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BRIEF COMMUNICATION

A Rare Coeliacomesenteric Trunk Arising from the Aorta and a Hepatophrenic Trunk Giving Rise to an Accessory Left Hepatic Artery: Proposal of a New Classification System for Hepatic Arterial Variations

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Abstract

Accurate knowledge of hepatic arterial variation is essential for both surgical planning and interventional radiology. Although numerous classification systems describe these variations, exceptionally rare configurations continue to challenge existing models. This report presents an unusual vascular pattern in which an accessory left hepatic artery originates as a single trunk from both the celiacomesenteric trunk (CMT) and the aorta, accompanied by an inferior phrenic artery forming a hepatophrenic trunk (HPT). Based on this case, we propose an alternative key intended to enhance current hepatic artery classification systems. A 79-year-old Turkish male undergoing evaluation for hypertension was found to have an atypical hepatic arterial pattern on abdominal computed tomography (CT). Three-dimensional reconstruction using the Vitrea software enabled precise assessment of vessel dimensions and spatial relationships. Imaging revealed the simultaneous presence of a CMT and a HPT. The CMT directly originated the proper hepatic artery (PHA) without a common hepatic artery (CHA). The PHA then bifurcated into the right hepatic artery (RHA) and left hepatic artery (LHA), while the gastroduodenal artery (GDA) arose distal to it. Separately, the HPT emerged from the aorta and divided into the accessory left hepatic artery (aLHA) and the inferior phrenic artery (IPA). Comparison with previously reported cases highlights the exceptional nature of this combined variation. Rather than adapting it within current systems, we introduce a new hepatic artery variation key derived from this configuration, offering a more flexible framework for future anatomical and clinical applications.

Keywords Hepatic artery · Celiacomesenteric trunk · Hepatophrenic trunk · Anatomical variation · Computed tomography angiography · Arterial classification

Abbreviations

A	Anterior
AIDR	Adaptive Iterative Dose Reduction
AiCE	Advanced intelligent Clear-IQ Engine
aLHA	Accessory left hepatic artery
CeT	Celiac trunk
CHA	Common hepatic artery
CMT	Celiacomesenteric trunk
CT	Computed tomography
GDA	Gastroduodenal artery
HPT	Hepatophrenic trunk
I	Inferior
IPA	Inferior phrenic artery
L	Left
LGA	Left gastric artery
LHA	Left hepatic artery
MIP	Maximum intensity projections
P	Posterior
rLHA	Replaced left hepatic artery
rRHA	Replaced right hepatic artery
S	Superior

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SA	Splenic artery
SMA	Superior mesenteric artey

1 Introduction

Anatomical variations of the hepatic arterial system are frequently encountered in abdominal surgery and interventional radiology, making their recognition essential for preventing iatrogenic complications and improving procedural safety [1]. In the standard configuration, hepatic arterial inflow is supplied by the proper hepatic artery (PHA), which arises from the celiac trunk (CeT) [2]. Nevertheless, 10–45% of individuals display deviations from this classical pattern, underscoring the broad spectrum of documented hepatic arterial origins [3]. Among these, the most common variant is a right heptaic artery (RHA) stemming from the superior mesenteric artery (SMA), whereas a left heptaic artery (LHA) originating from the inferior phrenic artery (IPA) remains among the rarest anomalies [4–7].

Embryologically, such variations arise from the early vascular structure of the dorsal aorta. Four ventral segmental arteries initially supply the developing foregut, which later correspond to the left gastric artery (LGA), splenic artery (SA), common hepatic artery (CHA), and SMA [8, 9]. Hepatic arterial differentiation begins around the fifth week of gestation, with recognizable branches by the seventh week [10]. Development proceeds in concert with the portal venous system, which guides the maturation of the arterial network [11]. The definitive hepatic arterial anatomy emerges as three embryologic segments form: the left lateral segment develops into the LHA and originates from the LGA; the right lateral segment becomes the RHA; and the central segment forms the CHA and its associated branches [12]. Because these segments follow separate developmental pathways, considerable anatomic variation is expected in adulthood.

Normally, the CeT which supplies the liver, spleen, pancreas, and stomach and the SMA which perfuses much of the intestines arise independently from the abdominal aorta [6, 13, 14]. During development, the omphalomesenteric artery forms from four roots; typically, the second and third regress while the first and fourth persist and fuse longitudinally, forming an arterial precursor that becomes the LGA and later the CeT. A separate embryonic channel subsequently develops into the SMA. As a result, the CeT and SMA appear as distinct branches in standard adult anatomy [13].

Occasionally, this developmental pathway deviates. Persistence of the first and fourth roots with regression of the second and third may prevent separation of the CeT and SMA, producing a shared arterial origin known as the celiacomesenteric trunk (CMT). Although rare, this variant has been documented in 0.42–3.0% of individuals [13, 15]. Identifying such variants is clinically important: unrecognized deviations may complicate hepatobiliary and gastrointestinal surgery, as well as transarterial oncologic procedures [16].

CMT is a rare vascular variation, and its coexistence with additional anomalous trunks represents an even more exceptional anatomical configuration (13,15). In particular, the simultaneous presence of a hepato-phrenic trunk (HPT) together with an accessory hepatic arterial supply constitutes a highly uncommon variation that is scarcely documented in the literatüre (7). Such complex arterial organizations challenge conventional descriptions based on classical hepatic arterial anatomy and reveal the limitations of widely used classification systems, which are primarily designed for more common branching patterns. Therefore, the recognition and detailed characterization of these unusual combinations are essential not only for accurate anatomical interpretation but also for improving preoperative planning and endovascular interventions. These rare configurations may also indicate the need for a revised interpretative framework or an alternative classification approach capable of incorporating multi-trunk and hierarchically complex arterial patterns.

2 Brief Report

A 79-year-old Turkish male undergoing evaluation for hypertension was found to have an unexpected hepatic arterial variation during routine abdominal CT (Fig. 1). To clarify the vascular anatomy, abdominal aortic CT angiography was performed using a Canon Aquilion ONE/GENESIS Edition system (Canon Medical Systems, Otawara, Japan). This 640-slice scanner allows dynamic volume acquisition in a single rotation, with a minimum rotation time of 0.275 s. A biphasic helical protocol was applied after intravenous delivery of a non-ionic iodinated contrast medium (Ultravist 370, Bayer Schering Pharma AG, Germany; 370 mg iodine/mL), administered via an automated injector with bolus tracking to ensure optimal aortic enhancement.

Imaging parameters included Ultra Helical mode, collimation of 0.5 mm × 160 (or 0.5 mm × 320), tube voltage of 120 kVp, and tube current regulated by SUREExposure modulation. Data were reconstructed using Advanced intelligent Clear-IQ Engine (AiCE) deep-learning algorithms or Adaptive Iterative Dose Reduction (AIDR) 3D Enhanced, with slice thicknesses of 1.0 mm or 0.5 mm for detailed evaluation. Post-processing was performed on the Vitrea workstation to create multiplanar, MIP, and volume-rendered images.

The present report describes an exceptionally rare vascular constellation discovered incidentally during Computed Tomography (CT) imaging for hypertension, with no related pathology. The patient exhibited both a CMT and a

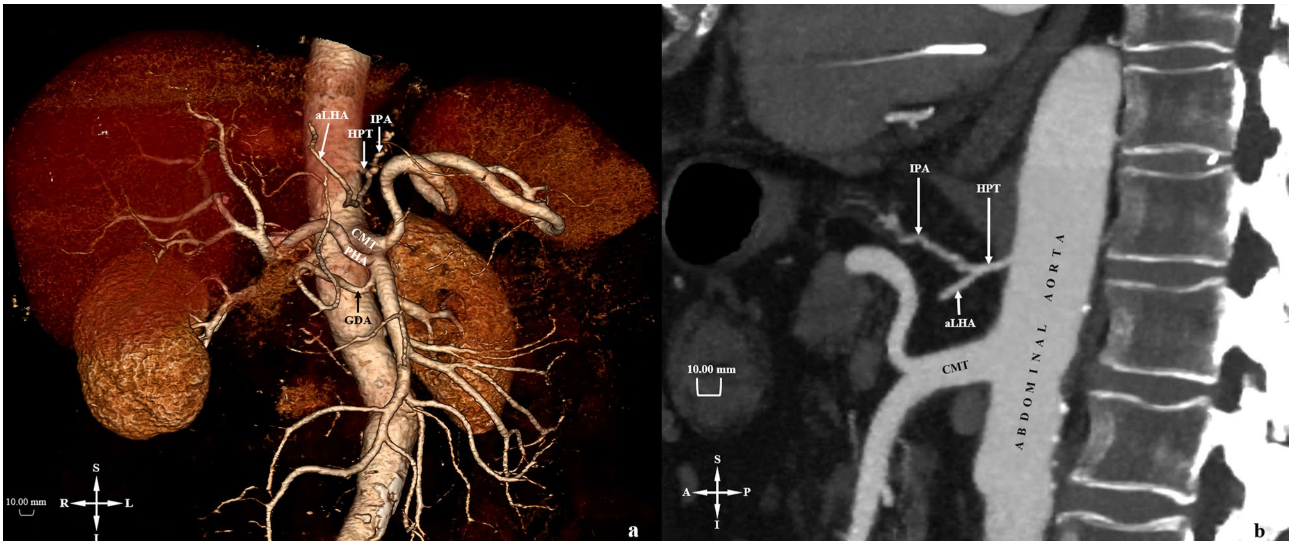

Fig. 1 **a** 3D image of hepatic artery variation on CT. **b** Sagittal plane image of hepatic artery variation on CT aLHA: Accessory left hepatic artery;A: Anterior CMT: Celiacomesenteric trunk;GDA: Gastroduodenal artery;HPT: Hepatophrenic trunk (aLHA and IPA);I: Inferior;IPA: Inferior phrenic artery;L: Left;P: Posterior;PHA: Proper hepatic artery;R: Right;S: Superior

hepato-phrenic trunk (HPT). The CMT originated directly from the abdominal aorta and continued as the PHA, with no CHA present. The PHA then divided into the RHA and LHA, while the GDA arose as the next branch from the CMT after the PHA. Independently, the HPT originated from the abdominal aorta and produced the accessory left hepatic artery (aLHA) and IPA. According to existing literature, the coexistence of a CMT and an aLHA originating from an HPT is extraordinarily uncommon.

Assessment of the arterial structures revealed a HPT arising in close proximity to a CMT (Fig. 1). The CMT originated at the L1 sublevel, forming a 66.7° angle and measuring 11.7 mm in diameter. The two trunks were separated by 21.7 mm. CHA was absent; instead, the vessel from the CMT continued as the PHA, which divided into the RHA and LHA. The GDA appeared as the subsequent branch from the CMT.

The HPT originated at the T12–L1 disc level, with a 62.1° angle and a 3.4 mm diameter. After a 12.1 mm course, it bifurcated into aLHA and IPA, measuring 2.7 mm and 1.9 mm in diameter, respectively.

This case underscores the need for meticulous vascular mapping before hepatobiliary or interventional procedures. Precise identification of atypical arterial patterns is essential to reduce complications and guide operative strategy. Moreover, the coexistence of these rare variations highlights limitations within current CRL and ex-CRL interpretive systems. By presenting a configuration not fully represented in existing schemes, this case supports the development of a more flexible and inclusive classification framework one that may improve anatomical interpretation, diagnostic accuracy, and procedural planning in future cases involving similarly complex hepatic arterial variants.

3 Discussion

3.1 CMT and HPT Dimensions

Published studies show considerable diversity in CMT morphology and spinal-level emergence Table 1). These discrepancies underscore the considerable heterogeneity in CMT anatomy. In our case, the CMT measured 11.7 mm at the lower L1 border, fitting within the range reported by Sohn et al. [17]. This measurement is slightly above the mean of Türkyılmaz et al. [15] but below the cadaveric value from Sheridan et al. [18]. Because Türkyılmaz et al. [15] reported population averages, our marginally higher single-case value remains acceptable. The larger diameter described by Sheridan et al. [18] may reflect individual or population-specific anatomy. The similarity between our findings and those of Singh [19] likely stems from comparable CT-based methods (Table 1).

The angle between the CMT and aorta was 66.7°, markedly greater than previously reported angles [19–21] (Table 1). This pronounced divergence likely reflects a distinctive developmental variant.

While literature describing the HPT is limited, Wu et al. [7] reported a 23 mm distance between the CeT and HPT. Our measured CMT–HPT distance of 21.7 mm is comparable, with minor differences likely attributable to the larger CMT diameter observed here.

Table 1 Morphological parameters of the CMT reported in the literature and findings from the present study

Parameters	Diameter	Vertebral level	Angle
Türkyılmaz et al. [15]	7.09 ± 1.27 mm	T12	
Sohn et al. [17]	8.7–13.4 mm	L1-L2	
Sheridan et al. [18]	1.3 cm		
Singh [19]		L1-L2/L1 upper	16°
Deshpande et al. [20]			13°
Saha et al. [21]			19°
Present study	11.77 mm	L1 lower	66.7°

CMT: Celiacomesenteric trunk

Although previous studies have reported a range of diameters and branching angles for the CMT, the morphometric differences observed in the present case are not merely numerical variations but may have important anatomical and procedural implications. A relatively larger trunk diameter may reflect altered embryological fusion patterns and can influence the distribution of blood flow between the hepatic and mesenteric territories [22]. Variations in the aorto-celiac branching angle have been shown to influence catheter shape selection and the technical success of selective cannulation during endovascular procedures, highlighting the procedural relevance of vascular geometry [23]. Detailed preoperative knowledge of celiac and hepatic arterial anatomy is crucial in hepatopancreatobiliary surgery, as vascular variations may alter the surgical approach, modify dissection planes, and increase the risk of inadvertent arterial injury. From a surgical perspective, these geometric features may change the exposure of the vascular pedicle and the orientation of dissection, particularly in hepatopancreatobiliary operations. Therefore, rather than representing isolated measurements, these morphometric findings should be interpreted as structural parameters that may alter both hemodynamic behavior and procedural strategy [24].

4 Branching Pattern

The hepatic arterial network encompasses a broad array of clinically significant variations. Haller's 1756 description of the CeT and its "Tripus Halleri" trifurcation into the LGA, SA, and CHA remains foundational and represents

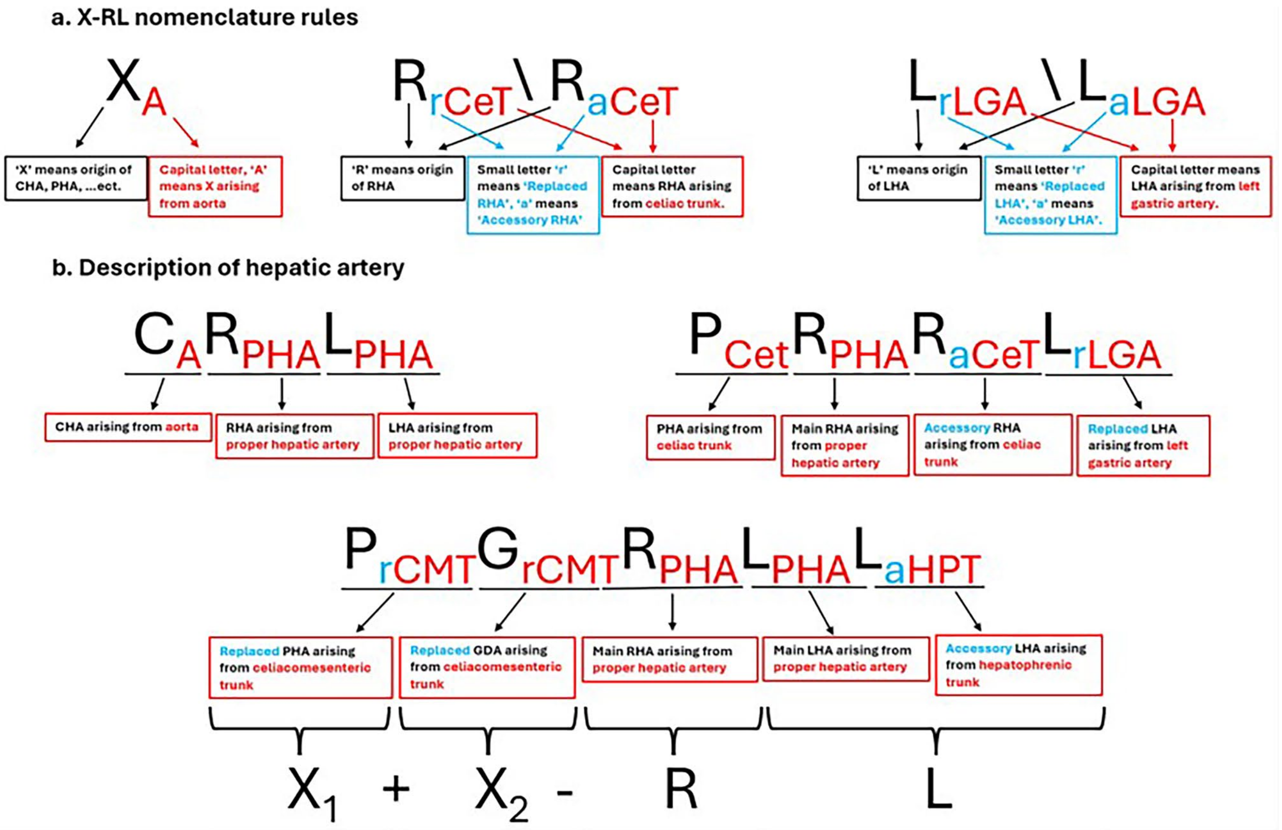

Fig. 2 Nomenclature rules of the X-RL classification system and examples of hepatic artery description based on this system. **a.** X-RL nomenclature rules. **b.** Description of hepatic artery

Table 2 New classification system of the hepatic artery variation

Label	Description
X (X_)	Origin of X, main trunk (CHA, PHA, …etc.)
X_{CeT} (Normal anatomy)	X arises from CeT
X_{rA}/X_{aA} (replaced/accessory)	X arises from aorta
X_{rCMT}/X_{aCMT} (replaced/accessory)	X arises from CMT
X_{rSMA}/X_{aSMA} (replaced/accessory)	X arises from SMA
X_{rO}/X_{aO} (replaced/accessory)	X arises from other artery
RHA (R_)	Origin of RHA
R_{PHA} (Normal anatomy)	RHA from PHA
R_{rCHA}/R_{aCHA} (replaced/accessory)	RHA from CHA
R_{rA}/R_{aA} (replaced/accessory)	rRHA/aRHA from aorta
R_{rCeT}/R_{aCeT} (replaced/accessory)	rRHA/aRHA from CeT
R_{rGDA}/R_{aGDA} (replaced/accessory)	rRHA/aRHA from GDA
R_{rSMA}/R_{aSMA} (replaced/accessory)	rRHA/aRHA from SMA
R_{rO}/R_{aO} (replaced/accessory)	rRHA/aRHA from other artery
LHA (L_)	Origin of LHA
L_{PHA} (Normal anatomy)	LHA from PHA
L_{rCHA}/L_{aCHA} (replaced/accessory)	LHA from CHA
L_{rGDA}/L_{aGDA} (replaced/accessory)	rLHA/aLHA from GDA
L_{rLGA}/L_{aLGA} (replaced/accessory)	rLHA/aLHA from LGA
L_{rO}/L_{aO} (replaced/accessory)	rLHA/aLHA from other artery

CeT: Celiac trunk;CHA: Common hepatic artery;CMT: Celiacomesenteric trunk;GDA: Gastroduodenal artery;LGA: Left gastric artery;LHA: Left hepatic artery;PHA: Proper hepatic artery;RHA: Right hepatic artery;SMA: Superior mesenteric artery

the most common branching pattern, occurring in 60–90% of cases [25, 26]. Later work by Lipshutz (1917) [27], Adachi (1928) [28], and Morita (1935) [29] introduced earlier classification systems for CeT variations. Michels' seminal 1966 classification organized hepatic arterial variations into ten types based on the presence of "replaced" and "accessory" hepatic arteries [30]. Hiatt et al. (1994) [31] subsequently condensed the scheme to six types for clinical usability, and Abdullah et al. (2006) [32] later streamlined it further into three main categories. Yan et al. (2020) [33] introduced the CRL system, based on 3D CT angiographic reconstructions, defining nine subtypes and demonstrating nearly complete classification coverage. Finally, in a meta-analysis on variations in the hepatic arterial system, Balcerzak et al. (2026) compared studies according to the Michels and Hiatt classifications and reported some unclassifiable cases [34].

In Michels' framework, the aLHA is included in Type V and Type VII, neither of which accommodates a CMT [30]. Similarly, Hiatt's Types II and IV acknowledge aLHA or rLHA variants but do not address CMT [31]. Abdullah et al.'s classifications describe variations involving aLHA and LGA but omit CMT [32]. Yan et al.'s Type V includes aLHA variations arising from multiple sources, but again does not represent the combined presence of an HPT and CMT [33]. In the meta-analysis conducted by Balcerzak et al., variations in the hepatic arterial system were evaluated based on the Michels and Hiatt classifications. Therefore, no cases matching the variation pattern described in our case were found in this study. Furthermore, the complex variations reported by the authors under the heading "unclassified" variations, namely the origin of the entire hepatic arterial system from the abdominal aorta via the CHA and the simultaneous origin of the aLHA from the LGA and the rRHA from the SMA, do not show any anatomical similarities with our findings [34].

Yan et al. introduced notation systems for CHA, RHA, and LHA origins (C_, R_, L_), with subscript modifiers (CA, C_S, C_L, C_O, etc.) indicating origin [30]. Applying this system to our case reveals limitations: absence of a CHA and direct origin of both RHA and LHA from the PHA render the CRL model insufficient. We propose introducing "P" to denote PHA as an origin category (e.g., P_A, P_S), allowing temporary classification but highlighting the need for expanded frameworks. The CRL system's Type 5o (CRL_{aO}) and Type 9o (C_ORL) theoretically include some "other" origins but were not observed in their dataset [33]. Remaining ambiguities especially in representing unconventional origins underscore the value of a key-based rather than type-based model. This allows the researcher take a look at the variation key and mentally construct the branching from the artery's exit point.

Our proposed X-RL key enables accurate reconstruction of branching sequences. Furthermore, the X-RL key can also be in the form of $X_1 + X_2 \ldots X_n$-RL. An example of this situation is indicated in our case. Accordingly, the present case is expressed as $P_{rCMT}G_{rCMT}R_{PHA}L_{PHA}L_{aHPT}$ (Fig. 2) (Table 2). According to this classification key, PHA arises from CMT in a replaced manner (P_{rCMT}), GDA also originates from CMT in a replaced manner (G_{rCMT}), RHA and LHA branch from PHA ($R_{PHA}L_{PHA}$), while an accessory LHA arises seperately from HPT (L_{aAHPT}) (Fig. 2).

Overall, the variations observed here exceed the boundaries of existing classification systems. Nonetheless, individual components have known precedents. Uflacker [35] listed the CMT as Type VI (< 1% prevalence), and Tubbs et al. [36] as Type V (1%–2%). The combination of aLHA with IPA is also extremely rare [5, 7, 37]. Covey et al., indicated in the table section of their study that aLHA originates from RIPA without a detailed explanation of the origin of this variation in the results section [37]. This makes it difficult to clearly assess the source of this difference in the literature. However, our case is exceptional because the HPT originates directly from the aorta, a pattern documented only once previously by [7]. Their cadaveric study described two aLHA branches, but functional considerations suggest that the CHA-origin branch represents rLHA and the HPT-origin branch an aLHA [35, 38]. Our in vivo imaging, combined with the simultaneous CMT variant, produces a configuration distinct from all previously reported examples.

The rarity of HPT variants likely reflects their very low prevalence and the limitations of earlier 2D imaging [7]. Three-dimensional reconstruction enabled precise visualization of small vessels, facilitating accurate identification. Because such subtle branches can be easily overlooked, recognizing them is crucial to preventing ischemic complications during hepatobiliary or interventional procedures. Early detection improves planning and enhances patient outcomes.

5 Conclusion

The concurrent presence of a CMT and an HPT, each supplying major hepatic branches, represents an exceptionally rare arterial pattern not captured by existing classification systems. Three-dimensional imaging enabled clear delineation of their origins, branching sequences, and spatial relationships, underscoring the value of advanced reconstruction for identifying subtle yet clinically important variations. Recognizing such configurations is crucial for surgical and interventional safety, as unexpected arterial anatomy may increase the risk of ischemia or inadvertent injury.

Comparison with published classifications including those of Michels, Hiatt et al., Abdullah et al., and the CRL model reveals significant limitations in accommodating complex patterns. The key-based naming system proposed here provides a more flexible and descriptive alternative for documenting atypical hepatic arterial anatomy. This case highlights the importance of meticulous vascular assessment and contributes to ongoing efforts to refine hepatic arterial classification frameworks.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s44411-026-00562-w.

Author Contributions CB and OC conceived and designed the study. OC and NK were responsible for data collection and acquisition. CB and OC contributed to data management and interpretation. CB and NK analyzed the data. NK participated in figure design and photographs. CB, OC and NK participated in drafting the article, critically revising it for important intellectual content, and writing the manuscript. All authors have given final approval of the version to be submitted.

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Data Availability No datasets were generated or analysed during the current study.

Declarations

Conflict of interest The authors declare no competing interests.

Ethical Approval All procedures conducted in this study involving human participants adhered to the ethical standards and were in accordance with the 1964 Helsinki Declaration and its subsequent amendments or comparable ethical standards. Formal consent was not required for this study.

Consent to Publish All authors consent for publication

Consent to Participate Not applicable.

Informed Consent Informed consent was obtained from the patient prior to radiological imaging.

Statement Regarding Research Involving Human Participants and/or Animals Not applicable.

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