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INFERIOR PHRENIC ARTERY EMERGING FROM THE PHRENIC-ADRENAL TRUNK: A RARE ANATOMICAL FINDING

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ARTIGO ORIGINAL

RESUMO

Introdução: As artérias frênicas inferiores (AFIs) são vasos pequenos e pareados que mais comumente surgem da aorta abdominal e do tronco celíaco. No entanto, um amplo espectro de variações anatômicas tem sido descrito, incluindo origens das artérias renais, gástrica esquerda, hepática e gonadais. Essas variações possuem implicações clínicas e cirúrgicas relevantes, especialmente em procedimentos envolvendo o diafragma, glândulas adrenais, fígado e órgãos abdominais superiores. **Relato de Caso:** Durante uma dissecção de rotina de um feto humano feminino com 33 semanas de idade gestacional, foi observada uma origem incomum da artéria frênica inferior direita (AFID). O vaso emergiu de um tronco comum com a artéria supra-renal inferior direita, aqui designado como tronco frênico-adrenal, que se originou da artéria renal direita. O tronco media 1,16 mm de comprimento e 1,1 mm de diâmetro, localizado a 2,55 mm da superfície lateral da aorta abdominal. Desse tronco, a AFID ascendeu anteriormente ao pilar direito do diafragma em direção à superfície inferior do hemidiafragma direito, enquanto a artéria supra-renal inferior supria a glândula adrenal ipsilateral. Nenhuma anomalia vascular adicional foi identificada. **Conclusão:** Este caso descreve uma rara variante anatômica da AFID emergindo de um tronco frênico-adrenal originado da artéria renal direita. A conscientização sobre tais variações aprimora o conhecimento anatômico e apoia intervenções clínicas, cirúrgicas e radiológicas mais seguras e eficazes no abdome superior.

Palavras-chave: Variação Anatômica; Morfometria Vascular; Vascularização do Diafragma; Aorta Abdominal; Tronco Celíaco; Artéria Renal.

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ABSTRACT

Introduction: The inferior phrenic arteries (IPAs) are small, paired vessels that most commonly arise from the abdominal aorta and celiac trunk. However, a wide spectrum of anatomical variations has been described, including origins from the renal, left gastric, hepatic, and gonadal arteries. These variations have relevant clinical and surgical implications, especially in procedures involving the diaphragm, adrenal glands, liver, and upper abdominal organs. **Case Report:** During a routine dissection of a female human fetus at 33 weeks of gestational age, an unusual origin of the right inferior phrenic artery (RIPA) was observed. The vessel emerged from a common trunk with the right inferior suprarenal artery, herein designated as a phrenico-adrenal trunk, which originated from the right renal artery. The trunk measured 1.16 mm in length and 1.1 mm in diameter, located 2.55 mm from the lateral surface of the abdominal aorta. From this trunk, the RIPA ascended anteriorly to the right diaphragmatic crus toward the inferior surface of the right hemidiaphragm, while the inferior suprarenal artery supplied the ipsilateral adrenal gland. No additional vascular anomalies were identified. **Conclusion:** This case describes a rare anatomical variant of the RIPA arising from a phrenico-adrenal trunk originating from the right renal artery. Awareness of such variations enhances anatomical knowledge and supports safer and more effective clinical, surgical, and radiological interventions in the upper abdomen.

Keywords: Anatomical Variation; Vascular Morphometry; Diaphragm Vascularization; Abdominal Aorta; Celiac Trunk; Renal Artery.

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Introduction

The inferior phrenic arteries (IPAs) are a pair of small-caliber vessels that typically arise from the lateral aspect of the abdominal aorta, distal to the aortic hiatus, or from the celiac trunk. However, given the notable anatomic variability of abdominal vascularization, the IPAs may, less commonly, originate from the renal, common hepatic, left gastric, superior mesenteric, or gonadal arteries [Kahn PC, 1967; Marcinkowska et al., 2023]. This anatomic variability is extensively documented, and recent investigations indicate that the IPAs are anatomically more significant than previously assumed, owing to their strategic location and the rich collateral network they form [Marcinkowska et al., 2023]. The IPAs may arise as a common trunk that subsequently bifurcates into the right and left inferior phrenic branches, or as independent vessels—the right inferior phrenic artery (RIPA) and the left inferior phrenic artery (LIPA) [Whitley et al., 2021]. Although they predominantly supply the diaphragm, the IPAs may also contribute substantially to the blood supply of the stomach, spleen, adrenal gland, liver, and adjacent structures [Sehgal et al., 2025; Marcinkowska et al., 2023].

Anatomically, the IPA ascends along the anterior surface of the diaphragmatic crus. Along its course, it gives rise to branches to the adrenal gland, termed the superior suprarenal arteries [He et al., 2024]. Upon approaching the diaphragmatic dome, the IPAs typically bifurcate into two principal branches: an anterior branch, longer in extent, which proceeds anterosuperiorly toward the margin of the central tendon of the diaphragm; and a posterior branch, shorter in length, which extends laterally over the costal and lumbocostal origins of the diaphragm [Greig et al., 1951].

A consistent direct connection is observed between the phrenic arteries and the internal thoracic arteries and their respective branches, forming an anastomotic arterial ring circumferentially around the medial leaflet of the diaphragmatic tendon. From this ring, branches emerge that perfuse the muscular fibers toward the periphery of the diaphragm. These branches anastomose with vessels from the intercostal arteries, constituting the costophrenic arcades that accompany the fibers of the crura and the costal segments of the diaphragm [Comtois et al., 1987].

Elucidating the anatomical variations in the origin of the IPAs is of paramount

importance in multiple surgical scenarios, notably in diaphragmatic repairs, adrenalectomies, and upper gastrointestinal interventions [Sehgal et al., 2025]. Mastery of these variants is crucial both for interventional radiological procedures, such as embolization, and for precise surgical planning aimed at optimizing therapeutic outcomes [Marcinkowska et al., 2023]. Additionally, the IPAs have been implicated as a primary source of postoperative hemorrhage in liver transplant recipients and in living donors undergoing right hepatic lobectomy [Lee JW et al., 2006]. Specifically, the RIPA may serve as an extrahepatic arterial supply route to hepatocellular carcinoma (HCC), offering both direct access to the tumor and a conduit for transcatheter embolization in cases of unresectable HCC [Shin SW et al., 2006; Basile A et al., 2008; Lee DHo et al., 2009; Marcinkowska et al., 2023]. The IPAs may also be etiologically responsible for life-threatening hemorrhage arising from pseudoaneurysms, trauma, or iatrogenic diaphragmatic injuries induced by cardiopulmonary resuscitation, in addition to playing a protective role in the perfusion of vital organs in settings of stenosis of major arteries [Marcinkowska et al., 2023]. The primary objective of the present study is to report a case of an atypical origin of the RIPA, specifically its emergence from a common trunk with the right inferior suprarenal artery (RISA), a variation scarcely documented in the literature. This description seeks to enrich the anatomical knowledge base by characterizing rare vascular configurations.

Case Report

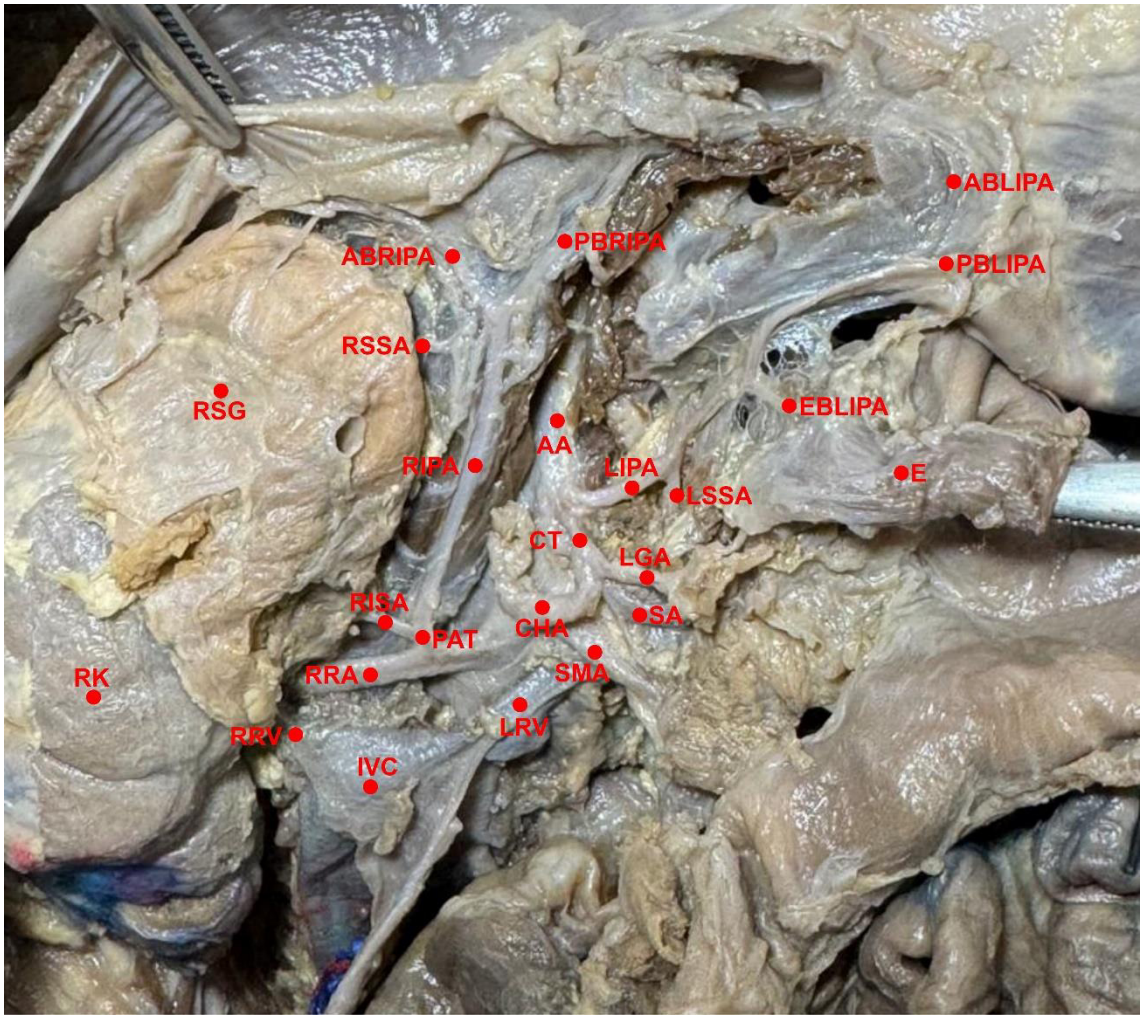
During a routine anatomical dissection conducted at the Morphology Laboratory of the Federal University of Sergipe, a significant anatomical variation in the origin of the RIPA was identified in a female human fetus of approximately 33 weeks' gestational age. The RIPA was observed to arise from a common arterial trunk with the RISA, which was designated the phrenic–adrenal trunk (PAT) **(Figure** 1). This PAT measured 1.16 mm in length and 1.1 mm in diameter, and its primary origin was from the right renal artery (RRA), at a distance of 2.55 mm from the lateral aspect of the abdominal aorta.

After originating from the phrenic–adrenal trunk, the RIPA coursed medial to the right adrenal gland, ascending along the anterior surface of the ipsilateral diaphragmatic crus. Its trajectory terminated on the inferior surface of the diaphragmatic dome, where it ramified terminally to supply the inferior region of the diaphragm. Concomitantly,

after arising from the common trunk, the RISA followed a superolateral course toward the right adrenal gland, supplying this structure.

The remaining visceral arteries originating from the AA—including the celiac trunk (CT), superior mesenteric artery, renal arteries, and the LIPA—displayed usual courses and branching patterns for human anatomy, with no evidence of relevant anatomical alterations or variations.

Figure 1 - Anomalous origin of the RIPA from the phrenic–adrenal trunk arising from the RRA.



AA — abdominal aorta; **ABLIPA** — anterior branch of the left inferior phrenic artery; **ABRIPA** — anterior branch of the right inferior phrenic artery; **CHA** — common hepatic artery; **CT** — celiac trunk; **E** — esophagus; **EBLIPA** — esophageal branches of the left inferior phrenic artery; **LGA** — left gastric artery; **SA** — splenic artery; **LIPA** — left inferior phrenic artery; **LRV** — left renal vein; **IVC** — inferior vena cava; **LSSA** — left

superior suprarenal artery; **PAT** — phrenic–adrenal trunk; **PBLIPA** — posterior branch of the left inferior phrenic artery; **PBRIPA** — posterior branch of the right inferior phrenic artery; **RIPA** — right inferior phrenic artery; **RISA** — right inferior suprarenal artery; **RK** — right kidney; **RRA** — right renal artery; **RRV** — right renal vein; **RSG** — right suprarenal (adrenal) gland; **RSSA** — right superior suprarenal artery.

Discussion

The IPAs may arise from various sources, with the abdominal aorta (25.2% to 63.05%) and the CT (30.44% to 47.28%) being the most prevalent [Pick & Anson, 1940; Gurses et al., 2015; Aslaner et al., 2017]. Although the classical pattern describes the abdominal aorta as the most common origin, recent Studies such as those reviewed by Marcinkowska et al. (2023) indicate that the celiac trunk may be a more frequent origin for the IPAs in certain populations, challenging the traditional view. However, substantial discrepancies in frequency between these two origins have been reported in other studies, in which an aortic origin was observed in 70% to 87.5% of cases, whereas the CT accounted for less than 10% of occurrences [Pulakunta et al., 2007; Anupama et al., 2013].

Other, less frequent origins include the renal artery, the left gastric artery, and the hepatic artery, in that decreasing order of occurrence [Basile et al., 2008; Kulkarni et al., 2020]. Greig et al. (1951) and Pick & Anson (1940) also reported the origin of the RIPA from the spermatic (gonadal) artery. The review by Marcinkowska et al. (2023) further highlighted other rare variations, such as the left inferior phrenic artery arising from an accessory left hepatic artery, the RIPA arising from an accessory right hepatic artery and from the dorsal pancreatic artery, and the LIPA arising from the splenic artery, underscoring the breadth of observed vascular anomalies. The frequency of IPA origins across different studies is presented in **Table** 1.

Table 1 — Frequency of IPA origins

Origin Types	Celiac Trunk		Abdominal Aortal		Left Renal		Right Renal		Left Gastric		Hepatic	
	RIPA	LIPA	RIPA	LIPA	RIPA	LIPA	RIPA	LIPA	RIPA	LIPA	RIPA	LIPA
Loukas et al., 2005 n = 600	120 (20%)	141 (23.5%)	114 (19%)	135 (22.5%)	-	15 (2.5%)	51 (8.5%)	-	9 (1.5%)	6 (1%)	6 (1%)	3 (0.5%)

Aslaner et al., 2017 n = 2000	307 (15.3%)	403 (20.1%)	252 (12.6%)	252 (12.6%)	-	20 (1%)	104 (5.2%)	1 (0.05%)	41 (2%)	24 (1.2%)	1 (0.05%)	5 (0.25%)
Greig et al., 1951 n = 850	176 (20.7%)	222 (26.1%)	196 (23%)	187 (22%)	-	-	34 (4%)	4 (0.47%)	11 (1.3%)	11 (1.3%)	3 (0.35%)	1 (0.12%)
Gurses et al., 2015 n = 46	6 (13.04%)	8 (17.4%)	17 (36.97%)	12 (26.08%)	-	-	2 (4.34%)	-	1 (2.17%)	-	-	-
Pick & Anson, 1940 n = 404	80 (19.8%)	111 (27.48%)	93 (23%)	86 (21.28%)	-	2 (0.5%)	21 (5.2%)	-	4 (0.99%)	5 (1.23%)	1 (0.24%)	-
Kulkarni et al., 2020 n = 944	177 (17.69%)	278 (29.45%)	225 (23.83%)	181 (19.17%)	-	7 (0.74%)	59 (6.25%)	-	9 (0.95%)	6 (0.64%)	1 (0.11%)	-
Basile et al., 2008 n = 400	82 (20.50%)	88 (22%)	98 (24.50)	95 (23.75%)	-	2 (0.5%)	11 (2.75%)	-	8 (2%)	-	1 (0.25%)	-
Shefna et al., 2019 n = 160	29 (18.13%)	23 (14.38%)	43 (26.88%)	54 (33.55%)	-	1 (0.63%)	3 (1.88%)	-	-	-	2 (1.25%)	-

In this regard, among the less prevalent origins for the IPAs—namely the renal, left gastric, and hepatic arteries—the RIPA has shown a higher frequency compared with the LIPA [Loukas et al., 2005; Shefna et al., 2019]. This result corroborates the present study, in which an anomalous origin was located on the right side. However, this finding diverges substantially from the observations of Sehgal et al. (2025), who, in a study of 203 arteries, identified variations specific to the LIPA in 62 vessels (30.77%), whereas the RIPA exhibited variations in 47 vessels (23.15%).

Given the complexity and breadth of origin variations for the IPAs, Marcinkowska et al. (2023) proposed a simplified classification system for clinical purposes, grouping origins into categories such as the hepatic arteries, the celiac trunk and its branches, the renal arteries, the abdominal aorta, the dorsal pancreatic artery, and the spermatic (gonadal) artery. This proposal is intended to facilitate the identification and management of these variations in surgical and radiological settings.

Moreover, the RIPA and LIPA may originate from a common trunk, rather than exclusively from independent origins. Studies have reported this common origin ranging from 11.33% to 31% [Greig et al., 1951; Loukas et al., 2005], indicating a significant prevalence of this configuration.

Recent reports continue to underscore the complexity of the origin of the IPAs. In the present study, we identified an uncommon configuration in which the RIPA and

the RISA originated from a PAT from the RRA. Moreover, different variations have been reported in the literature, such as the origin of the RIPA from hepato-splenic, hepato-gastric, and gastro-splenic trunks [Pavlov et al., 2024]; a hepato-spleno-mesenteric–phrenic trunk [Hogea et al., 2021]; and a gastro-phrenic trunk [Piao et al., 1998; Terayama et al., 2017]; in addition to a common trunk involving the RIPA, the RISA, and the right superior suprarenal artery, reported by Olewnik et al. (2018). In this context, the case reported here expands the spectrum of available data on the diversity of trunks related to the IPAs, confirming the coexistence of different vascular combinations and their practical relevance.

Recognition of variations in the origin of the IPAs is crucial for clinical practice and for the proper conduct of diagnostic and therapeutic procedures. Hong et al. (2006) reported that, in liver transplantation, the RIPA can be one of the main sources of postoperative hemorrhagic complications, accounting for up to 5% of observed events. In addition, the IPAs may be directly involved in the blood supply of HCCs. Tanabe et al. (1998), in studies of patients with HCC using selective IPA angiography, observed that in 14 of 126 cases (11%) analyzed, the carcinoma was supplied by the IPAs. Six of these tumors had an almost exclusive arterial supply from this source, particularly in hepatic segments I, IV, and VII.

This evidence is clinically relevant, as embolization for HCC is traditionally performed via the hepatic artery, often without considering the potential contribution of extrahepatic supply, such as that arising from the IPA. Marcinkowska et al. (2023) corroborate this relevance, highlighting that RIPA and LIPA account for more than half of the collaterals involved in the supply of extrahepatic hepatic malignancies, with the RIPA being most frequently implicated. This deeper understanding of variations is also essential for accurate diagnosis, using techniques such as magnetic resonance angiography (MRA) and multidetector computed tomography angiography (MDCTA), which allow detailed visualization of the IPAs prior to interventions. In this way, the present study expands knowledge regarding the complexity of the IPAs and supports clinical practice.

Conclusion

The identification of a common trunk between the RIPA and RISA represents an anatomical variation that is scarcely documented in the literature. This configuration underscores the relevance of up-to-date, in-depth knowledge of abdominal vascularization, given the inherent complexity of this region. Accordingly, the present case report contributes meaningfully to the understanding of the morphological diversity of the IPAs and emphasizes the need for their precise recognition in therapeutic, radiological, and surgical contexts, with the aim of optimizing intervention planning, minimizing risks, and improving clinical outcomes.

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CONFLICT OF INTERESTS

The authors declare no conflict of interests.

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