



## A Study of the Proximal Part of Inferior Phrenic Artery in Cadavers

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**DR. TAPIYAWALA KRUTIB.**<sup>1</sup>

**DR. NATARAJAN M.**<sup>2</sup>

1 Speciality Medical Officer

2 Professor

Department of Anatomy, Seth G. S. Medical College, Parel, Mumbai

### Corresponding Author:



Dr. Kruti B. Tapiyawala  
 M.D. Anatomy  
 3/85 Umar Mansion  
 Building, Saat Rasta, Arthur  
 Road,  
 Mumbai-400011  
 (Maharashtra, India)

+91-8108999660, 022-23052167



krutitapiyawala@gmail.com

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### Abstract:

**AIM:** To study the morphology of proximal part of inferior phrenic artery. **OBJECTIVES:** To determine the vertebral level of origin of inferior phrenic artery bilaterally and to note variations of the proximal part of inferior phrenic artery. **MATERIALS AND METHODS:** Fifty embalmed cadavers were dissected. The vertebral level of origin and variations were noted. **RESULTS:** The vertebral level of origin of inferior phrenic artery was located at the level of IVD T12-L1 in 30% cases on the right side and in 25.5% cases on the left side. In 3/50 (6%) cases on the right side and in 4/51(7.8%) on the left side, inferior phrenic artery arose from the celiac trunk. In 20/50 (40%) cases, inferior phrenic artery arose bilaterally from celiac trunk. Out of these 20 cases, it arose as a common trunk from celiac trunk in 4 (8%) cases & as an independent origin from celiac trunk in 16 (32%) cases. In 1/50 (2%) cases on the right side and in 1/51 (1.96%) cases on the left side, inferior phrenic artery arose from superior mesenteric artery. In 2/50 (4%) cases on the right side, inferior phrenic artery arose from the renal artery. In 1/50 (2%) cases on the left side, there were presence of 2 inferior phrenic arteries, both arising from the celiac trunk. **CONCLUSION:** The present study provides a comprehensive data about the proximal part of the inferior phrenic artery which will help in interpretation of radiographs and during surgery of different types of abdominal pathology in Indian population. Awareness of these variations can prevent potential intra-operative and post-operative complications.

**KEYWORDS:** celiac trunk, inferior phrenic artery, vertebral level of origin, proximal part

### Introduction:

The inferior phrenic artery (IPA) is the most common source of extrahepatic collateral blood supply for hepatocellular carcinoma (HCC) and frequently supplies HCCs located in the bare area of the liver.<sup>1</sup> So, an unresectable HCC can be treated by transcatheter embolization of not only its typical blood supply, the right or left hepatic arteries, but also by embolization of a right inferior phrenic

artery (RIPA), if involved. Such “extra-hepatic” collateral arterial supply to HCC may arise after successful embolization of a hepatic artery, or may exist concurrently with the hepatic arterial supply. 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 left inferior phrenic artery (LIPA) after treatment of left gastric artery embolization.<sup>2</sup> Other pathological conditions including hemoptysis, diaphragmatic or hepatic bleeding due to trauma or surgery, and bleeding caused by gastroesophageal problems (eg. Mallory-Weiss tear or gastroesophageal cancer) may be related to the IPA. Radiologists must be familiar with the normal spectrum of IPA anatomy so that detection and adequate interventional management can be achieved.<sup>1</sup> Hence, preoperative vascular evaluation is mandatory in planning radiological and surgical procedures of the subphrenic region of the upper abdomen with emphasis on the extrahepatic collateral arteries.<sup>3</sup>

### Materials and Methods:

Fifty formalin-fixed cadavers in the department of anatomy of the tertiary care hospital were dissected carefully. This study was conducted over a period of two years. All the cadavers were ranging between the age group of 18-65 years at the time of death. None of the abdomen showed any evidence of previous surgery. After meticulous dissection, satisfactory exposure of the ventral branches of abdominal aorta was done. Counting of vertebra was done from below upward, by identifying the sacral promontory first and labelling the vertebra immediately above that as fifth lumbar vertebra (L5) and so on and so forth. This counting of vertebra was also confirmed by identifying the 12<sup>th</sup> rib and tracing it to the 12<sup>th</sup> vertebra. Length of each vertebral body was measured. Each vertebra was divided into upper, middle and lower third. The vertebral level of origin of inferior phrenic artery and any variations of its proximal part were noted bilaterally.

### Results:

In this study, fifty embalmed cadavers were used. Out of 50 cadavers, 43 cadavers were male and 7 cadavers were female. All cadavers were within 18-65 year age group at the time of death.

Abbreviations used are:

U- Upper one third (1/3<sup>rd</sup>) of the vertebra

M- Middle one third (1/3<sup>rd</sup>) of the vertebra

L- Lower one third (1/3<sup>rd</sup>) of the vertebra

D- Intervertebral Disc (IVD) between the vertebrae

R- Right side

L- Left side

**Table 1. Vertebral level of origin of inferior phrenic artery**

Sr. no.	Vertebral level	Right side		Left side	
		No. of specimens	Percent age (%)	No. of specimens	Percent age (%)
1	DT 11-12	00	00	01	2.0
2	UT 12	00	00	01	2.0
3	MT 12	06	12	06	11.8
4	LT 12	08	16	10	19.6
5	DT 12- L 1	15	30	13	25.5
6	UL 1	05	10	07	13.7
7	ML 1	07	14	04	7.8
8	LL 1	04	08	07	13.7
9	DL 1- L2	05	10	02	3.9
<b>Total</b>		50	100	51*	100

\*In 1 case, on the left side 2 Inferior phrenic arteries were present.

The vertebral level of origin of inferior phrenic artery was found to be located between middle 1/3<sup>rd</sup> of T12 to IVD L1-L2 on the right side and between IVD T11-T12 to IVD L1-L2 on the left side. In 15(30%) cases, it was located at the level of IVD T12-L1 on the right side and in 13 (25.5%) cases; it was located at the level of IVD T12-L1 on the left side.

### Variations found in the present study:

a) Source of origin of inferior phrenic artery:

1. From coeliac trunk: In 3/50 (6%) cases on the right side and in 4/51 (7.8%) on the left side, inferior phrenic arteries arose from the coeliac trunk. In 20/50 (40%) cases, inferior phrenic artery arose bilaterally from coeliac trunk. Out of these 20 cases, it arose as a common stem from coeliac trunk in 4 (8%) cases & as an independent origin from coeliac trunk in 16 (32%) cases.
  2. From superior mesenteric artery: In 1/50 (2%) cases on the right side and in 1/51 (1.96%) on the left side, inferior phrenic artery arose from the superior mesenteric artery.
  3. From renal artery: In 2/50 (4%) cases on the right side, inferior phrenic artery arose from the renal artery.
- b) Number of inferior phrenic arteries: In 1/50 (2%) cases on the left side, there was presence of 2 inferior phrenic arteries, both arising from the coeliac trunk.

## Discussion:

### a) Source of origin of inferior phrenic artery:

**Ask R<sup>4</sup>** et al. in 2013 dissected 100 cadavers of Asian origin (75 males and 25 females). They found variant branching pattern of the LIPAs in 29% of the male cadavers and 28% of the female cadavers. The total incidence of variant branching pattern of the LIPAs was 29%. In 12 male cadavers and 3 female cadavers LIPA was found to arise from celiac trunk. The origin of the LIPA from the left gastric artery was found in 7 male and 2 female cadavers. From the left hepatic artery, LIPA was found to arise in 3 male cadavers. The variant branching pattern of the RIPA was found in 36% of the male cadavers and 32% of the female cadavers. The total incidence of variant branching pattern of the RIPA was 35%. In 7 male cadavers and 2 female cadavers LIPA was found to arise from celiac trunk. The origin of the RIPA from the left gastric artery was found in 2 male and 1 female cadavers. From the right hepatic artery, RIPA was

found to arise in 2 male cadavers. **Wadhwa A<sup>5</sup>** et al dissected 30 cadavers in the Anatomy department at Punjab. They found that on both right and left side the IPA arose independently in 66.6% cases and by a common trunk in 33.3% cases. **Tiwari S<sup>6</sup>** et al in 2012 dissected 50 adult cadavers in the Department of Anatomy at Bangalore. The origin of inferior phrenic arteries from coeliac trunk was seen in 5 (10%) specimens. Out of 5 specimens, RIPA alone was arising from the coeliac trunk in 1 (20%) specimen. In 2 (40%) specimens LIPA alone was arising from coeliac trunk. In 2 (40%) specimens, both IPA were seen arising from coeliac trunk. **Songür A<sup>7</sup>** et al found single trunk of IPA arising from coeliac trunk in 4.2%. **Gwon DI<sup>1</sup>** et al performed 383 interventional procedures related to the IPA from March 2001 to 2005. Out of 383 IPA angiograms, in 39.7% celiac axis, in 15.4% renal artery, in 3.7% left gastric artery, in 2.1% hepatic artery, in 0.3% SMA and in 0.3% contralateral IPA was found as the site of origin of IPA. **Pulakunta T<sup>8</sup>** et al in 2007 dissected 32 adult cadavers in the departments of Anatomy at Manipal and Mangalore. The IPA was found to arise from celiac trunk on left side in 1 case, bilaterally from celiac trunk in 1 case, from gastric artery on left side in 1 case and from renal artery on right side in 1 case. **Petrella S<sup>9</sup>** et al dissected 89 cadavers. They found that in 31 (34.83%) cadavers, the IPAs had their origin in the celiac trunk. On analysis of presence of IPAs in 31 cadavers, it was found that in 61.29% of 31 cadavers or 21.35% of the overall cadavers, LIPA had its origin at the left contour of the celiac trunk and 16.13% of 31 cadavers or 5.62% of the overall cadavers, RIPA had its origin at the right contour of the celiac trunk. In 22.58% of 31 cadavers or 7.86% of total, both arteries of which 16.13% or 5.62% of the total had their origin independent of each side of celiac trunk and in 6.45% or 2.25% of the total from one celiac trunk. **Loukas M<sup>2</sup>** et al. in 2005 examined 300 formalin-fixed adult human cadavers. It was observed that both RIPA and LIPA arose bilaterally from the celiac trunk without a common stem in 37% and

with a common stem in 11%. Both RIPA and LIPA arose bilaterally from the right renal artery without a common stem in 4%. Both RIPA and LIPA arose bilaterally from the left gastric artery without a common stem in 1%.

In the present study, in 20/50 cases (40%) IPA arose bilaterally from coeliac trunk. Out of these 20, it arose as a common stem from coeliac trunk in 4 (8%) cases and as an independent origin from coeliac trunk in 16 (32%) cases. In 1/50 (2%) cases on the right side and in 1/51 (1.96%) on the left side, inferior phrenic artery arose from the superior mesenteric artery. In 2/50 (4%) cases on the right side, inferior phrenic artery arose from the renal artery.

**Table 2. Comparison of source of origin of inferior phrenic artery in present and past studies**

Source of origin	Percentage					
	Wadhwa A <sup>5</sup> et al		Loukas M <sup>2</sup> et al		Present study	
	Right	Left	Right	Left	Right	Left
<b>Coeliac trunk</b>	35	30	40	47	46	47.1
<b>Superior Mesenteric Artery</b>	-	-	-	-	2	1.96
<b>Renal artery</b>	10	5	17	5	4	0
<b>Left gastric artery</b>	-	-	3	2	0	0
<b>Hepatic artery proper</b>	-	-	2	1	0	0

**b) Number of inferior phrenic arteries:** Studies pertaining to the present variation were not found in literature reviewed till date.

**c) Vertebral level of origin of inferior phrenic artery:** Studies pertaining to the present parameter were not found in literature reviewed till date.

The following embryological basis may be explained for the different vertebral levels of various branches and variations found. Each primitive dorsal aorta gives off somatic arteries (intersegmental branches to the body wall), a caudal continuation which passes into the body stalk (the umbilical arteries), lateral splanchnic arteries (paired segmental branches to the mesonephric ridge), and ventral splanchnic arteries (paired segmental branches to the digestive tube). The lateral splanchnic arteries supply, on each side, the mesonephros, metanephros, testis or ovary and the suprarenal gland. All these structures develop, in whole or in part, from the intermediate mesenchyme, later termed the aorta-gonad-mesonephros region. One testicular or ovarian artery and three suprarenal arteries persist on each side. The phrenic artery a branch from the most cranial suprarenal artery and the renal artery arises from the most caudal.<sup>10</sup> Additional inferior phrenic arteries may be regarded as branches of persistent lateral splanchnic arteries.

### Conclusion:

In conclusion, the present study provides a comprehensive data about the proximal part of inferior phrenic artery which will help in interpretation of radiographs and during surgery of different types of abdominal pathology in Indian population. Awareness of these variations can prevent potential intra-operative and post-operative complications.

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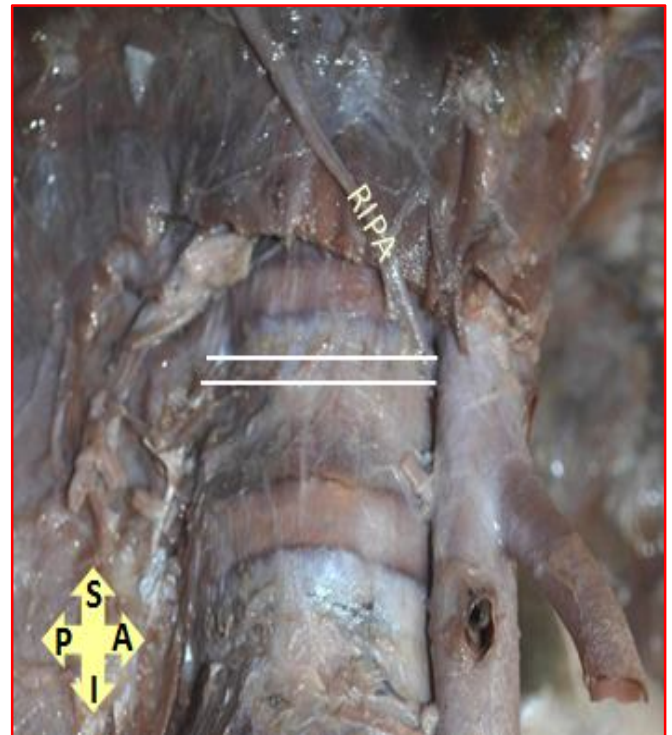
Authors also acknowledge the immense help received from the scholars whose articles are cited and included in references of this manuscript. The

authors are also grateful to authors/ editors/ publishers of all those articles, journals and books from where the literature for this article has been reviewed and discussed.

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**Figure 1: Illustration showing determination of vertebral level of origin of right inferior phrenic artery (RIPA)**



**Figure 2: Illustration showing right inferior phrenic artery (RIPA) and left inferior phrenic artery (LIPA) arising from coeliac trunk (CT) by common stem (CS) (viewed from anterior aspect) (SMA-Superior mesenteric artery)**

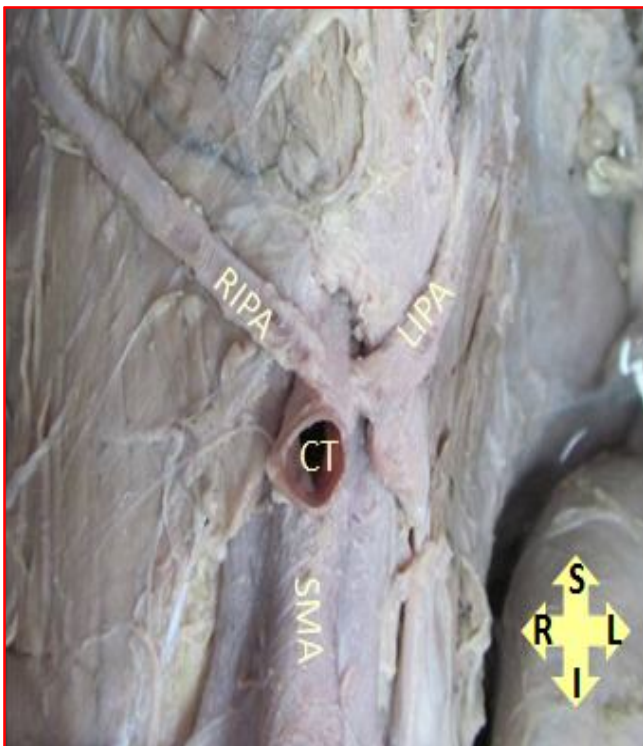


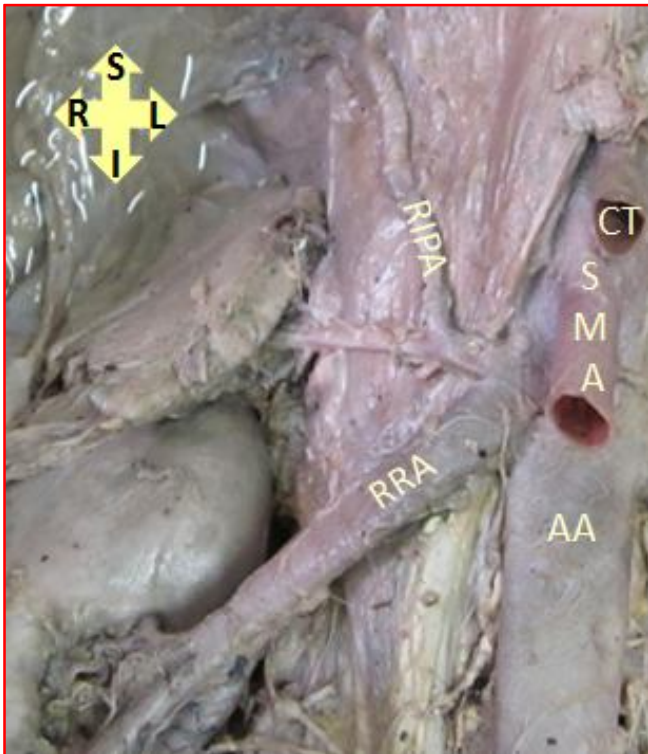
**Figure 3: Illustration showing right inferior phrenic artery (RIPA) and left inferior phrenic artery (LIPA) arising from coeliac trunk (CT) independently (viewed from anterior aspect) (SMA-Superior mesenteric artery)**

**Figure 4: Illustration showing right inferior phrenic artery (RIPA) arising from superior mesenteric artery (SMA) (viewed from anterior aspect) (CT- Coeliac trunk, RRA- Right renal artery)**



**Figure 5: Illustration showing right inferior phrenic artery (RIPA) arising from right renal artery (RRA) (viewed from anterior aspect) (CT- Coeliac trunk, SMA- Superior mesenteric artery, AA- Abdominal aorta)**





**Figure 6:** Illustration showing presence of two left inferior phrenic arteries (LIPA) both arising from coeliac trunk (CT) (viewed from anterior aspect) (SMA-Superior mesenteric artery)

