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## RESEARCH ARTICLE

### CAUDATE LOBE TUMOR RESECTION ANATOMY AND SURGICAL TREATMENT TECHNIQUES; 22 CASE REPORTS IN ONE MEDICAL CENTER

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#### ABSTRACT

**Background:** Caudate surgical resection is considered to be the most effective method and the main indication for treating tumors in the caudate lobe and that is still a challenge for hepatobiliary surgeons. Our objective is to present two new main concepts; one is the fourth porta hepatis, the other is that large caudate lobe tumors could be defined if the size of the tumor is larger than 5cm.

**Methods:** of the 22 patients who underwent caudate lobe tumors resection between January 2013 and December 2016, we performed various surgical approaches for resecting the caudate lobe tumors.

**Results:** There were 12 male, 10 female patients, age ranging between 15 and 74 years. The indications were hepatocellular carcinoma in seven patients, hemangioma in six patients, focal nodular hyperplasia in two patients, cholangiocarcinoma in seven patients. Left-sided approach was performed in one case, right-sided approach in two cases, a combined approach in 17 cases, and anterior approach in one case. There was no death in the postoperative period.

**Conclusions:** Caudate lobe is not only a hepatic segment but can also be defined as an Accessory liver, and it has individual bile duct and blood vessels which we define as a fourth porta hepatis. Caudate lobe Tumor size and location is the main factor that influences the choice of surgical approach.

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## INTRODUCTION

Caudate lobe (segment 1) is located between the left and right liver lobes, it lies posterior to the hilum and anterior to the inferior vena cava (IVC) and may envelop this structure circumferentially, and under the terminal portion of the main hepatic vein (Abdalla, Vauthey et al. 2002). Hepatic caudate lobe resection has been considered to be the last field of hepatic lobectomy. In recent years, with the development of the study of the anatomy of the caudate lobe of liver and its relationship with the peripheral blood vessels, and the improvement of hepatic blood flow control technology, the resection rate of caudate lobe tumors rises obviously. However, caudate resections still remains a big challenge for surgeons because of the high risks, including unique location, complicated relations with the adjacent blood vessels. (Hawkins, DeMatteo et al. 2005). According to Couinaud's classification, the caudate lobe is defined as liver segment 1 (Couinaud 1989, zeng-Qing Wen 2008), and in accordance

with Kumon's method, caudate lobe is divided into three parts (Chaib, Ribeiro et al. 2007, Tian, Chen et al. 2014): The Spiegel lobe is located under the lesser omentum to the left of the inferior vena cava (IVC), the paracaval portion is located anteriorly by the intrahepatic vena cava, and The caudate process is shaped like tongue projection between the inferior vena cava and the portal vein (Chaib, Ribeiro et al. 2009). The goal of our research is to define the methods of surgical treatment of caudate lobe tumor and present two new main concepts; one is the fourth porta hepatis, the other is that caudate lobe tumors could be defined as giant tumors if the size of the tumor is larger than 5cm.

## MATERIALS AND METHODS

From 2013-01-01 to 2016-10-20 all patients with liver tumors treated at Shandong provincial hospital were entered into a prospective hepatobiliary database. A total of 22 patients underwent caudate lobe resection. 12(54.6%) male patients, 10(45.4%) female patients, the mean of age was 48.6 with range (15-74) years. The pathological diagnoses of tumors were: 7 cases of hepatic cell cancer (31.8%), 6 cases of

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hemangioma (27.3%), 2 cases of Focal Nodular Hyperplasia (9.1%), and 7 cases of cholangiocarcinoma (31.8%). Among the 22 cases, the tumor was located in the right side of the caudate lobe in 2 cases (9.1%), in the left side of the caudate lobe in one case (4.5%), in the Spiegel lobe in one case (4.5%), in the caudate process in one case (4.5%), and in total caudate lobe in 17 cases (77.3%). The mean standard deviation of tumors' size was  $30 \pm 20.9$  with range (6-80 cm<sup>2</sup>). Descriptive statistical analysis was performed by software SPSS 16.0 (SPSS, Inc., Chicago, IL).

### Surgical Techniques

All patients were treated under general anesthesia, the inverted L-incision extending from the xiphoid till 1cm above the umbilicus and then 4cm laterally to the right for an excellent exploration of the liver had been used. After clear exploration of the liver and (Abdalla, Vauthey *et al.* 2002) ruling out intra-abdominal metastasis, then the caudate tumors were then palpated. Mobilization of the liver was started by dividing the falciform ligament and cut off the coronary, triangular, hepatorenal and hepatogastric ligaments, making the liver free and moveable. Exposing and inspecting the caudate lobe then continued resection. Caudate resection can be performed as isolated resection or combined with other segments of the liver (Sarmiento, Que *et al.* 2002, Chaib, Ribeiro *et al.* 2009). Caudate lobe resection techniques are difficult and still remain a challenge for hepatobiliary surgeons, it may lead to serious complications, but as long as we understand the preoperative evaluation of liver functional reserve, extent of liver cirrhosis and the relationships between the caudate lobe tumor and IVC in preoperative liver function tests (LFTs), spiral CT, MRI, color Doppler ultrasound and other examinations, together with understanding of the liver and caudate lobe anatomy, then grasp the surgical indication to select the appropriate incision and surgical approach, all these factors are important for a safe and feasible caudate lobe resection. Accordingly, we performed various types of surgical approaches, which include: the right side approach; left side approach, an anterior transhepatic approach, left and right side combined approach.

#### Right side approach

This is used for caudate process tumor and in combined resection with right hemihepatectomy, making the whole liver moveable by dividing its ligaments, then turning the right hepatic lobe towards the left to separate and resect the caudate lobe (Chaib, Ribeiro *et al.* 2007). If there is metastasis in the right hepatic lobe, with no obvious liver cirrhosis, we first resect the right hepatic lobe and then resect the caudate lobe, because the right side approach is not suitable in case of cirrhosis. Regarding cases when the tumor is large and invading the right hepatic lobe, for better exposure of the caudate and to easily operate and control the possibility of heavy bleeding, in the patients with good liver functions, it's necessary to consider resection of the right posterior lobe or right hemihepatectomy.

#### Left side approach

This is used for tumors located in Spiegel lobe and in combined resection with left hemihepatectomy. The hepatogastric and retrocaudal ligaments were divided. The left hepatic lobe was mobilized and rotated to the right to expose the caudate lobe. The branches from the portal vein, hepatic

artery, bile duct and short hepatic vein were divided and ligated. And then the parenchyma was dissected to separate the caudate lobe (Ahanatha Pillai, Sathyanesan *et al.* 2013). For cases of large tumors invading the liver left lobe, left lateral lobe resection or left hemihepatectomy can be considered first, that is to fully expose the caudate lobe and make it easy to operate and control the possibility of massive bleeding, in case of emergency bleeding, we should totally block the hepatic blood flow. However, in combined liver resection, we should fully evaluate the liver function of patients, to prevent the occurrence of postoperative liver failure.

#### Performing the left side approach, surgeons should pay attention to the following points:

- Injury of left hepatic artery should be avoided during division and dissection of the hepatogastric ligament.
- During exposure of the third porta hepatis, the short hepatic veins should be cut off and ligated on the wall of IVC, avoiding the huge hemorrhage.
- When the IVC is completely surrounded by caudate lobe tissue, this makes it difficult by the left side approach alone; sometimes it is necessary to be combined with the right side approach.

#### Left and right side combined approach

This is used for isolated caudate lobe resection. (Yi Wang 2010). Choosing this approach is appreciated for isolated caudate lobe resection and large size caudate tumors. This approach starts by separating the liver from its ligaments, liver mobilization is achieved by dividing the hepatic round ligament, the falciform ligament, up to ventral surface of the suprahepatic inferior vena cava, then exposing the second hepatic porta, the next step is pulling down the liver from the diaphragmic surface to expose suprahepatic inferior vena cava. In the right side of the liver, the coronary, triangular, and hepatorenal ligaments were divided, the liver was then pulled up to the left to separate the right adrenal gland in order to expose the suprahepatic inferior vena cava. After the liver parenchyma between the caudate lobe and the main liver was transected, the tumors were removed. The short hepatic veins were dissected, divided, and ligated caudal cranially. These veins were best approached from the right side, when there was a huge tumor with small cavity space. (Tian, Chen *et al.* 2014).

#### Anterior transhepatic approach

This is used for paracaval portion tumors, especially when the tumor is close to the main hepatic vein or in case with cirrhosis. The median approach can be used for a better surgical exposure, and it reduces the risk of operation by providing a good view and access to perform a complete caudate lobe resection. Anterior approach is performed by dissecting the liver parenchyma from the midline. The liver ligaments were divided, then the right and the left liver parenchyma pulled aside to expose the caudate lobe. The caudate lobe artery, vein and bile duct which are branches from the first porta hepatis were divided and ligated to separate the caudate lobe from the first porta hepatis, then the venous ligament and short hepatic veins were divided and the caudate lobe was completely resected. An anterior hepatic transection is indicated for paracaval portion small tumors. It is usually a safe and potentially curative surgical option (Chaib, Ribeiro *et*

al. 2009). This method is less used if the tumor is huge, because the anterior approach requires segmental resection, which prolongs the operation time and increases the risk of bleeding. (Tanaka, Shimada *et al.* 2005, Lee, Hwang *et al.* 2007, Ahanatha Pillai, Sathyanesan *et al.* 2013).

### Prevention and control of bleeding

Caudate lobe tumor resection can be performed in most patients with pringle maneuver (15 minutes of occlusion alternating with 5 minutes of liver revascularization). Three operative steps are required for safety during caudate resection (Ahanatha Pillai, Sathyanesan *et al.* 2013): firstly, starting with controlling the inflow to the caudate lobe, which includes the dissection, ligation, and cutting the branches that arise from the portal vein and hepatic artery along the base of the umbilical fissure. Secondly, controlling outflow of the caudate then division of the caudate-caval ligament (CCL), which allows the Spiegel caudate to be rotated and elevated from IVC, and the retrocaudate veins are dissected with careful individual ligation, this can be performed safely by the right-sided approach. Lastly, a careful division of the caudate lobe in respect with dissection and transection of the parenchyma located between the caudate and segments within the right and left side of hepatic lobes along with ligation of caudate bile ducts.

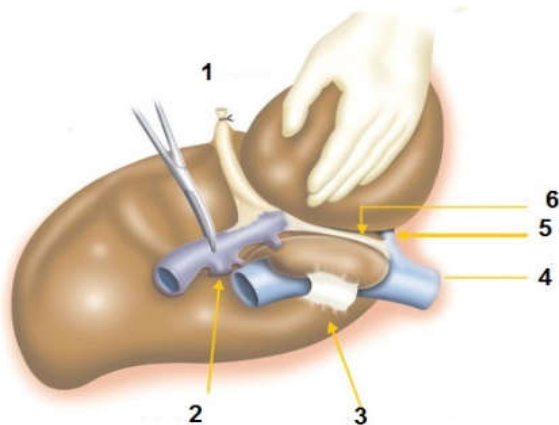


Figure 1. View of the caudate from the left 1. Round ligament. 2. Right portal vein. 3. Dorsal ligament. 4. Inferior vena cava 5. Left hepatic vein. 6. Ligamentum venosum



Figure 2. CT scan showing the caudate lobe tumor

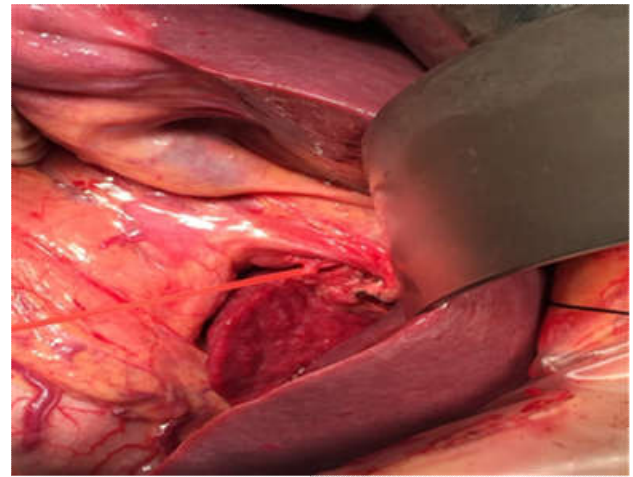


Figure 3. Operative picture showing the caudate lobe tumor and caudate lobe artery

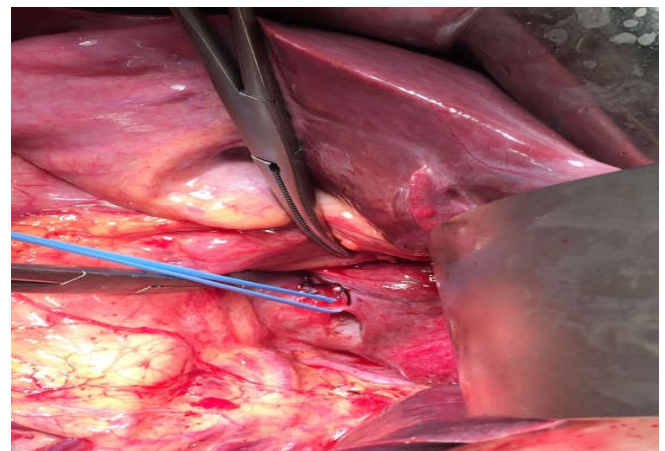


Figure 4. Operative picture showing the caudate lobe vein

## RESULTS

The operations were completed successfully, There was no mortality in the postoperative period; all patients were treated by active caudate lobe tumor resection. Isolated caudate lobe resection in 17 cases (77.3%) were performed by the left and right side approach, and Spiegel resection in one case (4.5%) was performed by the left side approach, right side caudate lobe resection in 2 cases (9.1%) were performed by the right side approach, left side caudate lobe resection performed in one case (4.5%) by the left side approach, and the caudate process tumor resection in one case (4.5%) performed by the Anterior transhepatic approach. There were complications in the postoperative patients but were not serious, including: ascites, liver dysfunction, hypoproteinemia and bile leakage. All patients were treated and recovered by corresponding symptomatic treatment.

## DISCUSSION

Well understanding of the special anatomy of caudate lobe of the liver is very important for hepatic surgeons. The caudate lobe is located in front of the inferior vena cava and between the first and second porta hepatis. The left side of the caudate lobe to the left of the inferior vena cava is the Spiegel lobe, the right side of the caudate lobe to the right of the inferior vena cava is the caudate process, and the middle side of the caudate lobe to the surface of the inferior vena cava is the paracaval

portion (figure1(Chaib, Ribeiro *et al.* 2009)). The blood supply of the caudate lobe is complicated, the inflow vessels originate from the portal vein and hepatic artery, the outflow vessels of the caudate lobe are directly drained to the inferior vena cava by the hepatic short veins. Moreover, the liver inflow and outflow vessels are short and it is hard to be isolated and ligated when mobilizing the caudate lobe. Caudate lobe tumors are fed by multiple branches that arise from left, right and middle hepatic arteries, which make them ineffective and difficult to be treated with Percutaneous ethanol injection (PEI)(Matsumoto, Iwaki *et al.* 2002), and trans-arterial chemoembolization (TACE)(Yamamoto, Hirohashi *et al.* 2003), so caudate surgical resection is considered to be the most effective method and the main indication for treating tumors in the caudate lobe(Sarmiento, Que *et al.* 2002, Dong, Li *et al.* 2015). In previous studies, it was reported that there are three porta hepatis (Shibata, Maetani *et al.* 2002, Peng, Li *et al.* 2003, zeng-Qing Wen 2008): The first porta hepatis, the second porta hepatis, and the third porta hepatis. The history of the development of the concept and theory of the porta hepatis from the first porta hepatis to the third porta hepatis, were as a result of easy bleeding caused by blood vessel injuries when performing the surgery.

Despite the development of understanding the anatomy of the liver and its porta hepatis, caudate lobe resection is still a challenge for hepatobiliary surgeons. It was also reported (Dong, Lau *et al.* 2012) that the Hepatolithiasis leads to the left and right hepatic lobe atrophy and compensatory hypertrophy of the caudate lobe. These patients accepted subtotal liver resection, only with reserving caudate lobe because the enlarged caudate lobe has become the mainstay of the maintenance of the liver functions; Combining that with our findings on CT scan (Figure 2), and in dissecting the caudate lobe when performing the operations, we conclude that due to the caudate lobe's special anatomy and physiological function, the fact that it has individual bile duct and blood in and outflow vessels (Figure 3,4), and has strong compensatory function which acts as an accessory liver in some cases(Dong, Lau *et al.* 2012). In accordance with that, it is reasonable to define a fourth porta hepatis, which consists of the inflow blood vessels supply to caudate lobe and bile drainage ducts from caudate lobe. It is not only a hepatic segment, but it is an accessory liver which has direct and entire hepatic venous drainage into IVC. The presence of the fourth porta hepatis might be a new anatomical concept reflecting the progress of modern surgical techniques, that will help further construction of the anatomical basis of caudate lobe, moreover it will be more conducive to the hepatobiliary surgeons to pay more attention to the anatomical characteristics of the caudate lobe, which will help to further improve the safety of caudate lobe surgery, shorten the operation time and reduce the incidence of intraoperative and postoperative risk and complications ultimately. The most common tumors of caudate lobe consist of hemangioma and primary malignant tumors. Its symptoms are generally late and lack specificity of clinical manifestations, only a few patients experience lumbar back discomfort. Therefore, the detection and diagnosis of caudate lobe tumors mainly depend on the imaging examination. The term "giant liver tumor" has been proposed to indicate a tumor of >10cm size (Toro, Mahfouz *et al.* 2014). According to our findings to compare the tumor size in the caudate lobe with other segments of the liver, we consider the tumor in the caudate to be giant or large if the tumor size is >5cm, due to the special anatomy of the caudate lobe.

We noticed clinically that if the mass size is greater than 5cm, the tumor is very close to the first, second and third porta hepatis, moreover, it is a tough job to dissect the fourth porta hepatis, which is very necessary to mobilize and remove the caudate lobe tumors. Unfortunately, this increases the risk of damaging the important vessels mentioned above, and massive intraoperative hemorrhage usually occurs. Therefore the definition of giant caudate lobe tumor (size >5cm) is much more helpful to evaluate the surgical risks and select the optimal surgical treatment plans.

## Conclusions

Regarding its special anatomy and functions, caudate lobe is not only a hepatic segment but can also be defined as an accessory liver. The definition of the fourth porta hepatis and the giant or large caudate lobe tumor (size>5cm) might be helpful to improve understanding the anatomy of caudate lobe. Consequently, reduce the incidence of intra and postoperative risks and complications.

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