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Original article

Variations in the source of origin of inferior phrenic artery: a cadaveric study

B. Akhilandeswari[a,*], Priya Ranganath[b]

[a]Associate Professor, Department of Anatomy, Bangalore Medical College and Research Institute, Bengaluru, Karnataka
[b]Associate Professor, Department of Anatomy, Bangalore Medical College and Research Institute, Bengaluru, Karnataka

KEYWORDS

Inferior phrenic artery, Right inferior phrenic artery, Celiac trunk, Hepatocellular carcinoma.

ABSTRACT

Introduction: The right and left inferior phrenic arteries perfuse the diaphragm. They may originate either from the aorta, celiac trunk, or from the renal artery. Most textbooks of human anatomy give little information regarding the functional anatomy of the inferior phrenic artery. In the past few years, however, more articles have been published regarding the arterial supply in cases of hepatocellular carcinoma. The inferior phrenic artery is seen as an important source of collateral arterial supply to hepatocellular carcinoma, the hepatic artery being the main source. *Materials and methods*: A cadaveric study was conducted in the Anatomy Department of Bangalore Medical College during the years 2009–2011. Manual dissection was done to identify the inferior phrenic arteries, and their origins were traced. *Results*: The inferior phrenic artery arose from the aorta in 53.125%, celiac trunk in 28.125%, renal artery in 15.625%, and the superior mesenteric artery in 3.125% of the 32 cadavers studied. The right inferior phrenic artery arose from aorta in 56.25%, celiac trunk in 18.75%, renal artery in 18.75%, and superior mesenteric artery in 6.25% cases. The left inferior phrenic artery arose from aorta in 50%, from celiac trunk in 37.5%, and the rest arose (12.5%) from the renal artery. *Discussion*: The results were compared with those of earlier studies so that such findings could be applied in the treatment of hepatocellular carcinoma. The significance of this information is due to the fact that an unresectable hepatocellular carcinoma can be treated by transcatheter embolization of the right inferior phrenic artery, in case it is involved.

1. Introduction

The right and left inferior phrenic arteries supply multiple organs including the diaphragm, suprarenal glands, esophagus, stomach, liver, inferior vena cava, and retroperitoneum.[1]

The inferior phrenic arteries (IPA) perfuse the diaphragm. They originate directly from the abdominal aorta above its celiac trunk, by a common aortic stem or from the celiac trunk, sometimes one is from the aorta and the other from a renal artery. Each artery runs upward in front of the crus of the diaphragm. The left artery runs posterior to the esophagus and then to the left of the esophageal opening in the diaphragm. The right artery runs behind the inferior vena cava, and then along the right of its opening. Close to the central tendon of diaphragm, each artery divides into medial and lateral branches. Small branches are also given by the IPA to the liver and spleen.[2]

Most textbooks of human anatomy offer very little information regarding the functional anatomy of the IPA. In the past few years, more articles have been published regarding the arterial supply in the case of hepatocellular carcinoma (HCC). The IPA is found to be an important source of collateral arterial supply to HCC, the hepatic artery being the main source.[3]

Transcatheter arterial chemoembolization (TACE) is largely used in the treatment of nonresectable HCC. Collateral arterial supply to HCC other than that from hepatic artery can develop according to the site of the tumor and the adhesions between liver and other organs. Of these the right IPA is the most common and significant. The left IPA can also give

*Corresponding author: Tel: +91 (0) 9945221023, 080 26492048
E-mail address: akhilandeswarib@gmail.com. (B. Akhilandeswari)

collaterals to HCC. The branches of the left inferior phrenic artery (LIPA) perfuse the left dome of the diaphragm and the esophagogastric region. The LIPA gives collateral supply to the stomach in case of gastric arterial occlusion. So, during a TACE procedure, gastric and esophageal damage can occur if nontarget embolization is done.[4]

The significance of this information lies in the fact that even an unresectable HCC can be treated by transcatheter embolization of a right inferior phrenic artery (RIPA), if involved. This is in addition to the embolization of the right and left hepatic arteries (LHA).[5]

The knowledge of the arterial anatomic variations is very important for the clinical, radiological, and surgical diagnosis. Since it is known that the IPA vary in relation to their origin, the present study is to verify these variations so that such findings could be applied during the treatment of hepatic cancer.

2. Materials and methods

The study was conducted in the Anatomy Department, Bangalore Medical College and Research Institute, Bangalore, over a period of 3 years (2009–2011). The sample comprised 32 formalin-fixed cadavers, ages ranging from 22 years to 80 years (24 males, 8 females) (32 right and 32 left inferior phrenic arteries). Routine manual dissection was done to open the abdomen following the instructions of Cunningham's manual.[6] After removal of the lesser omentum, the proximal part of abdominal aorta and its branches were traced out. Later, after the removal of the stomach and pancreas, the origins of the IPA were confirmed. The frequency and anatomical pattern of the origin of the right and left inferior phrenic arteries were observed and noted.

3. Results

Table 1 shows the percentage of the different origins of the RIPA and LIPA as noted in the present study. Of the 64 arteries studied, 34 (53.125%) had normal origin from aorta. Of these 34 arteries, 18 were of the right side (RIPA) and 16 were of the left side (LIPA). The IPA arose from the celiac trunk (Fig. 1) in 18/64 (28.125%) sides. Of the 32 right and 32 left sides studied, the origin of RIPA from celiac trunk was 6/32 (18.75%) and of LIPA 12/32 (37.5%). The renal artery origin of IPA (Fig. 2) was seen in 10/64 (15.625%) cases. The percentage of RIPA arising from renal artery was 18.75% (6/32) and LIPA was 12.5% (4/32). Other origins of IPA i.e., from superior mesenteric artery were seen in 2/64 (3.125%) cases. Of these, only RIPA 2/32 (6.25%) arose from superior mesenteric artery (Table 1).

Table 1 – Percentage of the various origins of inferior phrenic artery seen in the present study.

Site of origin of IPA	Number of cases (%)	RIPA	LIPA
From aorta	34/64 (53.125%)	18/32 (56.25%)	16/32 (50%)
From celiac trunk	18/64 (28.125%)	6/32 (18.75%)	12/32 (37.5%)
From renal artery	10/64 (15.625%)	6/32 (18.75%)	4/32 (12.5%)
From others (superior mesenteric artery)	2/64 (3.125%)	2/32 (6.25%)	0%

IPA: Inferior phrenic artery; RIPA: Right inferior phrenic artery; LIPA: Left inferior phrenic artery.

4. Discussion

Comparison of the percentage of various origins of IPA in the present study with that in previous studies is shown in Table 2. The origin of IPA from the celiac trunk was reported in 74% of the 200 cadavers by Michels[7] and in 47.8% by Pick and Anson.[8] Exposure of the celiac axis and the possible origin of IPA from it were analyzed by Petrella et al.[9] The results showed the presence of IPA from the celiac trunk in 31 (34.83%) among the 89 cadavers studied.

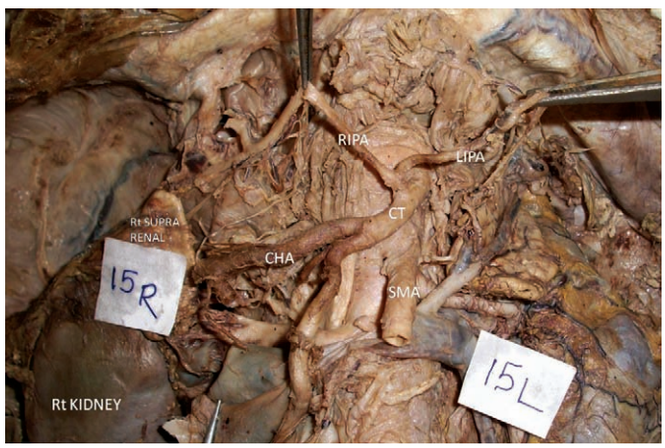

Fig. 1 – Both inferior phrenic arteries arising from the celiac trunk (RIPA – right inferior phrenic artery, LIPA – left inferior phrenic artery, CT – celiac trunk, SMA – superior mesenteric artery, CHA – common hepatic artery).

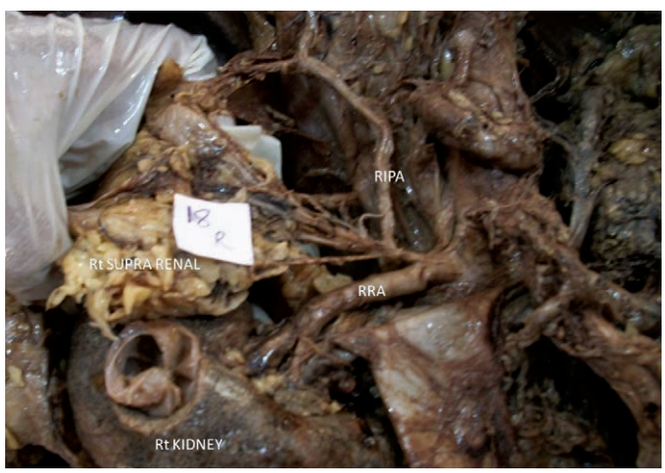

Fig. 2 – The right inferior phrenic artery arising from the right renal artery (RIPA – right inferior phrenic artery, RRA – right renal artery).

Table 2 – Comparison of the percentage of various origins of inferior phrenic artery in the present study with those of earlier studies.

Source of origin of IPA	Pick and Anson[8] (200 cadavers)	Piao et al[10] (68 cadavers)	Gwon et al[11] (383 cadavers)	Pulakunta et al[5] (32 cadavers)	Present study (2011) (16 cadavers)
From aorta	45.1%	61.6%	38.6%	87.5%	53.125%
From celiac trunk	47.8%	28.2%	39.7%	6.25%	28.125%
From renal artery	5.8%	10.19%	15.4%	3.125%	15.625%
Others (SMA, LGA, HA)	2.3%		LGA – 3.7%, SMA – 0.3%, HA – 2.1% opp IPA – 0.3%	3.125% (LGA)	3.125%

IPA: Inferior phrenic artery; SMA: Superior mesenteric artery; LGA: Left gastric artery; HA: Hepatic artery.

Table 3 – Comparison of the percentage of various origins of right inferior phrenic artery and left inferior phrenic artery in the present study with those of earlier studies.

Source of origin of IPA	Gokan et al[12] 16 (HCC cases CT study)		Loukas et al[3] 300 cadavers (normal i.e., without HCC)		Basile et al[14] 200 (HCC cases MDCT study)		Present study 32 cadavers (normal)	
	RIPA	LIPA	RIPA	LIPA	RIPA	LIPA	RIPA	LIPA
From aorta	31.25%	31.25%	38%	45%	49%	47.5%	56.25%	50%
From celiac trunk	37.5%	50%	40%	47%	41%	44%	18.75%	37.5%
From renal artery	12.5%	18.75%	17%	5%	5.5%	1%	18.75%	12.5%
Others (SMA, LGA, HA)	In remaining cases, the origin of RIPA could not be identified		5% (LGA – 3%, HA – 2%)	3% (LGA – 2%, HA – 0.5%)	4.5% (LGA – 4%, HA – 0.5%)	7.5%	6.25% (SMA)	0%

IPA: Inferior phrenic artery; HCC: Hepatocellular carcinoma; MDCT: Multidetector computed tomography; CT: Celiac trunk; RIPA: Right inferior phrenic artery; LIPA: Left inferior phrenic artery; SMA: Superior mesenteric artery; LGA: Left gastric artery; HA: Hepatic artery.

Piao et al did a study on 68 Japanese cadavers and found that the IPA arose from the aorta in 61.6%, from the celiac trunk in 28.2% and the remainder 10.19% arising from either renal, left gastric, or middle adrenal arteries.[10] Out of 32 cadavers, Pulakunta et al observed that the IPA arose from the celiac trunk in two cases (6.25%), one from the left gastric artery (LGA) (3.125%) and the other from the right renal artery (3.125%).[5] The rest 28 cases (87.5%) had the usual aortic origin. The IPA arose from the celiac trunk in 39.7%, from aorta in 38.6%, and from the opposite IPA in 0.3%.[11] Loukas et al in a study of 300 cases observed that the RIPA arose from the celiac trunk in 40% cases, from aorta in 38%, from renal artery origin in 17%, from LGA in 3%, and from hepatic artery proper in 2%.[3] The LIPA arose from the celiac trunk in 47%, aorta in 45%, renal artery in 5%, LGA in 2%, and hepatic artery proper in 1% of cases. Topaz et al presented three patients with a new anatomic vascular variant of which one was with the right renal artery giving a common trunk of the IPA.[1]

When compared with other studies, the results of the present study agree with those of Piao et al[10] while being different from those of Pulakunta et al.[5] Pulakunta et al[5] record a higher percentage (87.5%) of aortic origin of IPA than that in the present study (53.12%). While earlier authors (Gwon et al, Pulakunta et al)[11,5] have reported the origin of IPA from LGA and hepatic artery, such a finding was not seen in our study. In our study, we found superior mesenteric artery as a source of RIPA in two cases.

The RIPA and LIPA have been known for their provision of extrahepatic collaterals to HCC. In a case of hepatic arterial occlusion or in cases where the hepatoma is close to the bare area of liver, IPA angiography is done. Selective TACE from IPA is preferred. In cases where proximal IPA is used for TACE, complications such as pleural effusion, basal atelectasis, weakness of diaphragm, and gastroesophageal ulcerations can occur.[4]

Table 3 shows the comparison of the percentage of origin of RIPA and LIPA from different sources. Gokan et al noted that the RIPA arose from the aorta in 31.25% of specimens and from the celiac trunk (most commonly on the left) in 44%.[12] They noted the origin of RIPA from the right renal artery in 12.5% of cases and <4% showed other origins of RIPA i.e., left gastric, hepatic, superior mesenteric, and spermatic arteries. Among 140 cases of RIPA angiography, the IPA arose from the opposite IPA in 14.3% cases.[4]

The interventional radiologist or oncologist needs to identify the origin of RIPA during transcatheter embolization of HCC. In this context, it will be of great help to know the variant origins of this artery and their frequencies.[5]

Due to the variable anatomy of its origin, cannulation of the RIPA can be challenging. In the case of patients with left suprarenal mass, tumor of left diaphragm or in the cases of esophagogastric junction hemorrhage, certain interventional procedures such as selective IPA angiography are necessary. The LIPA mostly originates from the celiac trunk or aorta or sometimes from LHA or LGA. When the origin of LIPA is not clear, LGA or LHA angiography is done to locate it.[13] Also, gastric hemorrhage due to LIPA bleeding has been noted after LGA embolization.[5]

5. Conclusion

The present study shows a higher incidence of both RIPA and LIPA from aorta than that in the earlier studies.

All interventionalists associated with TACE of HCC or gastroesophageal bleeding management using embolization need to be aware of this variant anatomy to prevent nontarget embolization. Radiologists must be familiar with the variants of IPA anatomy so that proper detection and correct intervention can be initiated when pathologic conditions related to IPA arise.

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