Clinical Relevance Of Variations In The Origin Of Inferior Phrenic Arteries

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Abstract : Introduction: The inferior phrenic arteries are major source of collateral arterial supply to hepatocellular carcinoma second only to the hepatic artery. The right inferior phrenic artery is one of the chief postoperative bleeding sources in liver transplant recipients. The aim of the present study was to identify the variations in origin of inferior phrenic arteries. Methods: We dissected inferior phrenic arteries in 100 human adult cadavers (75 males and 25 females) for the origin of both inferior phrenic arteries. Results: We found variant origin of left inferior phrenic artery in 22 male cadavers and in 7 female cadavers. The variant origin of right inferior phrenic artery was found in 27 male cadavers and in 8 female cadavers. Conclusion: The higher incidences of variant origin of inferior phrenic arteries have major clinical implications in the transcatheter arterial chemoembolization in hepatocellular carcinoma patients. [Astik R et al NJIRM 2013; 4(4) : 46-50]

Key Words: Inferior phrenic artery, Celiac trunk, Hepatocellular carcinoma, Transcatheter arterial chemoembolization (TACE)

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Introduction: The inferior phrenic arteries (IPA) usually arise from the abdominal aorta, just above the level of the celiac trunk, between the middle of the twelfth thoracic and first lumbar vertebrae. Each artery ascends and runs laterally anterior to the crus of the diaphragm, near the medial border of the suprarenal gland. The left IPA passes behind the esophagus and forwards on the left side of esophageal opening of diaphragm. The right IPA passes posterior to the inferior vena cava and then along the right of the diaphragmatic opening for the inferior vena cava. Each IPA has two or three small suprarenal branches. The capsule of the liver and spleen may also receive a small supply from the arteries[1].

Radiologists and laparoscopic surgeons must be familiar with the normal and variant spectrum of origins of the IPAs, so that detection and adequate interventional management can be achieved when pathological conditions like hepatocellular carcinoma (HCC), hemoptysis, diaphragmatic or hepatic bleeding due to trauma or surgery, related to the IPAs arise.

Material & Methods: IPAs of 100 cadavers of Asian origin (75 males and 25 females) were selected to dissect for routine educational purposes in the department of anatomy, GSL Medical College, Rajahmundry. The cadavers were embalmed immediately after death. The embalmed cadavers were labeled from 1 to 100. The abdomen was dissected through anterior abdominal wall approach. The stomach, liver, spleen, kidneys along with suprarenal glands, and intestine were removed and exposure of the origin of the IPAs were achieved following classical dissection procedures as provided by Cunningham's manual of practical Anatomy[2], taking care to preserve all arteries, sacrificing venae commitantes.

For the dissection of the cadavers, and for the investigations and materials which were used in the study, required permissions were taken from respective offices and departments of the institute and all the methods were followed in-line with international ethics and values.

Results: We found variant branching pattern of the left IPAs in 22 out of 75 (29%) in male and 7 out of 25 (28%) in female.

Consequently, the total incidence of variant branching pattern of the left IPAs was 29 out of 100 (29%) cases. In the remaining 71 (71%) cases, the origin and course of left IPA was found as per described in the standard textbook of anatomy.

Celiac trunk in addition to usual three branches viz. the left gastric artery, common hepatic artery and splenic artery, gave origin to the left IPA in 12 out of 22 males (Fig 1), and 3 out of 7 females. In all the cases, it passed upward and backward, behind the esophagus to reach the left dome of the

diaphragm where it divided into ascending and descending branches. The ascending branch terminated by anastomosing with its fellow in the central tendon of the diaphragm. The descending branch passed downward behind the spleen and terminated by supplying the diaphragm.

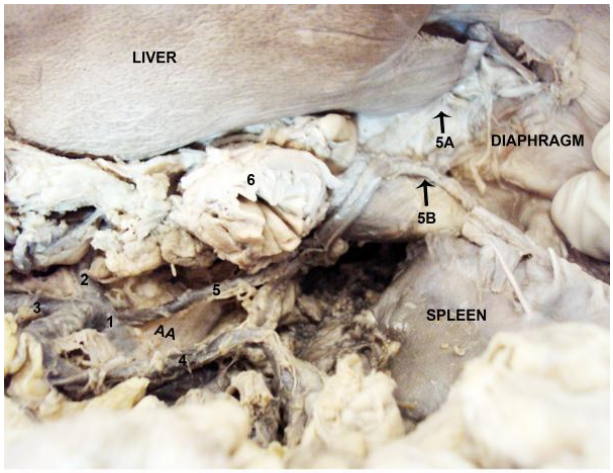

Figure 1. Origin of left inferior phrenic artery from the celiac trunk. (1: celiac trunk; 2: left gastric artery; 3: common hepatic artery; 4: splenic artery; 5: left inferior phrenic artery (LIPA); 5A: ascending branch of LIPA; 5B: descending branch of LIPA 6: cardiac end of stomach).

The other origin of the left IPA was from the left gastric artery in 7 out of 22 males (Fig 2) and 2 out of 7 females; from the left hepatic artery in 3 males.

Figure 2. Origin of left inferior phrenic artery from left gastric artery. (1: celiac trunk; 2: left gastric artery; 3: common hepatic artery; 4: left inferior phrenic artery (LIPA); 5: Left dome of diaphragm; 6: stomach).

We found variant branching pattern of the right IPAs in 27 out of 75 (36%) in males and 8 out of 25 (32%) in females. Consequently, the total incidence of variant branching pattern of the right IPAs was 35 out of 100 cases (35%). In the remaining 65 (65%) cases, the origin and course of right IPA was found as per described in the standard textbook of anatomy.

We found origin of right IPA from the abdominal aorta below the origin of superior mesenteric artery at the level of inter-vertebral disc between the first and second lumbar vertebrae in 16 out of 27 males (Fig 3), and 4 out of 8 female cases.

Figure 3. Origin of right inferior phrenic artery from the abdominal aorta below the level of origin of superior mesenteric artery. (1: abdominal aorta; 2: superior mesenteric artery; 3: right inferior phrenic artery (RIPA); 4: superior suprarenal artery; 5: inferior vena cava cut and reflected; 6: right crus of the diaphragm; 7: dome of diaphragm; 8: right kidney; 9: right suprarenal gland).

In all cases, it passed upwards on the right crus of the diaphragm, behind the inferior vena cava. The other origin of the right IPA was directly from the celiac trunk in 7 out of 27 males (Fig 4) and 2 out of 8 females; from left gastric artery in 2 out of 27 in males and 1 out of 8 females; from the right hepatic artery in 2 male cases.

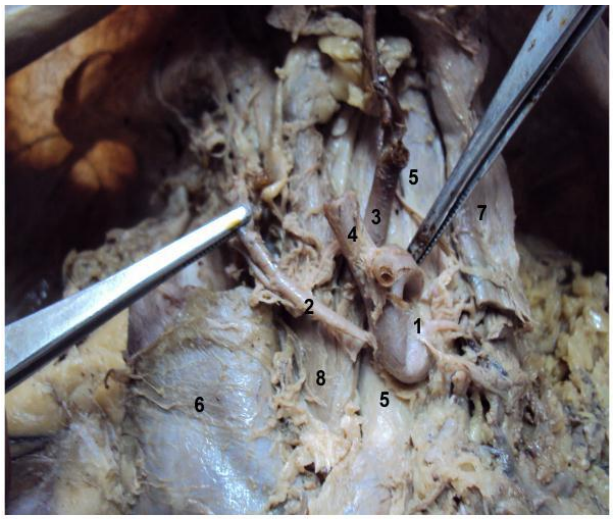

Figure 4. Right inferior phrenic artery (RIPA) arising from the celiac trunk (CT). (1: celiac trunk; 2: right inferior phrenic artery; 3: left gastric artery; 4: common hepatic artery; 5: abdominal aorta; 6: inferior vena cava; 7: left crus of diaphragm; 8: right crus of diaphragm).

Discussion: Gwon et al. performed 383 interventional procedures related to the IPA and found 346 HCCs in the bare area of the liver, which had extrahepatic collateral supplies from the IPA, amongst which they found three HCCs that were exclusively supplied by the right IPA. The development of extrahepatic collateral arteries that supply HCC interferes with effective control of the HCC by means of transcatheter arterial chemoembolization (TACE). To detect involvement of the IPA at an early stage, radiologists should be familiar with the possible variant origins of IPAs[3].

Occasionally inferior phrenic arteries arise from a common aortic origin with the celiac trunk, from the celiac trunk itself or from the renal artery.[1,4] The left inferior phrenic and right inferior phrenic arteries arose with almost equal frequency from the aorta and celiac trunk, either as a common trunk or independently. They arose with less frequency from the renal arteries and in rare cases from the left gastric artery, proper hepatic artery, superior mesenteric artery and spermatic arteries. Occasionally they arose from contra-lateral inferior phrenic artery[5].

Greig et al. dissected 425 cadavers and found that the left IPA arose more commonly from the celiac trunk (52.2%) than from the aorta (44%). Other origins of the left inferior phrenic artery were from the left gastric artery, left renal artery and an accessory left hepatic artery. The right IPA arose from the aorta in 46.1% and from celiac trunk in 41.4%. Other origins of the right IPA were from the right renal artery or an accessory renal artery, the left gastric artery, the hepatic artery or an accessory right hepatic artery, and the internal spermatic artery[6]. Loukas et al. reported that, out of 300 cadavers studied, the left IPA arose from the celiac trunk in 47%, aorta in 45%, left renal in 5%, left gastric in 2% and hepatic artery proper in 1% of the specimens. The right IPA arose from the celiac trunk in 40%, aorta in 38%, right renal in 17%, left gastric in 3% and hepatic artery proper in 2% of the specimens[7]. Pick & Anson[8] analyzed variation in origin of IPAs in 200 cadavers. They found aortic and celiac sources to be the most common (45.1 and 47.8%, respectively). They claimed common trunks variably for both as well, and even a common origin with the right internal spermatic artery. They found that < 7% arose variably from the renal (5.8%), left gastric (2.3%), or hepatic arteries (0.3%). We did not found any IPA arose from renal artery.

Gokan et al.[9] found most frequent origins of IPAs were from the aorta and celiac trunk, with 46% of specimens presenting an aortic origin, most commonly on the right side, and a celiac origin, most commonly on the left (52%). They also observed the Right IPA arising from the right renal artery in 9% of cases studied. They mentioned alternative origins from left gastric, hepatic, superior mesenteric and spermatic arteries in < 4% frequency on either the right or left sides.

Kimura et al. reported origin of the right inferior phrenic artery from the abdominal aorta between the superior mesenteric artery and right renal artery in 8%[10]. We found origin of right inferior phrenic artery below the origin of superior mesenteric artery in 20 cases. Cavdar et al. reported a case in which the left inferior phrenic artery and left gastric artery arose from the long celiac trunk (4.3 cm) via a common trunk[11].

Celiac trunk represents the original splanchnic segmental vessels of the seventh cervical segments

which migrate from its primitive level to its adult position by progressive pre-aortic anastomoses with successive new caudal stems. More common origin of inferior phrenic arteries from celiac trunk than from abdominal aorta can be explained on this embryological base as the diaphragm originally develops in the cervical region[12].

IPAs were chief extrahepatic sources for hepatocellular carcinoma particularly in patients who have undergone previous TACE procedures. In this setting, such collateral vessels should be sought on pre-procedural imaging[13-14]. Kim et al. found that the right IPA was the most common extrahepatic collateral vessel that supplied hepatocellular carcinoma. They found 1026 right IPAs as extrahepatic collateral vessels supplying hepatocellular carcinoma in 3179 patients and embolized 84% vessels; 78 left IPAs and embolized 74% vessels[4]. During liver transplantation, ligation of the right IPA is necessary for hepatectomy in the recipient and for right hepatic lobectomy in a living donor. If the ligation of this artery is not maintained adequately, bleeding from the right IPA can occur after liver transplantation[15].

Conclusion: The IPA is the most frequently encountered of the extrahepatic collateral arteries that supply HCCs located in bare area of liver. Because variation frequently exists in the origin of the IPA, it may at times be difficult for the angiographer to thoroughly study the IPA. Sound knowledge of the vascular anatomy and variations of the IPA is critical to effective interventional treatment of the pathologic conditions related to the IPA.

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