RESEARCH ARTICLE

Blood Supply of Caudate Lobe and Its Significance in Transplantation of Liver

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Abstract

Introduction: Liver is divided into eight functionally independent segments according to the Couinaud classification. These segments maintain their independent vascular inflow, outflow, and biliary drainage. Caudate lobe (segment I of liver) enables independent segments resection for transplantation. The main goal of liver transplantation is to achieve a graft with adequate volume, portal and arterial inflow, and efficient biliary drainage. Before doing liver transplantation, one should be well-versed with its vascular supply. At present, the right lobe is becoming popular for liver transplantation, whereas caudate lobe is also a substantial choice. This research is an attempt to study the blood supply of caudate lobe to highlight its role in transplantation.

Materials and methods: Microdissection of 50 caudate lobes was studied for morphometrical and arteriovenous analysis using piecemeal dissection in the Department of Anatomy, North Delhi Municipal Cooperation Medical College and Hindu Rao Hospital, New Delhi and Army College of Medical Sciences, New Delhi.

Results: On morphological analysis, the caudate lobe was found to be variable in shape, having notches and processes. Out of the 50 livers, 72% of cases represented deep notches up to 3–5 mm, and papillary process was seen only in 42% of cases. On piecemeal dissection, we observed that caudate lobe receives its blood supply mainly from left branch whereas caudate process is from right branch of portal vein (PV). The caudate lobe drains independently through hepatic vein to inferior vena cava (IVC). Hepatic vein was present on dorsal surface of caudate lobe; hence, it can be called a dorsal hepatic vein. However, there is no irregularity noticed in arteriobiliary pattern.

Conclusion: The vascular supply indicates that caudate lobe is an independent lobe and can also be used in transplant for pediatric cases and in adults with lower liver disease score and in combination with left lobe of liver.

Keywords: Anatomic independence, Caudate lobe, Liver transplantation, Spiegel's lobe.

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Introduction

As liver transplantations become increasingly popular, the main point of concern is which part of liver constitutes an ideal graft. Donor safety is of utmost importance when deciding which portion is best for the graft.[1] The main goal of a liver transplant is to provide a graft with sufficient size and adequate vascular inflow and outflow. Using smaller graft will be of no benefit to the recipient and removing larger graft from the donor will be devastating for the same.[2] Almost every portion of the liver has been used as a graft previously along with dual graft from two donors.[3] In most of the liver transplantation cases, mainly the right lobe is preferred for transplantation.[1]

With new advances in hepatobiliary surgery, caudate lobe has been increasingly accepted for human liver transplantation and various resection procedures have been reported. To increase the graft volume caudate lobe has also been used in living donor (LD)—related liver transplantation.[4] New surgery procedures also included the addition of left part of the caudate lobe in the usual extended left liver graft. This directly increases the graft volume by 9%.[5,6]

Caudate lobe's critical role in transplantation is due to its anatomic independence.[7] It is one of the four anatomical lobes of the liver.[8] Caudate is subdivided as Spiegel's lobe, caudate process and paracaval portion. Spiegel's lobe includes the caudate lobe proper and the papillary process, and the paracaval portion is part of the caudate lobe anterior to the inferior vena cava (IVC).[9] The caudate lobe is connected to the right lobe of the liver by the caudate process and the medial inferior part of the caudate lobe sometimes forms a papillary process, which passes toward left (sometimes anteriorly) into the region of the superior recess of the omental bursa.[10] Due to its independent blood supply and direct drainage of venous blood into IVC, caudate lobe is considered a self-sufficient entity.[11]

Caudate lobe's independent nature is beneficial as well as it is considered a small-sized graft for transplantation. Its use is being enhanced by surgeons as they use caudate lobe and left liver combination as a graft. This needs complete knowledge of caudate lobe and its various vascular patterns. A lot of research has been done in the past so many years and independent nature of caudate lobe was found, this article enlightens the caudate lobe's different vascular patterns and benefits of its independent nature in grafting.

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Materials and Methods

A total of 50 human liver prosected specimens were obtained from the Department of Anatomy, North Delhi Municipal Corporation Medical College and Hindu Rao Hospital, New Delhi, and Army College of Medical Sciences, New Delhi, India. These livers were procured from the donated bodies to the Department of Anatomy of respective colleges. Age and gender information was not recorded. Previous history or appearance of cirrhosis, metastatic disease, any kind of abdominal surgery or trauma, and other liver pathology were excluded from the current study.

Hepatic Measurements

Hepatic measurements were done on all selected intact liver specimens with digital vernier calipers and cotton threads. Firstly, caudate lobe, caudate process, and papillary process measurements were calculated with anterior-posterior (AP) and maximum and minimum transverse parameters (Figs 1 and 2). Later, using piecemeal dissection vascular patterns of caudate lobe were also studied.

Results and Analysis

The structural examination of caudate lobe, caudate process, and papillary process of the liver was done for its shape and various dimensions (Tables 1 to 3).

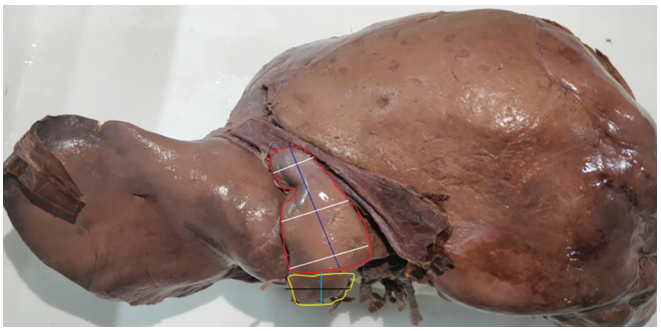


Fig. 1: Measurements of Spiegel's lobe; the red line demarcates caudate lobe outline, the blue line demarcates the AP dimension of the caudate lobe, and the white lines show the transverse dimension of the caudate lobe. The yellow line demarcates the papillary process, the black line shows transverse dimension of the papillary process and the sky blue line shows the AP dimension

Fig. 2: Measurements of the caudate process; red lines demarcate the caudate process, blue line demarcates the AP dimension of the caudate process and the white line shows the maximum transverse dimension of the caudate process

Vascular Pattern of Caudate Lobe

Blood supply to caudate lobe: Vascular patterns of caudate lobe and its processes were observed by using piecemeal method (Figs 3 to 6). Our findings suggest that blood supply of caudate lobe has two patterns (Figs 3 and 4). Venous drainage of caudate lobe was also studied (Figs 5 and 6).

- Pattern I
- Pattern II

Discussion

Liver transplantation is becoming popular because it is a lifesaving procedure for acute liver failure disease and chronic end-stage liver disease. Almost every part of the liver is being used for transplantation. Liver graft can be obtained from deceased donor (DD) or from a LD.[12] The key factor governing the success of liver transplantation is the size of the graft.[5] However, some surgeons believe that the undersized graft is the reason for failure and might not meet the metabolic needs of the recipient.

Earlier caudate lobe was advocated as the suitable part of liver for transplantation due to its independent supply, but nowadays right lobe is commonly used for transplantation. Though due to independent and rich vascular pattern, caudate lobe either independently or in combination with left lobe can be used for transplantation according to the required graft size in certain cases of pediatric patients.[6,13] One should not restrict the graft choice to only right lobe or left lobe instead it should depend on recipients' severity of liver disease together with its size and at the same time cause minimal damage to the donor.

It is estimated that left liver graft accounts for 28% of the recipient's liver volume. Caudate lobe alone is 3–4% of complete liver volume, whereas, in combination with left lobe, it accounts for additional 8–12% of volume.[6,14] Therefore, caudate lobe and left lobe of liver may serve as an alternative to the right lobe for transplantation.

The caudate lobe is a separate lobe situated on the posterior surface of liver. It is surrounded by the groove for IVC on the right, fissure for ligamentum venosum on the left, and porta hepatis anteriorly. Most of the liver gross abnormalities are congenital. These include absence of lobes, agenesis of the lobes, atrophy, or hypoplastic lobes. Other gross abnormalities include accessory

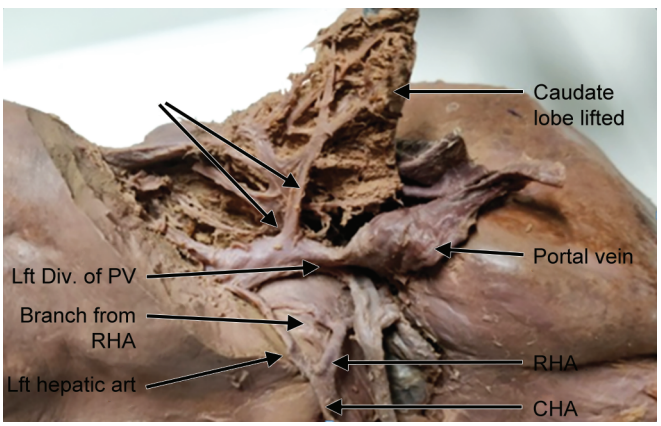
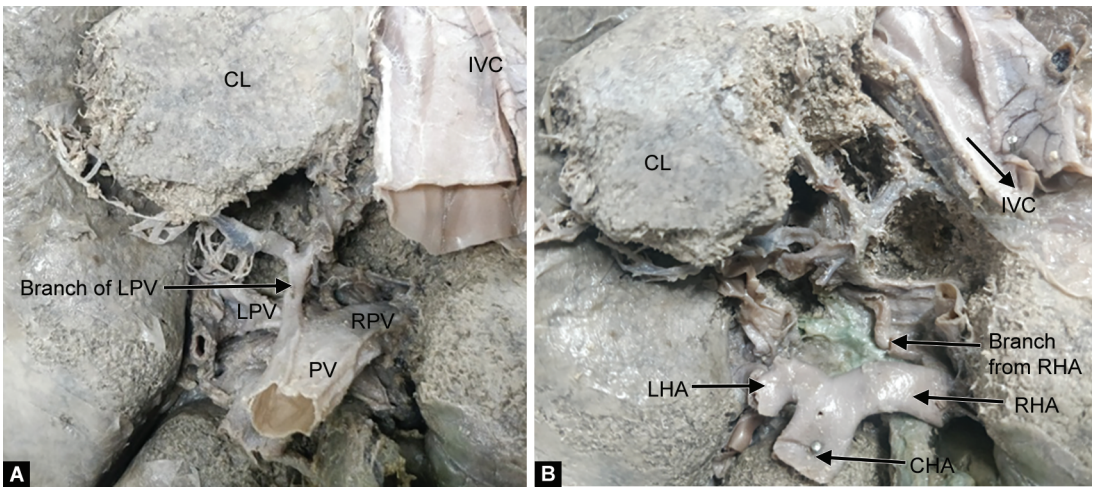
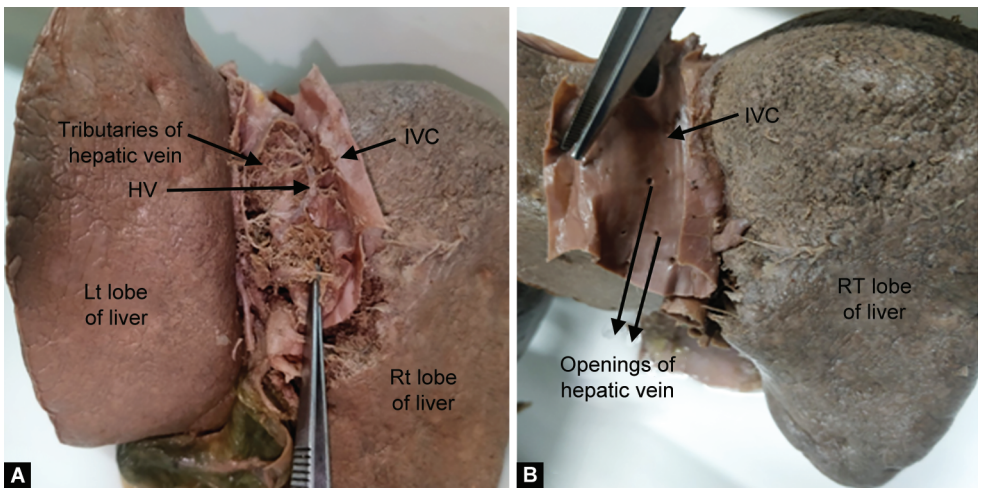


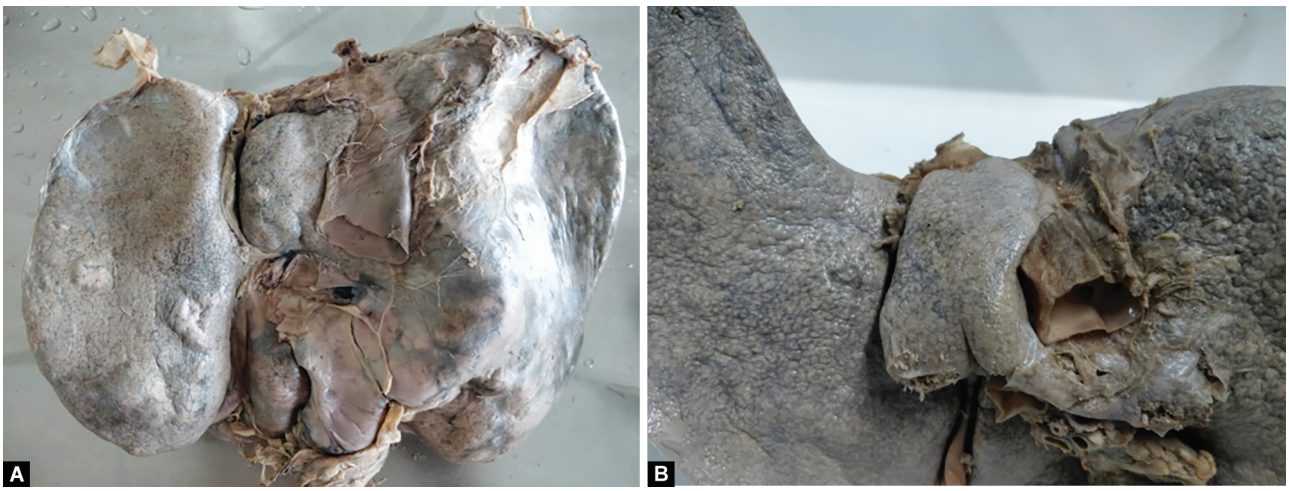
Fig. 3: Pattern I—PV and its left division supplying the caudate lobe and right division giving branches to the caudate process ($n = 22$). The caudate lobe was supplied by both the right and left divisions of the common hepatic artery



Figs 4A and B: (A) Showing the left portal vein (LPV) and its branch and right hepatic artery supplying the caudate lobe (*n* = 21); (B) Right portal vein (RPV) showing the branch from the right hepatic artery and LPV and RPV supplying the caudate lobe (*n* = 7); CHA, common hepatic artery; CL, caudate lobe; IVC, inferior vena cava; LHA, left hepatic artery; RHA, right hepatic artery



Figs 5A and B: (A) The piecemeal dissection of the caudate lobe showing the tributaries of the hepatic vein opening into the IVC; (B) IVC was cut open along its length to show the openings of the hepatic vein; HV, hepatic vein



Figs 6A and B: Process from the caudate lobe of the liver toward IVC containing dorsal hepatic vein

Table 1: Various shapes and the measurements of caudate lobe and caudate process

S. No.	Shapes of caudate lobe	Number of caudate lobe	Size range (caudate lobe) (cm)			Size range (caudate process)	
			AP (cm)	Transverse (minute)	Transverse (max)	AP (cm)	Transverse (cm)
1	Quadrilateral	15	3.9–5.5	1.0–3.2	1.7–3.5	1.0–2.2	0.4–1.7
2	Inverted triangle	15	4.8–6.3	1.5–2.6	2.4–3.0	0.5–2.6	0.5–3.0
3	Pyramidal	12	4.8–5.6	1.6–2.3	2.2–3.8	1.0–3.8	0.4–1.6
4	Irregular	5	5.5	2.0–3.2	2.8–3.5	1.6–2.8	0.5–1.7
5	Oblong	3	3.9	1.1	1.7	2.2	0.5

Table 2: Number of livers studied with papillary process and its various dimensions

S. No.	Number of specimens with papillary process	Total % of papillary process	Size range (papillary process)	
			AP (cm)	Transverse (cm)
1	21	42	0.9–2.8	0.8–2.2

Table 3: Mean and standard deviation (SD) of various measurements of caudate lobe and its processes

S. No.	Caudate lobe			Caudate processes			Papillary processes		
	Parameters	Mean	SD	Parameters	Mean	SD	Parameters	Mean	SD
1	Mean AP diameter	4.85	1.06	Mean length	1.7	0.74	Mean length	1.71	0.03
2	Mean transverse diameter (minimum)	1.84	0.57	Mean transverse diameter	1.1	0.63	Mean transverse diameter	1.73	0.41
3	Mean transverse diameter (maximum)	2.87	0.52	–	–	–	–	–	–

fissures and lobes. Accessory lobes emerge mostly from the right lobe. These structural abnormalities are potential sources for diagnostic error, which is an important step for any liver surgery or before going for liver transplant. In our study, different shapes of caudate lobe were seen where the most common were quadrilateral and inverted triangle shapes (50% of cases) (Table 1). The rest is pyramidal,[12] irregular,[5] and oblong[3] in shape. Some researchers also found rectangular, bicornuate, pear-shaped, heart-shaped, square- and dumbbell-shaped caudate lobes.[14]

The dimensions of caudate lobe proper and its processes were also observed in the current study. Papillary process was found in only 42% of cases with various dimensions (Tables 2 and 3). The variable size of papillary process can lead to various diagnostic mistakes. In computed tomography (CT) examination, small-sized papillary process can be mistaken as enlarged porta hepatis lymph node, whereas large-sized papillary process can displace gastric antrum and duodenum anteriorly.[10,15] Dixit et al. observed even the absence of caudate lobe and its processes in 7.14%.[16]

Caudate lobe blood supply is dependent on hepatic artery and portal vein (PV). Majority of its oxygen is delivered by PV. In our study, two vascular patterns were seen for caudate lobe and its processes. In pattern I, caudate lobe receives its supply from both left and right hepatic artery branches (Fig. 3). Left division of PV mainly supplies the caudate lobe, whereas caudate process receives small branches from right division of PV. This pattern was seen in 44% of the specimens. Right division of PV supplying caudate process was seen in 75% of specimens (Figs 3 and 4).

In 56% of cases, caudate lobe was supplied by the right hepatic artery (Fig. 4A) and the left division of PV. In almost all the specimen's left division of PV supplies the caudate lobe, but in 75% of liver specimens branches ramify from both the left division and bifurcation point of PV.

Caudate lobe is structurally considered a part of right lobe of liver but functionally, it is a part of left lobe. In the majority of the studies, it was found that left hepatic artery and left PV supply the caudate lobe.[17] In contrast, our study suggests that most of the specimens were found to be supplied by branches from right hepatic artery and left division of PV. Branches from bifurcation point of PV supplying caudate lobe were found in 17% of cases by Kogure et al.,[18] whereas we found in 42% of cases which is much higher in number than Kogure et al.

The venous drainage pattern of caudate lobe was mainly through small veins opening directly into the IVC (Figs 5A and B). In 30% of cases, a small process from caudate lobe was observed on its dorsal surface containing a small hepatic vein draining into IVC. This was named as dorsal hepatic vein (Figs 6A and B). No variation was observed for venous drainage of caudate lobe and its processes in the current study.

Conclusion

Caudate lobe can be considered a potential option for liver transplant graft. Caudate lobe addition increases the graft volume in left lobe LD and pediatric cases. Caudate lobe along with the left lobe of liver or right lobe graft is a considerable and promising approach for transplantation of liver.

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