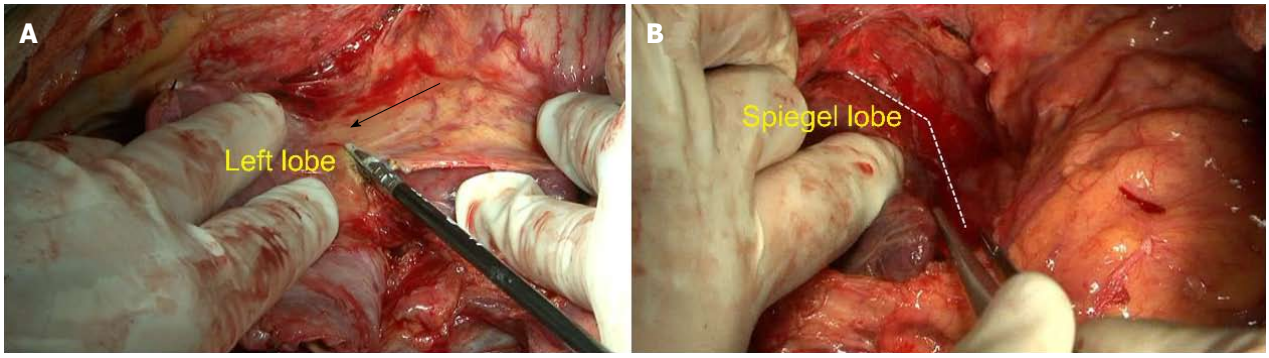

Figure 4 Marking of the left boundary of the caudate lobe. A: Divided Arantius ligament (black arrow); B: Left boundary of caudate lobe (white dotted line).

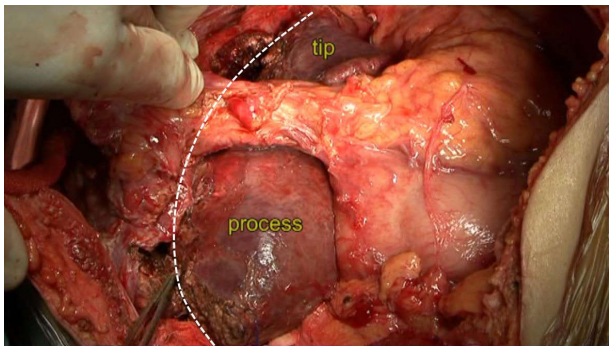

Figure 5 Identification of the right boundary of the caudate lobe. Peng's line was marked as the right boundary, which was from the upper tip to the process (white arc).

of the CL was located between the LHV and the IVC.

Step 6: Liver transection. Hepatic parenchyma was transected with the curettage and aspiration dissection technique using Peng's multifunction operative dissector[4,10].

The anatomic isolated caudate lobectomy is presented in the accompanying video (Supplement 1).

Statistical analysis

Clinical variables were described as median or mean ± SD. Discrete and continuous variables were analyzed by chi-square test and *t*-test, respectively. Survival time was analyzed by the Kaplan-Meier method. All data were analyzed by SPSS 16.0 software (SPSS Inc,

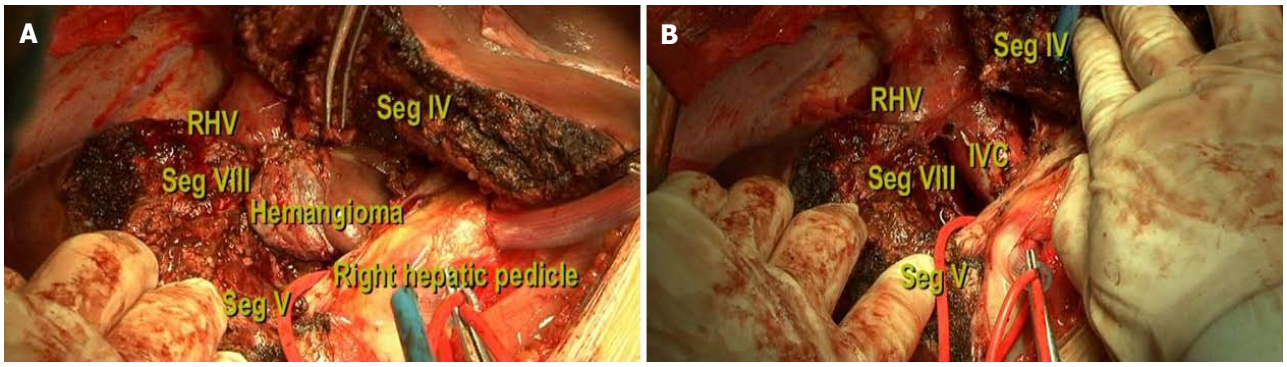

Figure 6 Splitting the liver by the anterior approach. A: The hemangioma was exposed; B: The hemangioma was removed and the major vessels were identified.

Table 2 Surgical data for all 20 patients with isolated caudate lobectomy

Surgical feature	Data
Approach	
LSR	4 (20)
RSR	6 (30)
CSR	7 (35)
AR	3 (15)
Procedure	
ICCL	4 (20)
IPCL	16 (80)
Blood loss in mL	600 (200-5700)
VIBT in mL	250 (0-2400)
Operation time in min	255 (110-510)
HSPO in d	14 (7-30)
Postoperative complication	
Incision infection	1 (5)
Ascites	3 (15)
Pleural effusion	2 (10)

Data are presented as *n* (%) or median (range). AR:Anterior resection; CSR: Combined sides resection; HSPO: Hospital stay post operation ; ICCL: Isolated complete caudate lobectomy; IPCL: Isolated partial caudate lobectomy; LSR: Left side resection; RSR: Right side resection; VIBT: Volume of intraoperative blood transfusion.

Chicago, IL, United States).

RESULTS

Among all patients, 4 cases received isolated complete caudate lobectomy (4/20, 20%), while 16 cases received isolated partial caudate lobectomy (16/20, 80%). Based on the type of dissection, there were 4 cases with the left approach (4/20, 20%), 6 cases with the right approach (6/20, 30%), 7 cases with the bilateral combined approach (7/20, 35%), 3 cases with the anterior approach (3/20, 15%) (Figure 6), and the hanging maneuver was also combined in 2 cases. The median tumor size was 5.5 cm (2-12 cm). The median intra-operative blood loss was 600 mL (200-5700 mL). The median intra-operative blood transfusion volume was 250 mL (0-2400 mL). The median operation time was 255 min (110-510 min), and the median post-operative hospital stay was 14 d (7-30 d).

There was 1 case of incision infection (1/20, 5%), 3 cases of ascites (3/20, 15%), and 2 cases of pleural effusion (2/20, 10%) (Table 2). There was no mortality and the median survival time for malignant tumor was 48 mo, with 1- and 3-year survival rates of 88.9% and 49.4%, respectively.

DISCUSSION

Due to abundant adjacent blood vessels of the CL, chemoembolization, radiofrequency ablation and other treatments are not appropriate for CL lesions[11]. Surgical resection is considered as the preferred method and anatomic resection can improve prognosis[7,12]. Hasegawa *et al*[6] believed that anatomic resection was one of the independent predictors of improved OS for HCC. However, the majority of anatomic resection refers to the segment Ⅱ to segment Ⅷ, excepting segment Ⅰ. Caudate lobectomy was once called a 'bloody gultch'[13]. While the resection of the tumor in the CL is not difficult today, it is still difficult to perform isolated anatomic resection for CL; the vast majority reports are from case reports. In this study, we mainly explored the possibility to establish a standard surgical flow for anatomical isolated caudate lobectomy[5,14,15].

Chaib *et al*[16] classified CL tumors into five types, depending on their locations, and this classification has clinical significance for small size tumors. However, in China, HCC is usually large and concurrent with cirrhosis. And, anatomic resection is necessary for longer survival. Blumgart's group[17] performed 150 cases of caudate resection, which led to a median survival for HCC of 32 mo. In 2013, Philips *et al*[18] reported their experience of caudate resection, having a median OS of 21 mo. Our results showed a median survival time of 48 mo for malignant patients, though this was not a comparison study.

Like other anatomic resections, the identification of the blood supply to one part or the whole CL is a prerequisite. The key steps are preoperative assessment and intra-operative identification of the precise boundary. We called this boundary as two tips, two boundaries and one virtual plane. The confluence of Arantius ligament and IVC was the upper tip, while the converging point of the right lobe and the caudate

process was the lower tip. The Arantius ligament is regarded as the left border of CL, while Peng's line is the right border. The plane of the retro-CL is the surface of the retro-hepatic IVC. In practice, resection of the CL along the Peng's line shows similar effects as intra-operative dye labeling, which is safe and convenient[5].

The advantages of the different surgical approaches are to perform CL resection easily. Left approach is suitable for the tumor located in the Spiegel lobe. Right approach is for resection of tumor located in the caudate process. For complete CL resection, we usually used the left and right approach. For giant CL tumors or the paracaval portion, the anterior approach should be used. The disadvantage of the anterior approach is that incidence of biliary fistula will be high because of hepatic parenchyma transection. The laparoscopic resection of the CL has been reported sporadically, and we will be working on this in the future.

During the resection, other surgical techniques can be used to reduce bleeding and increase surgical safety. These techniques include the selective control of inflow, the liver hanging maneuver and retrograde resection of the CL[15,19,20].

In conclusion, as an individual anatomic segment, caudate lobectomy remains a substantially challenging procedure. Our experience demonstrated that anatomic isolated caudate lobectomy can be done safely and effectively by establishing a surgical flow.

COMMENTS

Background

Caudate lobe (CL) is an important part of the liver and adjacent to the major blood vessels. Surgical resection is the preferred treatment for patients with malignant lesions in this area. However, CL resection remains a challenging procedure.

Research frontiers

The implementation of more CL resections is limited due to a lack of standard flow. The hotspot of this study is the establishment a standard surgical flow for anatomic isolated caudate lobectomy.

Innovations and breakthroughs

In recent years, the number of caudate lobectomies has increased. However, anatomic isolated caudate lobectomy is not common because of the difficult anatomical location and intraoperative bleeding. This study presents the recommendation of a surgical flow which facilitates the performance of anatomic isolated caudate lobectomy safely.

Applications

The surgical flow in this study was established according to prior experience and validated on the patient. Anatomic isolated caudate lobectomy can be done safely and effectively based on this flow.

Terminology

Peng's line is the right boundary of CL, from the CL tip to the right border of the caudate process. Peng's multifunction operative dissector is an electrosurgical instrument, which was used for transection hepatic parenchyma.

Peer-review

CL isolated resection is a rare and challenging procedure. I think that the strength of the paper is the description of the different techniques, detailed with intraoperative pictures. The authors deserve praise for having done a difficult job - the article has described a series of 20 resections in a decade. It may be expected that the authors will come up with a larger series in future. The description of operative steps is one of the strong points of this article.

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