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CT Angiographically Demonstrated Variation in Origin of Inferior Phrenic Arteries in Asian Population and its Clinical Implication with Review of Literature.

Sachal Sharma[1], Namita Singh[2], Murtaza Kamal[3] and Payal Malhotra[4]
[1]BL Kapoor Superspeciality Hospital, New Delhi.
[2]INMAS, Timarpur, New Delhi.
[3]Star Hospitals, Hyderabad.
[4]Rajiv Gandhi Cancer Institute and Research Center, New Delhi.

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ABSTRACT

The lack of ample amount of literature, limited size of the study group in the available studies and relating the potential clinical applications of variation of origin of inferior phrenic artery has validated the study so that additional information could be added to the present literature. Objective: Few dedicated studies have been available demonstrating variations in the origin of inferior phrenic in the present growing era of intervention radiology. The cause has been satisfied by studying a group of 100 patients and reviewing the available literature. Methods: A group of 100 patients that were the potential liver and renal donors were studied in a 40 slice CT scanner as pre transplant evaluation in the Department of Radiology, Institute of nuclear medicine and allied sciences, Timarpur, New Delhi. Results: The right inferior phrenic arteries arise from abdominal aorta in 41(42%) of cases, celiac axis 50(50%) ,right renal artery 7(7%) and from left gastric in 2(2%) of cases. The left inferior phrenic arise from aorta in 38(38%) of cases, celiac axis in 55(52%) of cases, left renal artery 4(4%), left gastric artery in 3(3%) of cases. Conclusion: The importance of the IPA is not limited to the arterial supply to the diaphragm. Practically any hepatic neoplasm (including metastatic disease to the liver) may receive blood supply from the IPA. Literature have been reviewed regarding variation in origin of inferior phrenic artery and its implication in surgical intervention.

Introduction

The IPA usually originates between the middle of the 12th thoracic and second lumbar vertebrae. The right IPA and left IPA originate with almost equal frequency from the aorta and celiac axis , either as a common trunk or independently (1).CT angiography performed by Rawat KS(2) in Rajeev Gandhi Cancer Institute and Research Centre revealed that the Inferior phrenic arteries variations were noted in 9(8.8%) patients. Right inferior phrenic artery arise from common hepatic artery in one, left inferior phrenic artery from left gastric artery in two, both inferior phrenic arteries from renal arteries in two, both inferior phrenic arteries from celiac trunk in one, right inferior phrenic artery from right renal artery in one, right inferior phrenic artery from celiac trunk in two patients were seen.

Study performed by Gowen et al(1) pointed out the various sites of origin of inferior phrenic artery in order of decreasing frequency i.e 1.Celiac axis 152(39.7%) .2. Aorta 148(38.6%), 3.Renal artery 59(15.4%), 4.Left gastric artery 14(3.7%), 5.Hepatic artery8(2.1%), 6.SMA 1(0.3%), 7.Contralateral IPA 1(0.3%).

Piano et al. (3) stated that the right and left inferior phrenic arteries occasionally originated as a common trunk from the aorta, celiaco-mesenteric system or adrenorenal system. He observed that inferior phrenic arteries were usually paired (left and right) and their origin were summarised as follows ;a)the aorta itself ;b) ventro -visceral arteries.(celiaco-mesentric system of the aorta)including the celiac trunk (28.2%)and left gastric artery (2.9%),c) the laterovisceral arteries (adreno-renal system of the aorta) including the middle suprarenal artery (2.9%)and renal artery(4.3%).

Okada et al. (04) described a case of absence of the celiac trunk in which the left middle suprarenal artery gave off the inferior phrenic artery, and the left middle suprarenal artery had a common arterial stem with the inferior phrenic and the aberrant renal arteries.

Manso et al (05) reported that the variation of the middle suprarenal artery was not rare although it generally originated from the abdominal aorta. They also said that this artery may originate from right or left inferior phrenic arteries, inferior or superior suprarenal arteries, superior mesenteric artery, right renal artery, celiac trunk and left renal artery. According to their observations, the number of the left or right middle suprarenal artery was generally one, and rarely originated from the celiac trunk.

Lippert and Pabst (06) (1985) pointed out that the right testicular artery originated from the right renal artery in 6% of the cases. Onderoglu et al (07)(1993) reported the right

Tele: 8130754954
E-mail address: drsachal@gmail.com

testicular artery giving rise to the inferior phrenic and the superior suprarenal arteries. Cicekcibasi et al (08)(2002) found a gonadal artery originating from the renal artery in 5.5% of their series.

Materials and methods

Pre transplant evaluation of living renal and liver donor is performed in a 40-row CT scanner.

(a)Patient preparation: Includes patient relevant clinical history, consent, cannulation with 18-20 gauge catheter, 1ml subcutaneous test dose of contrast.

(b)Scaning procedure: MDCT angiography will be performed by using a 40–row MDCT system (SIEMENS SOMATOM) with the protocol acquiring CT data in the arterial phase. As part of our protocol firstly a scout image is obtained .After this unenhanced CT scans will be obtained while keeping the protocol for the unenhanced acquisition as 140 kVp, 130–230 mA, 5-mm thickness, pitch of .9 mm per rotation, and 0.5-sec per rotation .The area from the lower thoracic spine to the symphysis pubis level with the patient in a supine position ,was adopted as the field of view. During examination ,an 18-20 angiocath needle inserted into the patients' antecubital vein was used to inject 120 ml of non-ionic iodinated contrast medium using the bolus tracking technique (rather than a predetermined delay time) with an automatic injector at a rate of 3-4ml/sec ,The estimated dose of contrast is 1-1.5ml/kgwt of the patient. Protocol is set for contrast MDCT in arterial phase. MDCT angiographic acquisition is initiated after a delay of 4–5sec when the threshold enhancement of 100 HU is exceeded in the abdominal aorta.

Images were acquired in arterial phase.The axial images obtained were transferred to a workstation for analysis. Three-dimensional volume-rendering technique (3D VRT), maximum intensity projection (MIP) and multiplanar reconstruction (MPR) images were used for evaluation.

Vascular system analysis

The raw data axial images obtained by MDCT angiography as well as the post-processed 3D VRT, MIP and MPR images were evaluated by two radiologists in consensus. Axial source images are the basis of the diagnostic process and must always be reviewed for the possible existence of nonvascular abdominal abnormalities. Maximum-intensity-projection reconstructions are conventional angiogram-like images depicting an excellent overview of vascular anatomy. The 3D volume-rendered images were created using the segmentation tool while the threshold criteria were adjusted to optimise anatomic detail and minimise venous contamination. Specific prescribed threshold values were not applied. High-attenuation structures (e.g., bone, bowel containing oral contrast material, or surgical clips) were removed using the 3D sculpting tool. The estimated time required to perform these manipulations ranged from 5 to 30 min for each case.

Results

Results are calculated in combination where b/l inferior phrenics have a common origin and separately for right and left IP's as in the same case individual IP's were seen to have different site of origin more frequently in the form of one arising from aorta and the other from celiac axis and less frequently one arising from renal artery and the other from celiac artery or aorta.

Out of 100 patients , the right inferior phrenic arteries arise from abdominal aorta in 41(42%) of cases, celiac axis 50(50%) ,right renal artery 7(7%) and from left gastric in 2(2%) of cases. The left inferior phrenic arise from aorta in 38(38%) of cases, celiac axis in 55(52%) of cases, left renal artery 4(4%), left gastric artery in 3(3%) of cases.

Quite frequently IP's are seen to arise from a common trunk from anterior of aorta or celiac trunk. Case is seen where a right inferior phrenic is seen to arise from right renal artery and an aberrant right renal artery is seen to arise from right inferior phrenic.

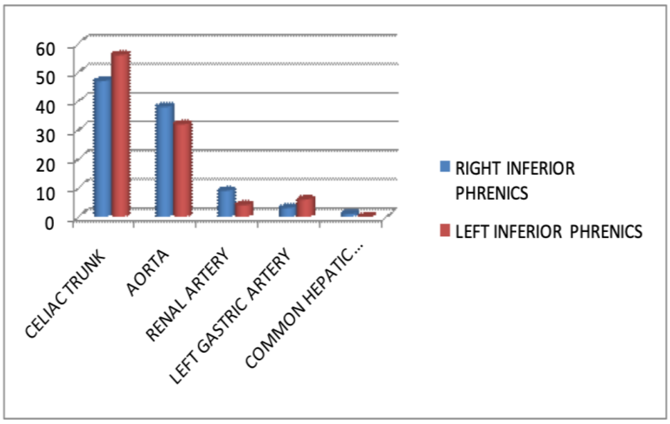

Fig 1.Comparative study of distribution of right and left inferior phrenic arteries

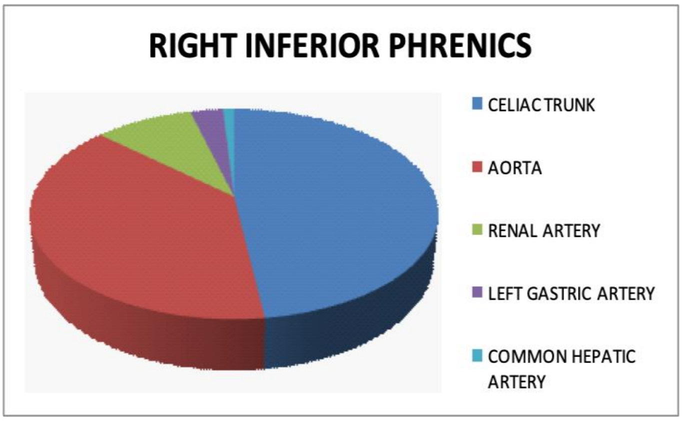

Fig 2.Distribution of right inferior phrenic artery in general population

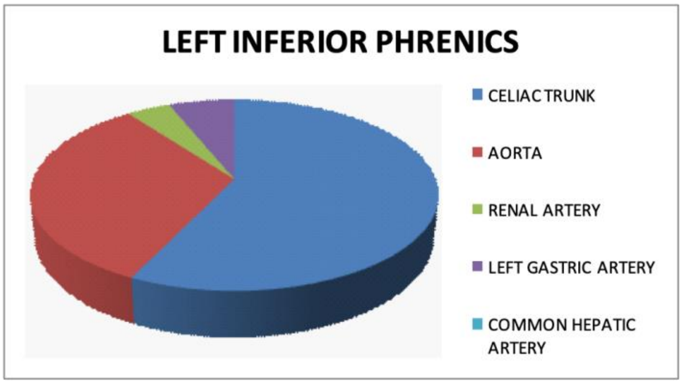

Fig 3.Distribution of left inferior phrenic artery in general population

Table 1. Comparative study of origin of right and left inferior phrenic arteries

Origin→	Celiac trunk	Aorta	Renal artery	Left gastric artery	Common hepatic artery
Right inferior phrenics	47	38	9	3	1
Left inferior phrenics	56	32	4	6	0

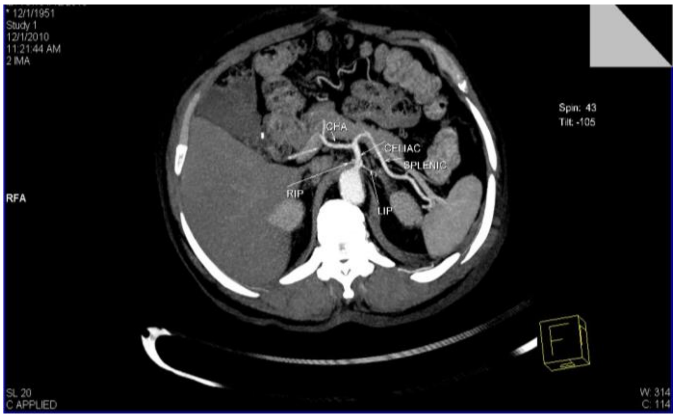

Fig 4. CT angiography axial MIP image showing RIPA and LIPA arising from celiac trunk

Fig 5. CT angiography coronal MIP image showing RIPA from Aorta and LIPA from celiac trunk

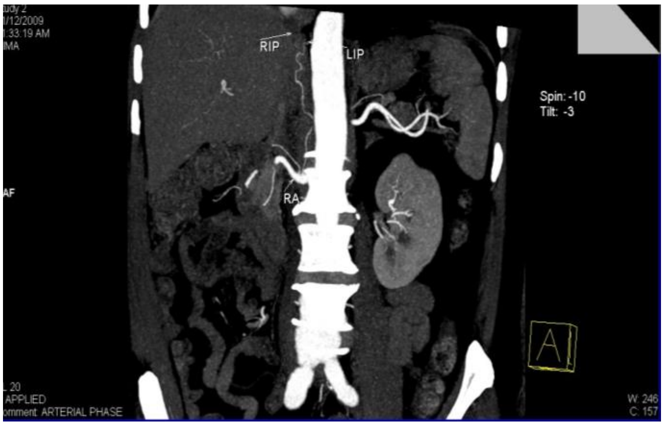

Fig 6. CT angiography Coronal MIP image showing RIPA from right renal artery and LIPA arising from aorta

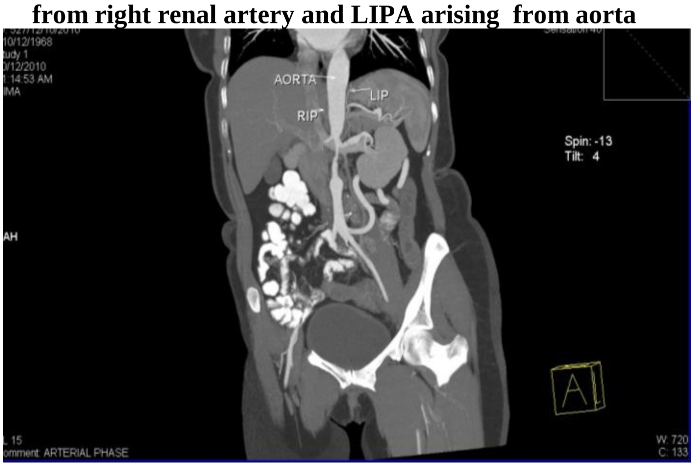

Fig. 7.Coronal MIP image showing RIPA from aorta and LIPA from left renal artery

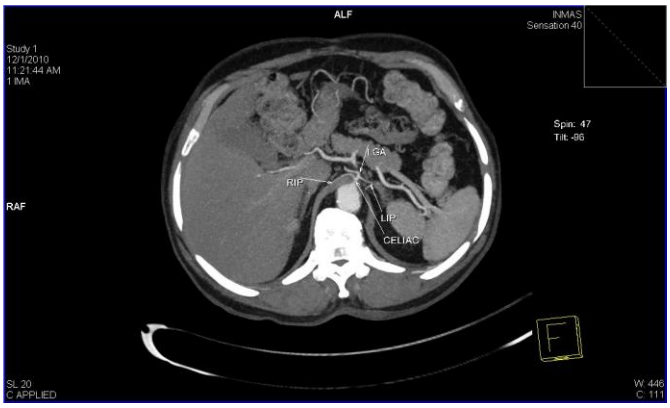

Fig 8. Axial MIP image showing RIPA from celiac trunk and LIPA from LGA

Fig 9.CT angiography axial MIP image showing RIPA arising from CHA

Discussion

Knowledge of all possible variations and particularly the origins of the left and right inferior phrenic arteries may be useful in the discussion and treatment of hepatic, suprarenal or diaphragmatic lesions. (09)

i. INTERVENTION:

Transcatheter treatment of HCC can be pursued through extrahepatic collateral vessels. RIPA is the most frequently used and important among the extrahepatic collateral arteries of HCCs. Arteriographic study of the RIPAs may be recommended routinely when the hepatic arteries have been interrupted in patients with hepatic neoplasms some variants in RIPA exist in the origin of the inferior phrenic artery, it may be troublesome for the angiographer to study the RIPA routinely. Therefore keeping in mind the variant anatomy of IPA identification of the vessel becomes easy. (10)

Because transcatheter embolization of HCC and other hepatic neoplasms often involves finding the root of the RIPA, the interventional radiologist or oncologist could potentially benefit from knowledge of common variations in origin of these vessels and their respective frequencies of occurrence. The importance of the IPA is not limited to the treatment of HCC. Practically any hepatic neoplasm (including metastatic disease to the liver) may receive blood supply from the IPA. In addition, there have been reports of gastric hemorrhage due to bleeding from the LIPA after treatment of the left gastric artery with embolization (11)

ii. TREATMENT OF HEMOPTYSIS:

Transcatheter bronchial artery embolization (BAE) is widely used for the treatment of hemoptysis and the immediate success rate is high, but there are still some hemorrhage recurrences. One of the common reasons for failure of BAE is collateral branches as blood supply. The inferior phrenic artery (IPA) is one of the most common collateral branches that is scarcely reported. Therefore exact anatomical origin of IPA's is required for embolization procedure. (12)

iii. LIVER TRANSPLANTATION:

The right IPA is clinically important because it acts as an extrahepatic collateral vessel(13,14) and runs in front of the right crus of the diaphragm and then behind the inferior vena cava . 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 IPA can occur after liver transplantation. (15,16)

IV. DECOMPRESSION OF CELIAC ARTERY:

The knowledge of independent celiac origin of inferior phrenic artery shows that surgeons must be cautious to avoid unintentional sectioning of small caliper arteries, as it may occur during the celiac artery decompression in the compression syndrome of the celiac trunk by the median arcuate ligament. (17)

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