

Anatomy of the Cystic Artery and Its Variations: Implications for Gallbladder Surgery

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ABSTRACT

Anatomical variations of the hepatobiliary arterial supply represent a significant challenge during gallbladder surgery, as they may increase the risk of hemorrhage and bile duct injury when not recognized promptly. Among these, hepatic arterial variations described by the Michels classification are particularly relevant because of their impact on the planning and performance of hepatobiliary procedures. We present the case of a 48-year-old male patient diagnosed with acute calculous cholecystitis who underwent laparoscopic cholecystectomy. During dissection of the hepatocystic triangle, a vascular variant corresponding to Michels type V was identified, characterized by the presence of an accessory left hepatic artery arising from the left gastric artery. Intraoperative recognition of this variant allowed modification of the surgical strategy, preservation of the accessory vessel, and successful completion of the procedure without vascular or biliary complications. The postoperative course was uneventful, and the patient was discharged the following day with outpatient follow-up demonstrating no evidence of complications. This case highlights the importance of thorough knowledge of hepatobiliary vascular anatomy, the Michels classification, and the systematic application of the Critical View of Safety to reduce the risk of iatrogenic injuries during laparoscopic cholecystectomy. Furthermore, it emphasizes the importance of recognizing anatomical variations as a fundamental element for optimizing surgical safety and improving clinical outcomes.

KEYWORDS: cystic artery; accessory left hepatic artery; Michels classification; laparoscopic cholecystectomy; anatomical variations; hepatobiliary surgery.

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INTRODUCTION

Laparoscopic cholecystectomy is the treatment of choice for gallstone disease and is one of the most commonly performed surgical procedures worldwide. Although it is considered a safe and standardized technique, vascular and bile duct injuries remain among its most significant complications, largely associated with anatomical variations of the biliary tree and hepatic arterial supply. Among these, the cystic artery exhibits considerable variability regarding its origin, number,

course, and anatomical relationships, which may complicate identification of key structures during hepatocystic triangle dissection and increase the risk of hemorrhage, arterial injury, or bile duct injury. Under normal anatomical conditions, the cystic artery arises from the right hepatic artery and divides into superficial and deep branches supplying the gallbladder. However, several studies have demonstrated that up to one-third of patients present clinically relevant anatomical variations. Likewise, hepatic arterial variations are classified

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according to the Michels classification, which describes ten anatomical patterns based on the origin of the hepatic arteries. Within this classification, type V corresponds to the presence of an accessory left hepatic artery arising from the left gastric artery, an uncommon but surgically significant variation because of its susceptibility to injury during hepatobiliary and gastric procedures. Preoperative or intraoperative recognition of these vascular variations enables appropriate surgical planning, facilitates achievement of the Critical View of Safety, and reduces the incidence of operative complications. In this context, we present the clinical case of a patient with a vascular variant corresponding to Michels type V, highlighting its anatomical relevance, intraoperative findings, and surgical implications for the safe management of the gallbladder.

CASE REPORT

A 48-year-old male patient with no significant surgical history presented to the emergency department with a 24-hour history of colicky pain localized to the right upper quadrant, radiating to the right scapular region, accompanied by nausea, vomiting, and episodes of oral intolerance. Physical examination revealed tenderness to deep palpation in the right upper quadrant with a positive Murphy's sign and no evidence of peritoneal irritation. Laboratory investigations demonstrated mild leukocytosis, while liver function tests were within normal limits. Hepatobiliary ultrasonography revealed a distended gallbladder containing multiple gallstones, moderate gallbladder wall thickening, and no

evidence of biliary duct dilatation, establishing the diagnosis of acute calculous cholecystitis.

An early elective laparoscopic cholecystectomy under general anesthesia was scheduled. Initial intraoperative exploration demonstrated a gallbladder with moderate inflammatory changes and pericholecystic adhesions, which were carefully released using blunt dissection and monopolar electrocautery. Dissection of the hepatocystic triangle was subsequently initiated to obtain the Critical View of Safety. During dissection, an atypical vascular arrangement was identified at the hepatic hilum. In addition to the usual left hepatic artery, an additional arterial vessel was observed arising from the left gastric artery and ascending toward the left hepatic lobe, consistent with an accessory left hepatic artery and compatible with a Michels type V anatomical variant. This vascular variation was recognized before division of any vascular structure, allowing modification of the surgical approach to preserve the accessory artery completely and prevent iatrogenic injury.

After careful identification of the cystic duct and cystic artery, the Critical View of Safety was successfully achieved. The cystic artery was clipped proximally and distally using titanium clips, followed by conventional division of the cystic duct. The gallbladder was then meticulously dissected from the hepatic bed using electrocautery, achieving satisfactory hemostasis without evidence of vascular or biliary injury. Finally, the surgical specimen was retrieved in an endoscopic retrieval bag through the umbilical port.

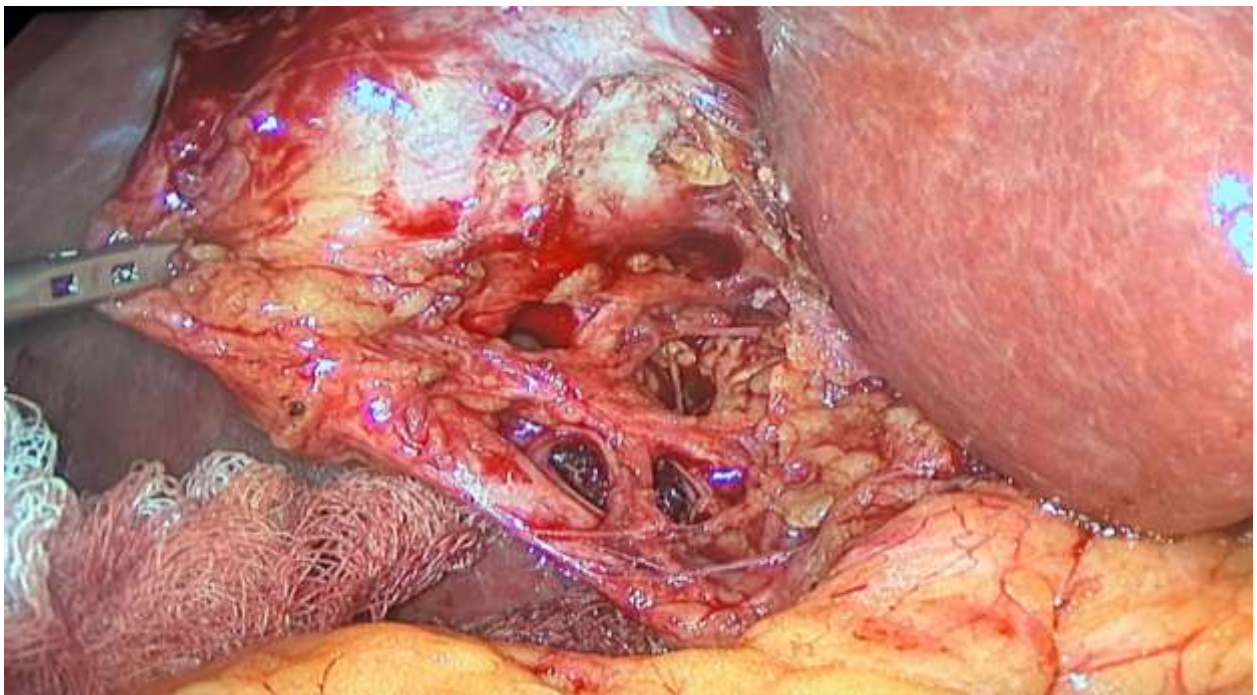


Image 1. Intraoperative image.

The operative time was 75 minutes, with an estimated intraoperative blood loss of 40 mL, and conversion to open surgery was not required. The postoperative course was

uneventful. The patient tolerated oral intake within the first postoperative hours, remained hemodynamically stable, and was discharged the following day without complications. At the 14-day outpatient follow-up, the surgical wounds had

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healed appropriately, the patient was pain-free, and there was no clinical evidence of biliary injury or impaired hepatic perfusion.

DISCUSSION

Anatomical variations of the hepatic arterial supply and the cystic artery represent one of the principal risk factors for complications during laparoscopic cholecystectomy. Failure to correctly identify these vascular structures may result in intraoperative hemorrhage, bile duct injury, injury to the right or left hepatic artery, conversion to open surgery, and even segmental hepatic ischemia. Therefore, a thorough understanding of hepatobiliary vascular anatomy remains an essential requirement for every hepatobiliary surgeon.

The Michels classification remains the most widely used system for describing hepatic arterial anatomical variations. Although originally developed from cadaveric anatomical dissections, it continues to be highly relevant because of its usefulness in interpreting findings observed on imaging studies and during surgical procedures. In the present case, a Michels type V variant was identified, characterized by the presence of an accessory left hepatic artery arising from the left gastric artery. Although this variation is less common than other anatomical patterns, its recognition is of considerable surgical importance because accidental injury to this vessel may partially compromise perfusion of the left hepatic lobe and increase the risk of hemorrhagic complications.

Several studies have demonstrated that variations of the cystic artery and hepatic arteries are more common than previously believed. Variations in the origin, course, and number of the cystic artery occur in approximately one-quarter of the population, whereas hepatic arterial variations may be found in up to 45% of individuals. These anatomical differences underscore the importance of meticulous dissection before ligating any structure within the hepatocystic triangle.

Achieving the Critical View of Safety remains the most effective strategy for reducing the incidence of biliary and vascular injuries during laparoscopic cholecystectomy. This concept, originally described by Strasberg, establishes that only two structures entering the gallbladder should be divided after complete dissection of the lower third of the gallbladder from the hepatic bed. The routine application of this technique facilitates early recognition of anatomical variations such as the one described in this case and helps prevent iatrogenic injuries.

In conclusion, recognition of the anatomical variants described by Michels, particularly those involving an accessory left hepatic artery, together with a comprehensive understanding of cystic artery anatomy and proper achievement of the Critical View of Safety, are fundamental elements for safe hepatobiliary surgery and for reducing the morbidity and mortality associated with vascular and biliary injuries.

Table 1. Michels Classification of Hepatic Arterial Variants

Type	Description
I	Normal anatomy: common hepatic artery → proper hepatic artery → right and left hepatic arteries.
II	Replaced left hepatic artery arising from the left gastric artery.
III	Replaced right hepatic artery arising from the superior mesenteric artery.
IV	Replaced right hepatic artery + replaced left hepatic artery.
V	Accessory left hepatic artery arising from the left gastric artery.
VI	Accessory right hepatic artery arising from the superior mesenteric artery.
VII	Accessory right hepatic artery + accessory left hepatic artery.
VIII	Combination of a replaced and an accessory hepatic artery (right or left).
IX	Common hepatic artery arising from the superior mesenteric artery.
X	Common hepatic artery arising from the left gastric artery.

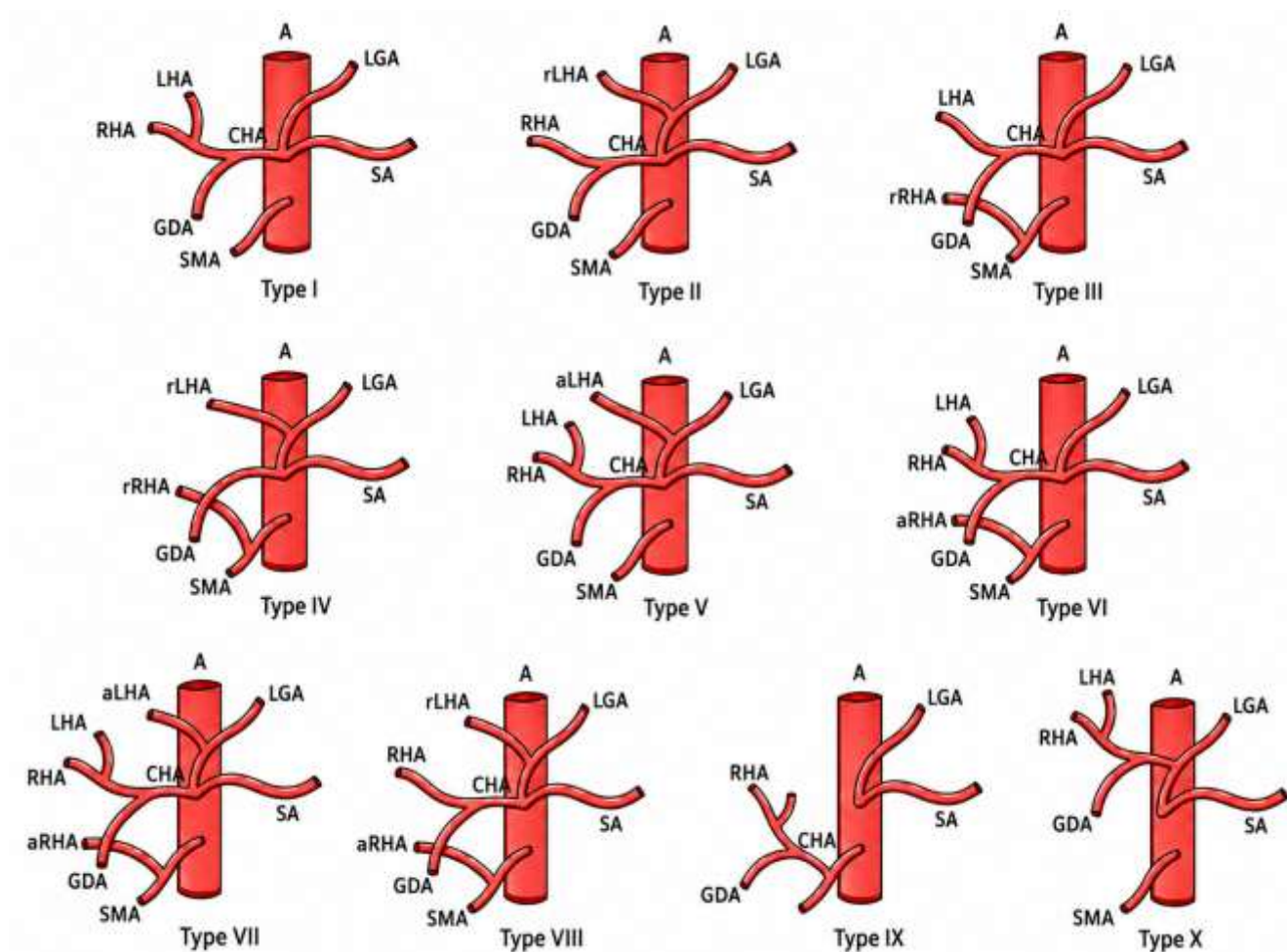


Image 2. Michels Classification of Hepatic Arterial Variants

Table 2. Variants of the Origin of the Cystic Artery

Origin	Approximate Frequency
Right hepatic artery	70–80%
Left hepatic artery	1–2%
Proper hepatic artery	2–4%
Common hepatic artery	1–3%
Gastroduodenal artery	<1%
Accessory or replaced right hepatic artery	5–15%
Other variants	<1%

Table 3. Complications Associated with Arterial Variants

Complication	Mechanism
Intraoperative hemorrhage	Injury to a variant cystic or hepatic artery.
Bile duct injury	Misidentification of biliary and vascular structures.
Conversion to open surgery	Bleeding or complex anatomy.
Hepatic ischemia	Injury to an accessory or replaced hepatic artery.
Bile duct necrosis	Compromise of its arterial blood supply.

Table 4. Key Principles for Safe Laparoscopic Cholecystectomy

Recommendation	Benefit
Identify the anatomy before ligating any structure	Reduces vascular injuries.
Achieve the Critical View of Safety	Decreases bile duct injuries.
Suspect anatomical variants when anatomy is unusual	Prevents misidentification of structures.

Perform meticulous dissection of the hepatocystic triangle	Facilitates recognition of accessory arteries.
Maintain adequate hemostasis	Improves surgical visualization.
Consider preoperative imaging when vascular anatomy is uncertain	Facilitates surgical planning.

CONCLUSION

Anatomical variations of the cystic artery and hepatic arterial supply are of paramount importance in hepatobiliary surgery because of their direct impact on the safety of laparoscopic cholecystectomy. A thorough understanding of these variations, particularly those described in the Michels classification, enables surgeons to anticipate unusual anatomical findings, perform more precise dissections, and reduce the risk of vascular and biliary injuries, which remain the most significant complications associated with this procedure.

The present case highlights the importance of intraoperative recognition of a Michels type V variant, characterized by an accessory left hepatic artery arising from the left gastric artery. Although this variation is uncommon and usually asymptomatic, its timely identification allowed preservation of hepatic arterial perfusion and successful completion of the laparoscopic cholecystectomy without complications, demonstrating the critical role of anatomical knowledge in surgical decision-making.

Furthermore, this case emphasizes that the systematic application of the Critical View of Safety, together with meticulous dissection of the hepatocystic triangle and careful recognition of potential vascular variations, represents the most effective strategy for preventing iatrogenic injuries. Whenever complex vascular anatomy is suspected, preoperative imaging studies and careful interpretation of intraoperative findings may significantly improve surgical outcomes.

Finally, the publication of case reports describing uncommon anatomical variants expands current knowledge of hepatobiliary anatomy and contributes to surgical education. Understanding these variations is not only of academic interest but also has a direct impact on clinical practice by promoting safer surgical procedures, reducing morbidity and mortality, and optimizing the management of patients undergoing gallbladder surgery.

REFERENCES

I. Andall, R. G., Matusz, P., du Plessis, M., Ward, R., Tubbs, R. S., & Loukas, M. (2016). The clinical anatomy of cystic artery variations: A review of over 9800 cases. *Surgical and Radiologic Anatomy*, 38(5), 529–539. <https://doi.org/10.1007/s00276-015-1600-y>

II. Asghar, A., Priya, A., Prasad, N., Patra, A., & Agrawal, D. (2024). Variations in morphology of cystic artery: Systematic review and meta-analysis. *La Clinica Terapeutica*, 175(3), 184–192. <https://doi.org/10.7417/CT.2024.5061>

III. Triantafyllou, K., et al. (2024). Surgical anatomy of the cystic artery: A systematic review with meta-analysis. *Annals of Anatomy*, 256, 152343. <https://doi.org/10.1016/j.aanat.2024.152343>

IV. Michels, N. A. (1951). The hepatic, cystic and retroduodenal arteries and their relations to the biliary ducts, with samples of the entire celiac arterial supply. *Annals of Surgery*, 133(4), 503–524. <https://doi.org/10.1097/0000658-195104000-00009>

V. Michels, N. A. (1966). *Newer anatomy of the liver and its variant blood supply and collateral circulation*. New York, NY: Hoeber Medical Division, Harper & Row.

VI. Hiatt, J. R., Gabbay, J., & Busuttil, R. W. (1994). Surgical anatomy of the hepatic arteries in 1000 cases. *Annals of Surgery*, 220(1), 50–52. <https://doi.org/10.1097/0000658-199407000-00008>

VII. Noussios, G., Dimitriou, I., Chatzis, I., & Katsourakis, A. (2017). The main anatomic variations of the hepatic artery and their importance in surgical practice: Review of the literature. *Journal of Clinical Medicine Research*, 9(4), 248–252. <https://doi.org/10.14740/jocmr2902w>

VIII. Dandekar, U., Dandekar, K., Chavan, S., & Ghodke, B. (2016). Cystic artery: Morphological study and surgical significance. *Anatomy Research International*, 2016, 7201858. <https://doi.org/10.1155/2016/7201858>

IX. Mlakar, B., Gadzijev, E. M., Ravnik, D., & Hribernik, M. (2003). Anatomical variations of the cystic artery. *European Journal of Morphology*, 41(1), 31–34. <https://doi.org/10.1076/EJOM.41.1.31.28103>

X. Komatsu, T., Matsui, O., Kadoya, M., Yoshikawa, J., Gabata, T., & Takashima, T. (1999). Cystic artery origin of the segment V hepatic artery. *CardioVascular and Interventional Radiology*, 22(2), 165–167. <https://doi.org/10.1007/s002709900357>

XI. Sabaa, L., & Mallarini, G. (2008). Multidetector row CT angiography in the evaluation of the hepatic artery and its anatomical variants. *Clinical Radiology*, 63(3), 312–321. <https://doi.org/10.1016/j.crad.2007.05.023>

XII. Mugunthan, N., Kannan, R., Jebakani, C. F., & Anbalagan, J. (2016). Variations in the origin and course of the right hepatic artery and its surgical significance. *Journal of Clinical and Diagnostic*

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- Research, 10(9), AC01–AC04.
<https://doi.org/10.7860/JCDR/2016/22126.8428>
- XIII. Asghar, A., Priya, A., Patra, A., Gupta, P., & Kumar, A. (2023). Moynihan's hump of the right hepatic artery in Calot's triangle: A systematic review and meta-analysis of its incidence and surgical importance. *Surgical and Radiologic Anatomy*, 45, 643–651. <https://doi.org/10.1007/s00276-023-03125-8>
- XIV. Strasberg, S. M., Hertl, M., & Soper, N. J. (1995). An analysis of the problem of biliary injury during laparoscopic cholecystectomy. *Journal of the American College of Surgeons*, 180(1), 101–125.
- XV. Hugh, T. B., Kelly, M. D., & Li, B. (1992). Laparoscopic anatomy of the cystic artery. *American Journal of Surgery*, 163(6), 593–595.