

# A Study of Variations in the Origin of Inferior Phrenic Artery in Adult Human Cadavers with Clinical and Embryological Significance

JYOTHI KRISHNARAJANAGAR CHANDRACHARI, PRATHAP KUMAR JAYARAMU, SHAILAJA SHETTY

## ABSTRACT

**Introduction:** The knowledge of variations of the arteries is important for the clinical, radiological and surgical diagnosis. The incidence of normal origin of inferior phrenic artery from abdominal aorta is 92%. Other sources of origin may be celiac trunk, renal artery, suprarenal, and hepatic, left gastric or superior mesenteric arteries accounting for 8% of cases.

**Aim:** To study the normal and anomalous origin of inferior phrenic artery and to discuss the embryological basis and clinical significance of the variations.

**Materials and Methods:** Fifty formalin fixed cadavers were dissected to observe the variations in the origin of inferior phrenic artery in the Department of Anatomy, M. S. Ramaiah Medical College, Bangalore.

**Results:** Inferior phrenic artery arose from abdominal aorta in forty three cadavers. Both right inferior phrenic

artery and left inferior phrenic artery arose as a common trunk from abdominal aorta in one cadaver. Right inferior phrenic artery originated from celiac axis in one cadaver. Left inferior phrenic artery originated from celiac axis in four cadavers. Both left and right inferior phrenic arteries originated as common trunk from coeliac axis in three cadavers. Right inferior phrenic artery originated as a common trunk with right renal artery from abdominal aorta in one cadaver and as a common trunk with accessory renal artery from the abdominal aorta in one cadaver.

**Conclusion:** Precise knowledge of usual and anomalous origin of inferior phrenic arteries are essential for surgeons, anatomists, researchers and interventional radiologist for performing transcatheter embolization of not only of hepatic artery but also of the right inferior phrenic artery, which is the commonest extrahepatic collateral supply of hepatocellular carcinoma.

**Keywords:** Coeliac artery, Hepatocellular carcinoma, Renal artery

## INTRODUCTION

Inferior phrenic arteries (IPA) are the chief arteries supplying the diaphragm. They usually originate from the dorsal surface of Abdominal Aorta (AA), just above the level of Coeliac axis/ Artery (CA) as paired arteries and occasionally it also arise from AA as common trunk with CA, from CA itself or from renal artery (RA) [1]. The Right Inferior Phrenic Artery (RIPA) and Left Inferior Phrenic Artery (LIPA) diverge from each other across the crura of the diaphragm and run obliquely upward and laterally along its inferior surface [2]. They also supply other organs like adrenal glands, oesophagus, stomach, liver and retroperitoneum [3]. As stated by Pick and Anson, Quain was the first person to describe the origin of inferior phrenic artery [4]. There are very few anatomy textbooks which gives clear descriptions of inferior phrenic artery. They

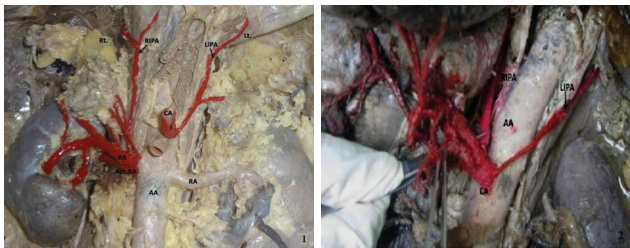
have received increased attention in recent days due to its clinical importance. Hepatocellular Carcinoma (HCC) is the commonest tumour of liver cell origin and hepatic artery was considered to be the major artery supplying it. The commonest source of extrahepatic collateral blood supply to HCC was Inferior phrenic arteries and most frequently supplies the tumours in the bare area of liver [5]. Any unresectable HCC is treated by transcatheter chemoembolization of hepatic artery as well as right inferior phrenic arteries. Accurate knowledge of the variation in the origin of inferior phrenic arteries is very beneficial for interventional radiologists, oncologists and for surgeons [6]. The present study has been taken up to highlight the various origins of inferior phrenic artery with their clinical importance and embryological basis and compare our observations with previous studies.

## MATERIALS AND METHODS

A study was conducted in Department of Anatomy, M S Ramaiah Medical College Bangalore. Fifty formalin fixed cadavers (42 Male and 08 Female), aged between 45-70 years were dissected for the study and it was conducted over a period of five years i.e., from 2010-2015. The cadavers with visible trauma, pathology or prior surgeries were excluded from the study. Routine dissection of the abdomen was carried out following the Cunningham's Manual of Practical Anatomy [7]. After removal of lesser omentum, the proximal part of abdominal aorta and its branches were identified and periaortic sympathetic plexus was removed. After removal of stomach and pancreas, the origin of inferior phrenic arteries was identified and then, they were traced both proximally and distally.

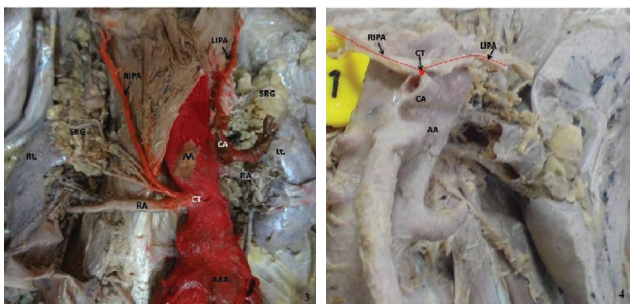
## RESULT

Out of 50 adult human cadavers studied, in 42(84%) cadavers the inferior phrenic artery arose from the abdominal aorta. Other unusual origins of inferior phrenic arteries are shown and summarized in [Table /Fig-1-8]. RIPA and LIPA originated as Common Trunk (CT) from the abdominal aorta in 1(2%) cadaver, RIPA originated from CA independently in 1(2%) cadaver and LIPA arose from CA independently in 4(8%) cadavers. Both LIPA and RIPA originated as common trunk from CA in 3(6%) cadavers. RIPA arose from right renal artery



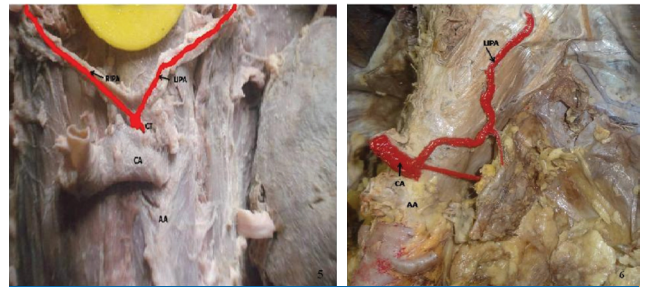
[Table/Fig-1]: Image showing the origin of RIPA from RA and LIPA from CA.

[Table/Fig-2]: Image showing the origin of RIPA and LIPA from CA independently.



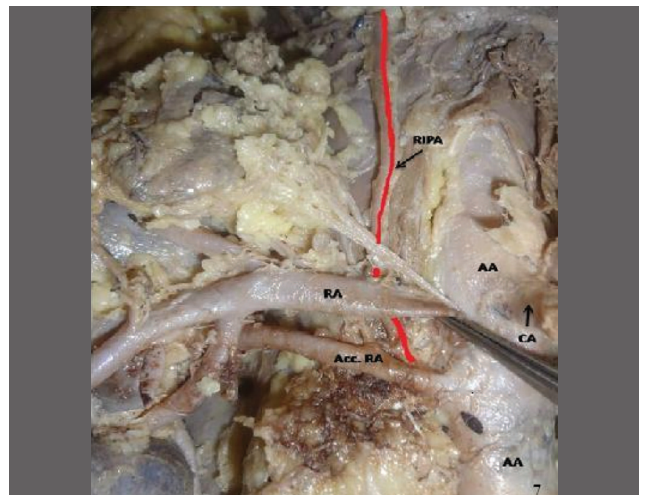
[Table/Fig-3]: Image showing the RIPA and LIPA arising as common trunk from AA and LIPA from CA.

[Table/Fig-4]: Image showing the origin of RIPA and LIPA from CA by a common trunk.



[Table/Fig-5]: Image showing the origin of RIPA and LIPA from AA by a common trunk.

[Table/Fig-6]: Image showing the LIPA from CA.



[Table/Fig-7]: Image showing the origin of RIPA from accessory RA.

Site of origin of IPA	Independent Origin		Common trunk (both IPA)	Common trunk (Right RA with RIPA)
	Right IPA	Left IPA		
Abdominal Aorta	42(82%)	42(82%)	1(2%)	1(2%)
Coeliac Axis	1(2%)	4(8%)	3(6%)	-
Renal Artery	1(2%)	-	-	-
Accessory Renal Artery	1(2%)	-	-	-

[Table/Fig-8]: Various source of origin of the inferior phrenic artery.

in 1(2%) cadaver and from accessory renal artery in 1(2%) cadaver. RIPA originated as a common trunk (CT) with right renal artery from abdominal aorta in 1(2%) cadaver.

## DISCUSSION

The vascular variations are commonly observed during dissection, the knowledge of variations in their origin, course and branches are very important for radiologists and surgeons [8].

The RIPA and LIPA arise with almost equal frequency from AA and CA, either independently or as a common trunk. Less frequently they also arise from left gastric, hepatic, superior

mesenteric and rarely from spermatic and from contra lateral IPA [5].

Gurses et al., studied the origin of inferior phrenic artery with special reference to their branches with clinical importance in twenty six cadavers and found that both RIPA and LIPA originated as common trunk from abdominal aorta in five cadavers. They also stated that RIPA arose from RA in two sides, from CA in one side and from left gastric artery in one side. The LIPA arose from CA in six sides [9].

Petrella et al., conducted a vast study on origin of inferior phrenic artery on eighty nine cadavers and reported that IPA arose from CA in 31 cadavers and among these in 19 (21.35 %) cadavers from LIPA arose from the left contour of CA which was similar to the results obtained by Pick and Anson, who reported 34(17%) out of 200 cadavers [10].

[Table /Fig-9] show, the various origins of IPA in our study and in various other studies.

The RIPA is the major collateral blood supply to HCC second only to hepatic arteries. Inferior phrenic arteries were found to have varied origin. These arteries are of small caliber and surgeons must be cautious to avoid unintentional sectioning of small caliber arteries, as it may occur during celiac artery decompression in compression syndrome of celiac trunk by median arcuate ligament [11]. Inferior phrenic arteries also supply adrenal gland, hence are important in angiographic examination of adrenal lesion [12].

Gwon et al., performed interventional procedures related to IPA and observed in 346 HCC cases which had extrahepatic collateral supply from IPA. The importance of IPA is not only with regard to treatment of HCC, but there are other pathologic conditions related to it, such as hemoptysis, hepatic bleeding, gastric bleeding due to Mallory- Weiss tear due to bleeding from LIPA [5,9,10].

The LIPA and its branches supply the left dome of diaphragm and also gastroesophageal junction. The LIPA supplies collateral arterial supply to stomach in case of gastric artery occlusion. During Transcatheter Arterial Chemo-Embolization (TACE) esophageal and gastric damage can occur if non target vessels are embolized [5,13].

Knowledge of variations in origin of IPA is useful in evaluating the efficacy and safety of TACE through IPA, and for treatment of hepatic, suprarenal and diaphragmatic lesions [14].

When IPA arises from RA or in common with RA, suprarenal arteries are always derived from RA, hence are important in angiographic examination of adrenal lesions and it is important to keep in mind while clamping the renal artery during nephrectomy [15]. [Table/Fig-9] tabulated the overview of previous studies which investigated the anatomy of the inferior phrenic arteries.

Authors	No. of cadavers	Origin of IPA		Other variations
		Abdominal Aorta (AA)	Coeliac Axis (CA)	
Anupama et al., [2]	50	35	RIPA (l) -2 LIPA (l) -2 Both IPA(CT) -1	RIPA, Acc. RA Middle Suprarenal Artery(MSRA)- arising as CT from right RA- 1  LIPA, MSRA,RA arising as CT from left RA-1
Gurses et al., [9]	26	5	RIPA(l)- 1	RIPA – from right RA-1 RIPA- from left gastric artery- 1  LIPA – from CT- 6
Pulakunta et al., [11]	32	28	RIPA (l) -1 LIPA (l) -2	LIPA-from left gastric artery-1  RIPA- from Right RA-1
Patel BG et al., [16]	39	23	RIPA (l) - 2 LIPA (l) - 12 Both IPA(CT) -2	
Manjunath et al., [17]	24	21	RIPA(l)-3 LIPA(l)-2	LIPA-from Left gastric artery-1
Wadhwa A et al., [18]	30	24	RIPA (l) -7 LIPA (l) -6 Both IPA (CT) -4	RIPA- from Right RA-2  LIPA-from Left RA-1
Akhi-landeswari et al., [19]	32	17	RIPA (l) -6 LIPA (l) -12	RIPA-from RA-6 LIPA-from RA -4 RIPA from Superior Mesenteric Artery-2
Present study	50	42	RIPA (l) - 1 LIPA (l) - 4 Both IPA(CT) -3	RIPA-from Right RA-1 RIPA-from Acc.RA-1 RIPA & Right RA(CT)- from AA-1 Both IPA(CT)-from AA-1

**[Table/Fig-9]:** Overview of the previous studies which investigated the anatomy of the inferior phrenic arteries and the present study.

## EMBRYOLOGICAL BASIS

The diaphragm is developed from four embryonic components: septum transversum, pleuroperitoneal membranes, dorsal mesentery of oesophagus and muscular ingrowths from lateral body wall [19]. The dorsal aorta in the thorax and lumbar region, gives thirty pair of arteries, which passes in between the successive somites. These are termed as dorsal intersegmental arteries. So the diaphragm which is developed from muscular ingrowths from lateral body wall is supplied by the dorsal branches of abdominal aorta through inferior phrenic artery [20].

The intestinal /vitelline arteries are connected by longitudinal anterior anastomosis and are four in number among which the proximal part of the 2<sup>nd</sup> and 3<sup>rd</sup> root disappears and distal portion joins with the first root to form classical three branches

of celiac artery [21]. The celiac axis and the inferior phrenic artery are derived from 6<sup>th</sup> pair of ventral splanchnic vessels. During foetal development, these arteries span and disappear, but if this longitudinal channels between the primitive vessels persists may lead to vascular variations [22].

## CONCLUSION

Inferior phrenic artery commonly takes origin from abdominal aorta, but other source of origin, like coeliac axis, renal artery and accessory renal artery were also observed. Right inferior phrenic artery is the commonest extrahepatic feeding artery supplying hepatocellular carcinoma. Any unresectable hepatocellular carcinoma is treated by transcatheter chemoembolisation of not only of hepatic arteries but also of right inferior phrenic arteries. Knowledge of all possible variations of inferior phrenic artery origin is essential for researchers, anatomists, interventional radiologist, oncologists and surgeons working in the area of inferior phrenic artery and while performing angiographic examination of adrenal lesions and during nephrectomy.

## REFERENCES

- [1] Standring S. Posterior abdominal wall and retroperitoneum. In: Gray's Anatomy, 39<sup>th</sup> ed. Edinburgh, Elsevier Churchill Livingstone: 2005: 1113-26.
- [2] Anupama D, Subhash LP, Suresh BS. Inferior phrenic artery, variations in origin and clinical implications- a case study. *Journal of Dental and Medical Sciences*. 2013;7(6):46-48.
- [3] Topaz O, Topaz A, Polkampally PR, Damiano T, King CA. Origin of a common trunk for the inferior phrenic arteries from their right renal artery: a new anatomic vascular variant with clinical implications. *Cardiovascular Revascularization Medicine*. 2010;11:57-62.
- [4] Pick JW, Anson BJ. The inferior phrenic artery: origin and supra-renal branches. *Anat Rec*. 1940;78:413-27.
- [5] Gwon DI, Ko GY, Yoon HK, Sung KB, Lee JM, Ryu SJ, et al. Inferior Phrenic artery: Anatomy, variations, pathologic conditions, and interventional management. *Radiographics*. 2007;27:687-705.
- [6] Kundu B, Ghosh I, Sarkar S, Sengupta G. Anomalous origin of right inferior phrenic artery. *Int J Anat Res*. 2014;2(2):394-96.
- [7] Romanes GJ. Cunningham's Manual of Practical Anatomy. In: the abdomen 15<sup>th</sup> edn, Vol 2, Oxford University Press, New York, Tokyo 2000; 142-53.
- [8] Lipshutz B. A composite study of the coeliac axis artery. *Ann Surg*. 1917;65:159-69.
- [9] Gurses IA, Gayretli O, Kale A, Ozturk A, Usta A, Sahinoglu K. Inferior phrenic arteries and their branches, their anatomy and possible clinical importance: an experimental cadaver study. *Balkan Med J*. 2015;32:189-95.
- [10] Patrella S, Rodrigues CFS, Sgrott ER, Fernandez GJM, Marques SR, Prates JC. Origin of inferior phrenic arteries in the celiac trunk. *Int J Morphology*. 2006;24(2):275-78.
- [11] Pulakunta T, Potu BK, Gorantla VR, Rao MS, Madhyastha S, Vollala VR. The origin of the inferior phrenic artery: a study in 32 South Indian cadavers with a review of the literature. *J vasc brass*. 2007;6(3):225-30.
- [12] Kahn PC. Selective angiography of inferior phrenic artery. *Radiology*. 1967;88:01-08.
- [13] Hieda M, Toyota N, Kakizawa H, Ishikawa M, Horiuchi J, Ito K. The anterior branch of the left inferior phrenic artery arising from the right inferior phrenic artery: an angiographic and CA study. *Cardiovasc Intervent radiol*. 2009;32(2):250-54.
- [14] Loukas M, Hullett J, Wagner T. Clinical anatomy of the inferior phrenic artery. *Clin Anat*. 2005;18(5):357-65.
- [15] Paraskevas GK, Raikos. Multiple aberrant coeliac trunk ramifications. *Singapore Med J*. 2011;52(7):147.
- [16] Manjunath CS, Kumar NBD, Koushik SR. Study of origin of inferior phrenic arteries. *Journal of recent trends in science and Technology*. 2014;11(2):205-06.
- [17] Patel BG, Gosai P, Shah K, Kannani SD. A cadaveric study of origin of inferior phrenic artery from celiac trunk. *J Med Sci*. 2013;2(2):21-23.
- [18] Wadhwa A, Soni S. A study of mode of origin of inferior phrenic artery in 30 adult human cadavers- clinical implications. *Global Journal of Medical research*. 2012;12(40):01-04.
- [19] Akhilandeswari B, Ranganath P. Variations in the source of origin of inferior phrenic artery: a cadaveric study. *Journal of the Anatomical Society of India*. 2013;62:06-09.
- [20] Moore KL, Persaud TVN. The developing human-clinically oriented embryology, 8<sup>th</sup> edn. Saunders publishers, Philadelphia, 2008.146-58.
- [21] Romer AS, Parson TS. The vertebrate body. 6<sup>th</sup> edn, Philadelphia, saunders college publishers, 1986. 458-69.
- [22] Kalthur SG, Sarda R, Bankar M. Multiple vascular variations of abdominal vessels in a male cadaver: embryological perspective and clinical importance. *J Morphol Sci*. 2011;28:152-56.

### AUTHOR(S):

1. Dr. Jyothi Krishnarajanagar Chandrachari
2. Dr. Prathap Kumar Jayaramu
3. Dr. Shailaja Shetty

### PARTICULARS OF CONTRIBUTORS:

1. Assistant Professor, Department of Anatomy, M S Ramaiah Medical College, Bangalore, India.
2. Assistant Professor, Department of Anatomy, M S Ramaiah Medical College, Bangalore, India.
3. Professor & Head, Department of Anatomy, M S Ramaiah Medical College, Bangalore, India.

### NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Dr. Jyothi Krishnarajanagar Chandrachari,  
Assistant Professor, Department of Anatomy,  
M S Ramaiah Medical College, M S R Nagar,  
MSRIT Post, Mathikere, Bangalore- 560054, India.  
E-mail: jyothimohank@gmail.com

### FINANCIAL OR OTHER COMPETING INTERESTS:

None.

Date of Online Ahead of Print: **Jun 3, 2016**

Date of Publishing: **Jul 01, 2016**