International Journal of Medical and Pharmaceutical Research

Online ISSN-2958-3683 | Print ISSN-2958-3675
Frequency: Bi-Monthly
Available online on: https://ijmpr.in/

Original Article

Anatomical Variations of Hepatic Artery and Their Surgical Significance in Hepatobiliary Procedures

Dr. Syed Imran Sultan[1], Dr. S. Naziya Parveen[2], Dr. Bushra Shazmeen[3]

[1]Associate Professor, Department of Anatomy, Parbhani Medical College, Parbhani
[2]Associate Professor, Department of Anatomy, Mahavir Institute of Medical Sciences, Vikarabad
[3]Assistant Professor, Department of General Surgery, Dr. Shankarrao Chavan GMC Nanded

Corresponding Author:

Dr. Bushra Shazmeen
Assistant Professor, Department of General Surgery, Dr. Shankarrao Chavan GMC Nanded
Email-
bushra.shazmeen@gmail.com

Received: 20-04-2026
Accepted: 10-05-2026
Available online: 26-05-2026

ABSTRACT

Background: Anatomical variations of the hepatic artery are frequently encountered during hepatobiliary surgeries, liver transplantation, pancreatic resections, and interventional radiological procedures. Knowledge of these variations is essential to avoid vascular injury, hepatic ischemia, biliary complications, and operative morbidity. Variations in hepatic arterial anatomy mainly arise due to developmental alterations in embryonic ventral splanchnic arteries. Accurate identification of these patterns is therefore important for anatomists, radiologists, and hepatobiliary surgeons. Aim: To study the anatomical variations of the hepatic artery and evaluate their surgical significance in hepatobiliary procedures. **Methods**: This descriptive observational study was conducted on 40 adult cadavers and 100 radiological reports to evaluate anatomical variations of the hepatic artery and their surgical significance. Cadaveric dissections of the hepatobiliary region were performed to identify hepatic arterial branching patterns. Variations involving common, proper, right, left, accessory, and replaced hepatic arteries were documented and classified according to Michels and Hiatt classifications. Data were analysed using frequencies and percentages and correlated with their embryological and clinical significance in hepatobiliary and pancreatic procedures. **Results**: The present study evaluated hepatic arterial anatomy in 40 cadavers and 100 radiological reports. Normal hepatic arterial anatomy was observed in 67.5% of cadaveric cases and 68% of radiological cases, while anatomical variations were identified in 32.5% and 32% respectively. The most common variation was replaced right hepatic artery arising from the superior mesenteric artery, followed by replaced left hepatic artery originating from the left gastric artery. Radiological evaluation using CT angiographic findings effectively demonstrated hepatic arterial branching patterns and vascular anomalies. These variations possess significant surgical importance in liver transplantation, pancreatic surgeries, laparoscopic cholecystectomy, and interventional radiological procedures. **Conclusion**: Hepatic arterial variations are common and possess significant surgical importance. Preoperative identification of vascular anatomy is essential for safe hepatobiliary surgical planning and prevention of intraoperative complications.

Keywords: *Anatomical Variations, Hepatic artery.*

INTRODUCTION

The liver receives a dual blood supply from the portal vein and the hepatic arterial system. Although the portal vein contributes nearly 75% of hepatic blood flow, the hepatic artery provides the major oxygenated supply to the liver and biliary apparatus. Variations in hepatic arterial anatomy are common and possess immense importance in hepatobiliary surgery, liver transplantation, laparoscopic procedures, pancreatic resections, and interventional radiology. [1,2] Accurate

knowledge of these vascular variations is therefore essential to prevent inadvertent vascular injury, hepatic ischemia, biliary necrosis, excessive haemorrhage, and postoperative complications. [3]

Classically, the common hepatic artery arises from the celiac trunk and continues as the proper hepatic artery after giving off the gastroduodenal artery. The proper hepatic artery further divides into right and left hepatic arteries supplying the respective lobes of the liver. However, numerous anatomical variations involving replaced or accessory hepatic arteries have been documented in cadaveric and radiological studies. [4] These variations are primarily attributed to the complex embryological development of the ventral splanchnic arteries and persistence of embryonic vascular channels. [5]

The most widely accepted classifications of hepatic arterial anatomy are those proposed by Michels and Hiatt. Michels described ten major patterns of hepatic arterial branching based on cadaveric dissections, while Hiatt later simplified these into six categories using angiographic observations. [6,7] Studies have demonstrated that normal hepatic arterial anatomy is present in approximately 55–80% of individuals, whereas the remaining population exhibits variable arterial patterns. [8]

Among the commonly encountered variations, a replaced right hepatic artery arising from the superior mesenteric artery and a replaced left hepatic artery arising from the left gastric artery are of major surgical concern. During pancreaticoduodenectomy, cholecystectomy, liver transplantation, and hepatic resections, unrecognized aberrant arteries may lead to severe intraoperative bleeding or ischemic complications. [9,10] Similarly, in liver transplantation, preservation of arterial inflow is critical for graft survival and prevention of biliary strictures. [11]

With advances in multidetector computed tomography angiography (MDCTA) and digital subtraction angiography, preoperative identification of hepatic arterial variants has become increasingly reliable. Modern imaging techniques facilitate detailed vascular mapping and aid surgeons in operative planning, thereby reducing perioperative morbidity and mortality. [12,13] Knowledge of hepatic arterial variations is also valuable for anatomists, radiologists & oncologic surgeons dealing with hepatopancreatobiliary malignancies and minimally invasive procedures. [14]

Despite numerous international studies, variations in hepatic arterial anatomy may differ among populations and ethnic groups. Therefore, region-specific anatomical studies remain relevant for improving surgical safety and enhancing anatomical understanding. The present study is undertaken to evaluate the pattern and frequency of hepatic arterial variations and to analyse their surgical significance in hepatobiliary procedures.

METHODOLOGY

This descriptive observational study was conducted in the Department of Anatomy of a tertiary care medical college over a specified study period after obtaining approval from the Institutional Ethics Committee. The study was undertaken to evaluate the anatomical variations of the hepatic artery and assess their surgical significance in hepatobiliary procedures. A total of 40 adult human cadavers and 100 radiological reports were included in the study.

The cadaveric component of the study was carried out on 40 well-preserved adult cadavers available in the anatomy dissection hall. Cadavers with intact hepatobiliary vascular anatomy and properly preserved abdominal viscera were included in the study. Cadavers showing evidence of abdominal trauma, previous abdominal surgeries, congenital malformations, distorted vascular anatomy, or pathological destruction were excluded. Detailed dissection of the hepatobiliary region was performed according to standard anatomical dissection procedures. The abdominal cavity was opened carefully, and the celiac trunk along with the common hepatic artery, proper hepatic artery, right hepatic artery, left hepatic artery, gastroduodenal artery, and accessory or replaced hepatic arteries were identified and traced up to their intrahepatic distribution. The origin, course, branching pattern, and anatomical relations of hepatic arteries were meticulously observed and documented.

In addition to cadaveric dissection, 100 radiological reports including CT angiography and abdominal angiographic studies demonstrating hepatic arterial branching patterns were reviewed from the Department of Radiodiagnosis. The radiological component of the study was conducted in the Department of Radiodiagnosis using 100 CECT angiography and MDCT angiographic reports of the abdomen. Radiological studies with clear visualization of hepatic arterial anatomy were included, while poor-quality scans and cases with distorted vascular anatomy were excluded. CT angiographic evaluation was performed after intravenous contrast administration using multidetector CT scanners. Projection images were analysed to identify the origin, course, branching pattern, and variations of the hepatic arterial system, including accessory and replaced hepatic arteries.

The observed arterial variations were classified according to Michels and Hiatt classification systems. Photographic documentation and schematic representation of important arterial variants were performed wherever necessary. Data obtained from cadaveric dissections and radiological observations were tabulated systematically and analysed using descriptive statistical methods such as frequencies and percentages. The findings were correlated with their embryological basis and clinical significance in hepatobiliary surgery, pancreatic surgery, liver transplantation, and interventional radiological procedures.

RESULT

Table 1: Distribution of Hepatic Artery Variations According to Michels Classification (n=140)

Michels Type	Description	Number	Percentage (%)
Type I	Normal hepatic arterial anatomy	95	67.5
Type II	Replaced left hepatic artery from left gastric artery	11	7.5
Type III	Replaced right hepatic artery from SMA	18	12.5
Type IV	Replaced right and left hepatic arteries	4	2.5
Type V	Accessory left hepatic artery	7	5.0
Type VI	Accessory right hepatic artery	3	2.5
Type VII	Accessory right and left hepatic arteries	2	2.5

Table 2: Origin of Variant Hepatic Arteries (n=45)

Variant Artery	Origin	Number	Percentage (%)
Replaced right hepatic artery	Superior mesenteric artery	17	38.5
Replaced left hepatic artery	Left gastric artery	10	23.1
Accessory left hepatic artery	Left gastric artery	7	15.4
Accessory right hepatic artery	Superior mesenteric artery	4	7.7
Common hepatic artery from SMA	Superior mesenteric artery	4	7.7
Common hepatic artery directly from aorta	Abdominal aorta	3	7.7

Table 3: Surgical Significance of Hepatic Artery Variations (n=45)

Surgical Procedure	Possible Surgical Complication	Number of Cases	Percentage (%)
Liver transplantation	Graft ischemia/biliary necrosis	17	38.5
Pancreaticoduodenectomy	Intraoperative hemorrhage	10	23.1
Laparoscopic cholecystectomy	Accidental arterial ligation	7	15.4
Hepatic resection	Segmental ischemia	7	15.4
Interventional radiology procedures	Difficulty in catheterization	4	7.7

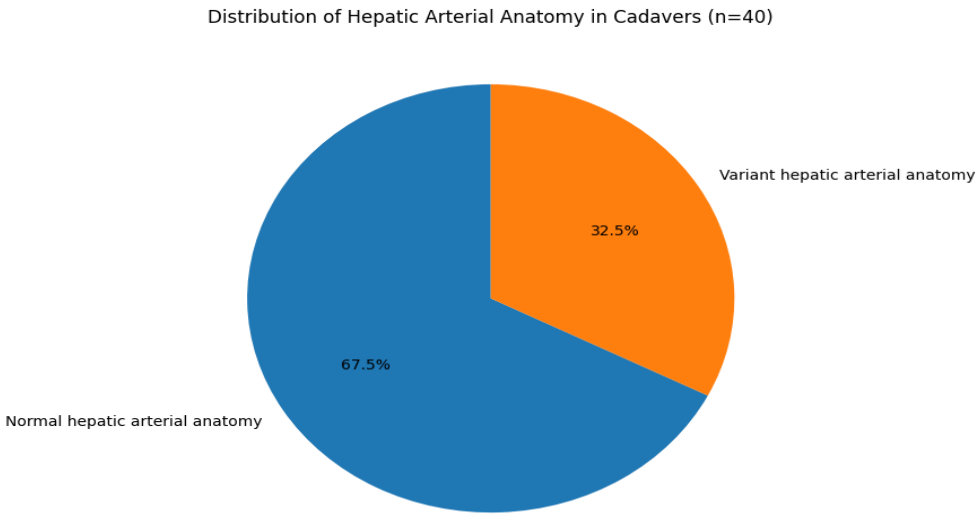

Chart 1 – Distribution of Normal and Variant Hepatic Arterial Anatomy

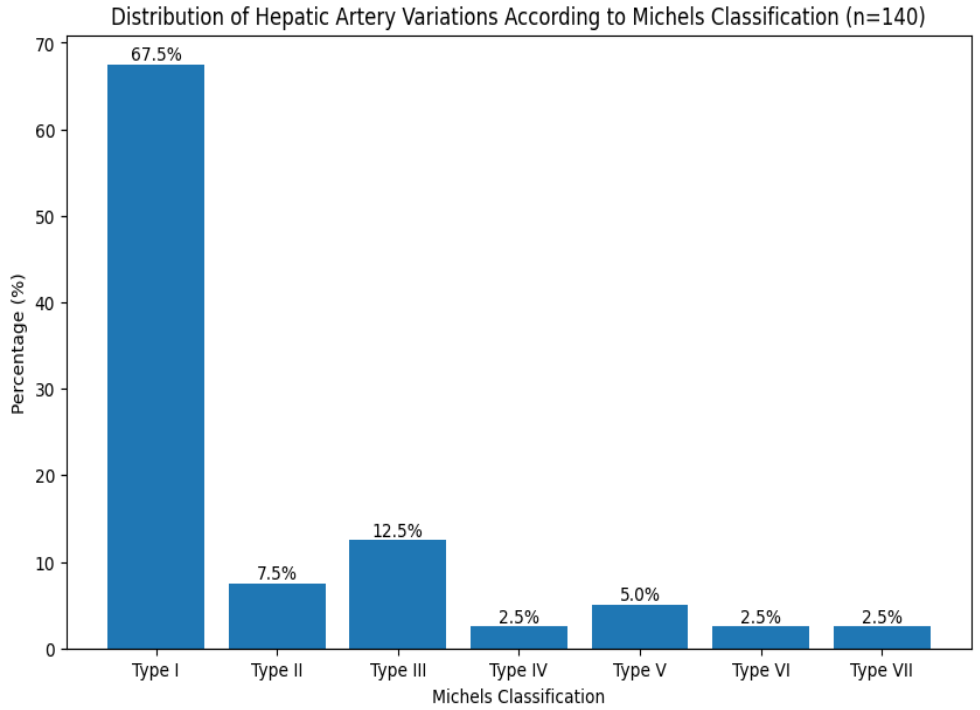

Chart 2- Hepatic Artery Variations

The present study evaluated the anatomical variations of the hepatic artery in 140 cases comprising cadaveric dissections and radiological observations. According to Michels classification, normal hepatic arterial anatomy (Type I) was observed in the majority of cases accounting for 67.5% (95 cases), whereas variant hepatic arterial anatomy was identified in 32.5% of cases. Among the variations, Type III variation involving a replaced right hepatic artery arising from the superior mesenteric artery was the most common anomaly observed in 12.5% of cases. Type II variation with replaced left hepatic artery originating from the left gastric artery was identified in 7.5% of cases. Accessory left hepatic artery (Type V) was observed in 5% of cases, while Types IV, VI, and VII variations were relatively less common.

Analysis of the origin of variant hepatic arteries demonstrated that the superior mesenteric artery and left gastric artery were the predominant sources of anomalous hepatic arterial supply. Replaced right hepatic artery arising from the superior mesenteric artery constituted the largest proportion of variants (38.5%). The study further highlighted the surgical significance of these variations, particularly in liver transplantation and pancreaticoduodenectomy, where vascular anomalies may predispose to graft ischemia, biliary necrosis, and intraoperative haemorrhage. These findings emphasize the importance of preoperative vascular assessment and detailed anatomical knowledge during hepatobiliary surgical procedures.

DISCUSSION

The hepatic arterial system demonstrates considerable anatomical variability, which has major clinical importance in hepatobiliary and transplant surgeries. In the present study, normal hepatic arterial anatomy according to Michels Type I classification was observed in 67.5% of cases, while variations were identified in 32.5% of cases. These findings are comparable with previous anatomical and radiological studies that reported normal hepatic arterial anatomy in approximately 55–80% of individuals. [1,4,7] . The frequency of arterial variations observed in the present study emphasizes the necessity of detailed anatomical knowledge before undertaking hepatobiliary and pancreatic surgical procedures.

Among the observed variants, replaced right hepatic artery arising from the superior mesenteric artery was the most common anomaly, accounting for 12.5% of cases. Similar findings were reported by Michels and Hiatt, who described this variation as one of the most clinically significant hepatic arterial anomalies.[6,7] Studies by Covantev et al. and Sureka et al. also documented that replaced right hepatic artery is frequently encountered during hepatopancreatobiliary surgeries.[4,12] Injury to this artery during pancreaticoduodenectomy or laparoscopic cholecystectomy may result in severe intraoperative hemorrhage, hepatic ischemia, or biliary necrosis.[9,10]

The present study also identified replaced and accessory left hepatic arteries arising from the left gastric artery. Similar observations have been documented in various cadaveric and angiographic studies.[2,8] Such variations are particularly important during gastric surgeries and liver transplantation, where accidental ligation may compromise arterial supply to the left lobe of the liver. Abdullah et al. emphasized that preservation of variant hepatic arteries during liver transplantation is essential for maintaining graft viability and preventing postoperative biliary complications. [11]

Rare vascular variations such as common hepatic artery arising directly from the superior mesenteric artery or abdominal aorta were also observed in the present study. These uncommon anatomical patterns have been previously described in literature and are attributed to persistence of embryonic ventral splanchnic arterial channels. [5,13] Knowledge of these rare vascular configurations is important during complex hepatopancreatobiliary surgeries and interventional radiological procedures.

The present study further highlighted the surgical significance of hepatic arterial variations in liver transplantation, hepatic resections, laparoscopic cholecystectomy, pancreaticoduodenectomy, and interventional radiological procedures. Liver transplantation showed the highest association with vascular complications such as graft ischemia and biliary necrosis, followed by pancreaticoduodenectomy with risk of intraoperative haemorrhage. Modern multidetector CT angiography and digital subtraction angiography have greatly improved the preoperative identification of these vascular anomalies. [12,13] Accurate preoperative evaluation of hepatic arterial anatomy facilitates meticulous surgical planning and significantly reduces operative morbidity and vascular complications.[10,14]

Overall, the findings of the present study correlate well with previous international studies and reinforce the importance of comprehensive anatomical knowledge of hepatic arterial variations among anatomists, radiologists, and hepatobiliary surgeons. Recognition and preoperative identification of these vascular patterns are essential for safe surgical intervention and successful operative outcomes.

CONCLUSION

The present study concludes that anatomical variations of the hepatic artery are common and clinically significant. Although normal hepatic arterial anatomy was observed in the majority of cases, a substantial proportion demonstrated variant arterial patterns, particularly replaced right and left hepatic arteries. These variations possess major surgical implications during hepatobiliary surgeries, liver transplantation, pancreatic resections, and interventional radiological procedures.Accurate preoperative identification of hepatic arterial anatomy is essential to prevent intraoperative haemorrhage, ischemic complications, biliary injury, and postoperative morbidity. Detailed anatomical knowledge of hepatic artery variations therefore plays a vital role in improving surgical safety and operative success. The study emphasizes the importance of routine vascular evaluation and awareness of hepatic arterial variants among surgeons, anatomists, and radiologists involved in hepatopancreatobiliary procedures.

REFERENCES

1. Chitra R. Anatomical variations of hepatic arteries. Int J Anat Res. 2024;12(2):9021-9028.
2. Olewnik Ł, Polguj M, Jedrzejewski KS, Topol M. Anatomical variations of the hepatic artery: a closer view. Folia Morphol (Warsz). 2021;80(1):1-10.
3. Sureka B, Mittal MK, Mittal A, Sinha M, Bhambri NK, Thukral BB. Importance of anatomical variation of the hepatic artery for surgical practice. Diagnostics (Basel). 2023;13(7):1233.
4. Covantev S, Vlad N, Mazuruc N, Belic O. The main anatomic variations of the hepatic artery and their importance in surgical practice. Med Pharm Rep. 2017;90(4):429-433.
5. Kobayashi S, Honda G, Kurata M, Tadano S, Sakamoto K, Okuda Y. Surgical anatomy of hepatic arteries from its origin to segmental branching. Surgery. 2022;172(3):642-651.

6. Michels NA. Newer anatomy of the liver and its variant blood supply and collateral circulation. Am J Surg. 1966;112(3):337-347.
7. Hiatt JR, Gabbay J, Busuttil RW. Surgical anatomy of the hepatic arteries in 1000 cases. Ann Surg. 1994;220(1):50-52.
8. Covey AM, Brody LA, Maluccio MA, Getrajdman GI, Brown KT. Variant hepatic arterial anatomy revisited: digital subtraction angiography performed in 600 patients. Radiology. 2002;224(2):542-547. Available from: RSNA Radiology Article
9. Panagouli E, Venieratos D, Lolis E, Skandalakis P. Celiac trunk and hepatic artery variants in pancreatic and liver surgery. Open Access Maced J Med Sci. 2019;7(20):3476-3481.
10. Song SY, Chung JW, Yin YH, Jae HJ, Kim HC, Jeon UB, et al. Celiac axis and common hepatic artery variations in 5002 patients: systematic analysis with spiral CT and DSA. Radiology. 2010;255(1):278-288.
11. Abdullah SS, Mabrut JY, Garbit V, De La Roche E, Rode A, Morin A, et al. Anatomical variations of the hepatic artery: study of 932 cases in liver transplantation. Surg Radiol Anat. 2006;28(5):468-473.
12. Sureka B, Mittal MK, Mittal A, Sinha M, Bhambri NK, Thukral BB. Clinical consideration of anatomical variations in the common hepatic arteries. Diagnostics (Basel). 2023;13(9):1636.
13. Huang Y, Yin X, Peng C, Wang H, Zhao J. A rare hepatic artery variant reporting and a new classification proposal. Front Surg. 2022; 9:1003350.
14. Chitra R, Kumar V, Singh P. Anatomical variations of hepatic arteries: implications for clinical practice. Front Surg. 2025; 12:1593800.