Section: Anatomy

Original Research Article

RADIOLOGICAL ANALYSIS OF HEPATIC ARTERY VARIATIONS BASED ON MICHEL'S CLASSIFICATION

Pallavi[1], Antony Sylvan D'souza[2], Ravi Bhaskar[3]

[1]Associate Professor, Department of Anatomy, Father Muller Medical College, Mangalore, India
[2]Professor, Department of Anatomy, Father Muller Medical College, Mangalore, India
[3]Professor, Department of Anatomy, Sri Siddartha Medical College, SSAHE, Tumkur, Karnataka, India.

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Corresponding Author:
Dr. Pallavi,
Email: pallavi84ravi@gmail.com

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ABSTRACT

Background: Hepatic artery variations are common and clinically significant, with reported prevalence ranging from 19.7% to 49%. These anatomical variations play a crucial role in hepatobiliary surgeries, liver transplantation, and interventional radiology, where unrecognized anomalies may lead to serious complications such as vascular injury or graft failure. Michel's classification provides a standardized framework to categorize these variations. This study aimed to evaluate the incidence and pattern of hepatic artery variations using multidetector computed tomography (MDCT) angiography. **Materials and Methods:** A cross-sectional study was conducted on 200 patients aged 18–80 years who underwent abdominal MDCT angiography over a period of two years. Patients with prior hepatic surgery or poor image quality were excluded. Imaging was performed using a 64-slice MDCT scanner with a standardized triple-phase protocol. Hepatic arterial anatomy was analysed using multiplanar reconstructions, maximum intensity projection (MIP), and volume rendering techniques (VRT). Variations were classified according to Michel's 10-type classification system, and data were analysed using SPSS software. **Results:** Normal hepatic arterial anatomy (Michel Type I) was observed in 64.5% of cases, while 35.5% showed variations. The most common variant was Type III (replaced right hepatic artery by the superior mesenteric artery), seen in 8.5% of cases, followed by Type II (replaced left hepatic artery by the left gastric artery) in 7.5%. Other variants, such as Types V and VI, were less frequent. Rare patterns such as Types IV, VII, and IX, were observed in a small proportion, while Types VIII and X were not identified. Additionally, 11% of cases demonstrated variations not included in Michel's classification. **Conclusion:** Hepatic artery variations are relatively common, with a significant proportion deviating from classical anatomy. MDCT angiography serves as a reliable, non-invasive modality for accurate preoperative vascular mapping. Recognition and classification of these variations using Michel's system are essential to minimize surgical complications and improve outcomes in hepatobiliary and transplant procedures.

INTRODUCTION

Anatomical variations of the hepatic artery are both prevalent and intricate, occurring in 19.7% to 49% of individuals.[1,2] These anomalies significantly influence hepatobiliary surgeries, liver transplantation, and endovascular interventions, where unrecognized variants can lead to iatrogenic injury, hepatic ischemia, or even graft failure.[3,4] Preoperative delineation is thus imperative, with non-invasive imaging modalities like multi-detector computed tomography (MDCT), computed tomography angiography (CTA), and magnetic resonance angiography (MRA) offering superior spatial resolution and diagnostic accuracy over conventional catheter angiography.[5,6]

To facilitate consistent reporting, Michel's classification—first proposed in 1966—categorises these variations into 10 types based on the origin and branching of replaced or accessory hepatic arteries,

most commonly from the superior mesenteric artery, left gastric artery, or gastroduodenal artery.[7] Types I through III represent the most frequent patterns (combined prevalence ~80%), while rarer types (IV–X) demand heightened vigilance due to their complexity.[8] This study aimed to determine the incidence and frequency of hepatic artery branching patterns in our population using MDCT angiography and to classify them systematically per Michel's 10-type framework.

MATERIALS AND METHODS

This cross-sectional study analysed multi-detector computed tomography (MDCT) angiography images from 200 consecutive patients aged 18-80 years who underwent abdominal aorta imaging for various clinical indications in a period of two years. Patients with prior hepatic surgery, vascular interventions, or motion artefacts compromising image quality were excluded.[2]

Imaging was performed using a 64-slice Philips Brilliance MDCT scanner (Philips Healthcare, Best, Netherlands) with a standardised triple-phase protocol (non-contrast, arterial, and portal venous phases). Arterial phase images were acquired following intravenous administration of 100-120 mL non-ionic iodinated contrast (350 mgI/mL) at 4-5 mL/sec via an 18-gauge antecubital cannula, with automated bolus tracking at the descending aorta (threshold: 150 HU; delay: 8 sec). Scan parameters included 120 kVp, 250 mAs, 1.5 mm collimation, 1.4 mm reconstruction interval, and pitch of 1.3.[1]

Post-processing utilised Philips Brilliance Workspace portal (v.4.5). Maximum intensity projection (MIP) reformations in coronal, sagittal, and oblique planes were generated from arterial phase source images to produce digital subtraction angiography (DSA)-like visualisation of distal branches. Volume rendering technique (VRT) reconstructions provided 3D vascular maps for optimal spatial assessment of the celiac axis, common hepatic artery (CHA), proper hepatic artery, right hepatic artery (RHA), and left hepatic artery (LHA).[2]

The hepatic artery origin, course, branching patterns, and replacement/accessory vessels were observed and noted with the radiologist's assistance. Variations were systematically classified according to Michel's 10-type system. (3) Interobserver discrepancies were resolved by consensus reading. Data were recorded in a structured proforma and analysed using SPSS v.25.0.

RESULTS

Table 1: Showing the details of variations

Type of Variation	Description of the variation	No. of cases (n=200)	Percentage
Type I	Normal anatomy	129	64.5%
Type II	Replaced LHA from the LGA	15	7.5%
Type III	Replaced RHA from the SMA	17	8.5%
Type IV	Replaced RHA and LHA	2	1%
Type V	Accessory LHA from the LGA	7	3.5%
Type VI	Accessory RHA from the SMA	4	2%
Type VII	Accessory RHA and LHA	1	0.5%
Type VIII	Replaced RHA and accessory LHA or replaced LHA and accessory RHA	0	0.0%
Type IX	Replaced CHA from the SMA	3	1.5%
Type X	Replaced CHA from the LGA	0	0.0%
NOD	Other types of variation	22	11%

Table 2: Statistical summary

Test	Comparison	Test statistic
Overall Distribution (χ^2)	Types I–X + NOD vs equal frequencies	$\chi^2 = 774.49$, df = 10**
Normal vs Variants (binomial)	**Type I (129) vs all variants (71)	n = 200, p_0 = 0.5**

Data expressed in *p<0.05, ** p<0.01 in comparison to normal control

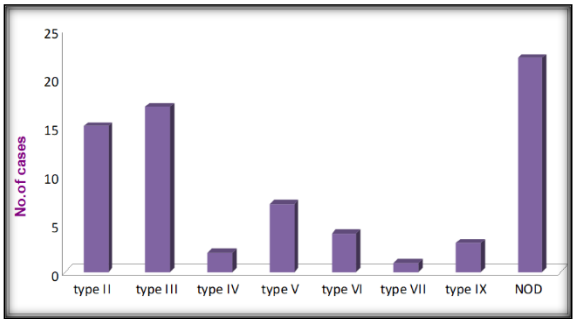

Figure 1: The distribution of hepatic arterial anatomy types

The distribution of hepatic arterial anatomy types differed highly significant from a uniform distribution ($\chi^2 = 774.49$, df = 10. Normal anatomy (Type I) was present in 64.5% of cases and was significantly more frequent than variant anatomy (129 vs 71; binomial test vs 50%:

The Data related to Hepatic arterial has been depicted in Table 1. Hepatic arterial anatomy conformed to Michel type I (normal pattern) in 129 of 200 cases (64.5%). Among the remaining 71 cases (35.5%), at least one variation from the classic pattern was identified.

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Michel type III, characterised by a replaced right hepatic artery arising from the superior mesenteric artery, was the most frequent variant, observed in 17 cases (8.5%). This was followed by type II, with a replaced left hepatic artery originating from the left gastric artery, seen in 15 cases (7.5%). Type V (accessory left hepatic artery from the left gastric artery) and type VI (accessory right hepatic artery from the superior mesenteric artery) were less common, being identified in 7 (3.5%) and 4 (2%) cases, respectively. Type IX, in which the common hepatic artery arises from the superior mesenteric artery, was documented in 3 cases (1.5%). Rare patterns included type IV (replaced right and left hepatic arteries) in 2 cases (1%) and type VII (accessory right and left hepatic arteries) in a single case (0.5%). No examples of Michel type VIII or type X were encountered in this cohort.

In addition, trifurcation of the common hepatic artery into the right hepatic, left hepatic, and gastroduodenal arteries was noted in 13 cases; these were considered a normal anatomical variant and were grouped under Michel type I. A further 22 cases (11%) demonstrated 15 distinct patterns that were not encompassed within the original Michel classification; these were collectively categorised as "not otherwise described" (NOD).

Figure showing the variations of the hepatic artery as described in Michels' classification

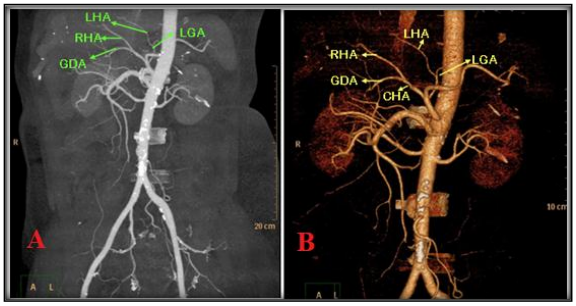


Figure 2: Coronal MIP image (a) and 3D reconstruced image (b) from CT angiographic data showing Type II of Michels' classification with replaced LHA arising from the LGA and the CHA dividing into the RHA and GDA

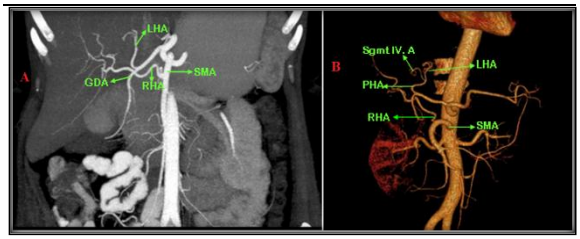


Figure 3: coronal and 3D reconstructed MIP CT angiograms demonstrating Type III with replaced RHA arising from the SMA and the CHA dividing into the LHA and the GDA

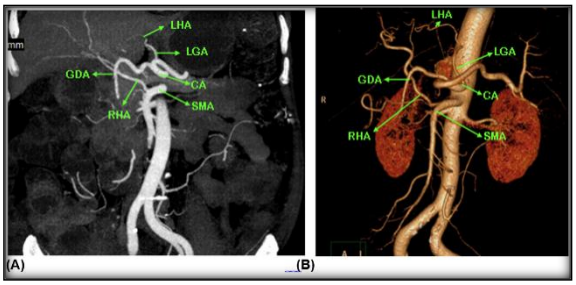


Figure 4: MIP CT angiogram of abdominal aorta showing coronal view (A) and 3D reconstruction (B) of Type IV with replaced RHA arising from the SMA along with replaced LHA from the LGA.

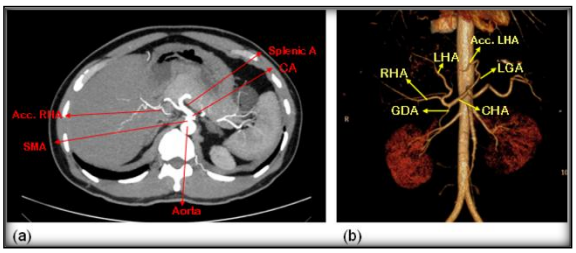
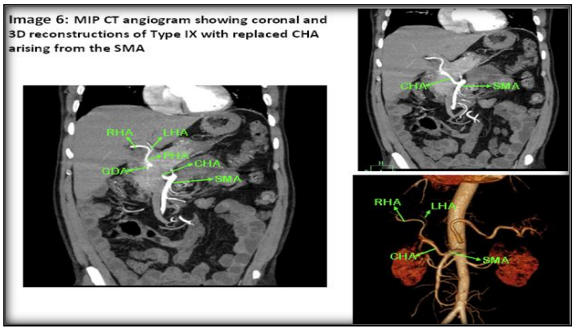


Figure 5: MIP CT angiograms of abdominal aorta showing axial view of Type VI with accessory RHA from the SMA (a) and 3D reconstructed image of Type V showing accessory LHA from the LGA (b)



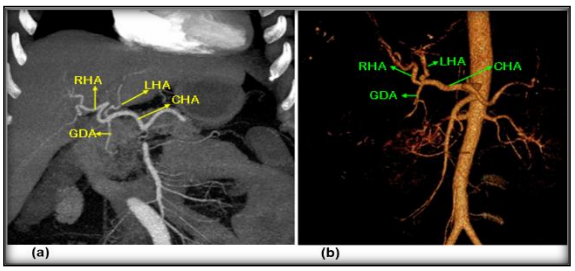


Figure 7: Coronal MIP image (a) and 3D reconstructed image (b) of CT angiographic data demonstrating Trifurcation of the CHA into the RHA, LHA and GDA

DISCUSSION

The variation of the hepatic artery has been investigated extensively in cadaveric series, in donor livers harvested for transplantation, and in vivo using catheter angiography and multidetector CT (MDCT) angiography, with Michel's 10-type classification remaining the most widely adopted framework for describing these patterns.[1] In our cohort, classic type I anatomy was present in 64.5% of cases, a value that lies within the broad range reported in large imaging and transplant series, where the prevalence of normal

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anatomy has varied from approximately 52% to more than 80%.[2,9–12] Such heterogeneity reflects differences in study design, imaging protocol, and population characteristics, but consistently confirms that non-classic hepatic arterial configurations are not uncommon.[1,2] Across most contemporary MDCT and surgical studies, Michel type III—defined by a replaced right hepatic artery arising from the superior mesenteric artery—emerges as the most frequent variant, with reported rates typically in the range of 6–12% and occasionally higher in selected cohorts.[1,2] The 8.5% frequency observed in our series is therefore broadly concordant with these prior data and reinforces the clinical relevance of this pattern. Because the replaced right hepatic artery is often the principal arterial supply to the right liver and extrahepatic bile duct, its presence has important implications in living donor liver transplantation and major hepatobiliary surgery, frequently necessitating additional dissection and tailored arterial reconstruction in both donors and recipients. [1,13]

In our material, type II (replaced left hepatic artery from the left gastric artery) was the second most common variant (7.5%), which is comparable to the 7–10% prevalence reported in some MDCT and transplant series, albeit higher than the very low rates described in others.[9–12] Type V (accessory left hepatic artery from the left gastric artery) ranked third (3.5%), again within the spectrum reported by large imaging cohorts, where accessory left hepatic arteries account for a substantial proportion of non-classic patterns.[9–11] Variants involving the left gastric artery (types II and V) are especially important during recipient hepatectomy and gastric or oesophageal surgery, as unrecognised branches may be inadvertently ligated at their origin, while they are usually less critical in living donors when the left lobe is not procured.[12,13]

The remaining Michel types (IV, VI, VII, VIII, IX, and X) were infrequent in our study, each accounting for only a small proportion of cases, in agreement with prior MDCT and transplant literature in which individual rare types generally occur in fewer than 3% of patients and some patterns (particularly type X) are absent altogether or documented only sporadically.[9–12] More complex configurations, such as types IV, VII, and VIII with multiple replaced or accessory hepatic arteries, often mandate multiple arterial anastomoses and have been associated with increased technical difficulty and a higher risk of hepatic arterial thrombosis or ischemic biliary complications after transplantation. Type IX, characterised by a common hepatic artery arising from the superior mesenteric artery, may require modification of the usual sequence of vascular reconstruction, whereas types II and III can be advantageous in split-liver and right-lobe graft procedures because their long, independent trunks are well-suited for arterial anastomosis.[12,14]

Overall, discrepancies in the reported incidence and distribution of Michel types among different series are likely attributable to variations in sample size, demographic composition, imaging resolution, and classification criteria, as well as to differences between cadaveric, transplant, and purely radiological cohorts. Nonetheless, the recurring observation across studies that approximately one-quarter to one-third of individuals exhibit non-classic hepatic arterial anatomy underscores the need for meticulous preoperative vascular mapping, particularly with high-quality MDCT angiography, to anticipate arterial anomalies and optimise surgical and interventional planning in hepato-pancreatobiliary practice.

CONCLUSION

Radiological characterisation of hepatic artery variations using Michel's classification remains a critical prerequisite for safe and effective hepatobiliary and transplant surgery, as it underpins preoperative planning and intraoperative decision-making. Advances in deep convolutional neural networks and radiology-oriented foundation models are now opening promising avenues to automate and standardise the interpretation of complex vascular anatomy on CT and MR angiography. By systematically addressing the limitations of traditional, manual image assessment, the proposed conceptual framework has the potential to support accurate three-dimensional vascular mapping and computer-aided diagnosis, thereby enhancing both efficiency and diagnostic confidence in routine clinical practice.[15]

REFERENCES

1. Noussios G, Dimitriou I, Chatzis I, Katsourakis A. The Main Anatomic Variations of the Hepatic Artery and Their Importance in Surgical Practice: Review of the Literature. J Clin Med Res. 2017;9(4):248–52.
2. Prabhasavat K, Homgade C. Variation of hepatic artery by 3-D reconstruction MDCT scan of liver in Siriraj Hospital. J Med Assoc Thai. 2008 Nov;91(11):1748–53.
3. Yassine EL Bouazizi, Mohamed Bouzroud, Mohamed Lamghari, Hakim Elkaoui, Nabil Mouatassim Billah, Amine Benkabbou, et al. Surgical implications of anatomical variations in hepatic arteries. World Journal of Advanced Research and Reviews. 2023 Aug 30;19(2):884–93.
4. Kayahan Ulu EM, Coskun M, Ozbek O, Tutar NU, Ozturk A, Aytekin C, et al. Accuracy of Multidetector Computed Tomographic Angiography for Detecting Hepatic Artery Complications After Liver Transplantation. Transplant Proc. 2007 Dec;39(10):3239–44.
5. Sahani D, Saini S, Pena C, Nichols S, Prasad SR, Hahn PF, et al. Using Multidetector CT for Preoperative Vascular Evaluation of Liver Neoplasms: Technique and Results. American Journal of Roentgenology. 2002 Jul;179(1):53–9.
6. Löschner C, Nagel S, Kausche S, Teichgräber U. Hepatic Arterial Supply in 1297 CT-Angiographies. RöFo - Fortschritte auf dem Gebiet der Röntgenstrahlen und der bildgebenden Verfahren. 2015 Jan 29;187(04):276–82.
7. Wu X, Kang J, Liu Y, Sun G, Shi Y, Niu J. A rare hepatic artery variant reporting and a new classification. Front Surg. 2022; 9:1003350.
8. Hiatt JR, Gabbay J, Busuttil RW. Surgical anatomy of the hepatic arteries in 1000 cases. Ann Surg. 1994 Jul;220(1):50–2.
9. Ugurel MS, Battal B, Bozlar U, Nural MS, Tasar M, Ors F, et al. Anatomical variations of hepatic arterial system, coeliac

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trunk and renal arteries: an analysis with multidetector CT angiography. Br J Radiol. 2010 Aug;83(992):661–7.
10. Zaki SM, Abdelmaksoud AHK, Khaled BEA, Abdel Kader IA. Anatomical variations of hepatic artery using the multidetector computed tomography angiography. Folia Morphol (Warsz). 2020 Jun 2;79(2):247–54.
11. Bolintineanu Ghenciu LA, Bolintineanu SL, Iacob R, Stoicescu ER, Zahoi DE. Hepatic arterial variations detected at multidetector computed tomography angiography in the Romanian population. Folia Morphol (Warsz). 2023 Jul 26.
12. López-Andújar R, Moya A, Montalvá E, Berenguer M, De Juan M, San Juan F, et al. Lessons Learned from Anatomic Variants of the Hepatic Artery in 1,081 Transplanted Livers. Liver Transplantation. 2007 Oct;13(10):1401–4.
13. Erbay N, Raptopoulos V, Pomfret EA, Kamel IR, Kruskal JB. Living Donor Liver Transplantation in Adults: Vascular Variants Important in Surgical Planning for Donors and Recipients. American Journal of Roentgenology. 2003 Jul;181(1):109–14.
14. Samuolyte A, Luksaite-Lukste R, Kvietkauskas M. Anatomical variations of hepatic arteries: implications for clinical practice. Front Surg. 2025; 12:1593800.
15. He Y, Yu H, Liu X, Yang Z, Sun W, Anwar S, et al. Deep learning-based 3D segmentation in computer vision: A survey. Information Fusion. 2025 Mar; 115:102722.

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