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CYSTIC ARTERY ARISING AT THE ORIGIN OF THE MIDDLE HEPATIC ARTERY: ANATOMICAL RELATIONSHIPS AND SURGICAL IMPLICATIONS

ARTÉRIA CÍSTICA ORIGINÁRIA DA ORIGEM DA ARTÉRIA HEPÁTICA MÉDIA: RELAÇÕES ANATÔMICAS E IMPLICAÇÕES CIRÚRGICAS

ARTERIA QUÍSTICA ORIGINARIA DEL ORIGEN DE LA ARTERIA HEPÁTICA MEDIA: RELACIONES ANATÓMICAS E IMPLICACIONES QUIRÚRGICAS

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ABSTRACT

Purpose. The cystic artery most commonly arises from the right hepatic artery, but clinically important variations in origin and course are well documented. This study describes an uncommon cystic artery arising at the origin of the middle hepatic artery, emphasizing its relationship with the common hepatic duct and the continuation of the middle hepatic artery toward hepatic segment IV. Methods. The hepatobiliary region of an adult female formalin-preserved cadaver was carefully dissected to expose the extrahepatic biliary tract, gallbladder, cystic artery, and hepatic arterial branches. The anatomical arrangement was documented photographically from complementary viewpoints. Results. The cystic artery arose at the origin of the middle hepatic artery rather than from the right hepatic artery. It crossed anterior to the common hepatic duct before proceeding toward the gallbladder. The middle hepatic artery was positioned to the left of the common hepatic duct and continued toward hepatic segment IV, whereas the right hepatic artery passed posterior to the duct. Conclusion. This configuration is surgically relevant because a vessel destined for the gallbladder shares its origin with a hepatic arterial branch that continues toward segment IV. Recognition of the proximal origin and distal hepatic continuation of these vessels may reduce the risk of vascular misidentification, hemorrhage, inadvertent hepatic arterial ligation, and biliary injury during hepatobiliary procedures.

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Keywords: Cystic Artery. Middle Hepatic Artery. Hepatic Segment IV. Common Hepatic Duct. Hepatocystic Triangle. Anatomical Variation. Cholecystectomy.

RESUMO
Objetivo. A artéria cística geralmente origina-se da artéria hepática direita, mas variações clinicamente importantes em relação à origem e curso são bem documentadas. Este estudo descreve uma artéria cística incomum que surge na origem da artéria hepática média, enfatizando sua relação com o ducto hepático comum e a continuação da artéria hepática média em direção ao segmento hepático IV. Métodos. A região hepatobiliar de um cadáver preservado em formalina de uma mulher adulta foi cuidadosamente dissecada para expor o trato biliar extrahepático, a vesícula biliar, a artéria cística e os ramos das artérias hepáticas. O arranjo anatômico foi documentado fotograficamente a partir de pontos de vista complementares. Resultados. A artéria cística originou-se na origem da artéria hepática média em vez de originar-se da artéria hepática direita. Ela cruzou anteriormente ao ducto hepático comum antes de prosseguir em direção à vesícula biliar. A artéria hepática média estava posicionada à esquerda do ducto hepático comum e continuou em direção ao segmento hepático IV, enquanto a artéria hepática direita passou posteriormente ao ducto. Conclusão. Esta configuração é cirurgicamente relevante porque um vaso destinado à vesícula biliar compartilha sua origem com um ramo da artéria hepática que continua em direção ao segmento IV. O reconhecimento da origem proximal e da continuação hepática distal desses vasos pode reduzir o risco de identificação incorreta de vasos, hemorragia, ligadura inadvertida da artéria hepática e lesão biliar durante procedimentos hepatobiliares.

Palavras-chave: Artéria Cística. Artéria Hepática Média. Segmento Hepático IV. Ducto Hepático Comum. Triângulo Hepatocístico. Variação Anatômica. Colecistectomia.

RESUMEN
Propósito. La arteria cística se origina más comúnmente de la arteria hepática derecha, pero hay variaciones clínicamente importantes en el origen y curso bien documentadas. Este estudio describe una arteria cística poco común que surge en el origen de la arteria hepática media, enfatizando su relación con el conducto hepático común y la continuación de la arteria hepática media hacia el segmento hepático IV. Métodos. La región hepatobiliar de un cadáver preservado en formalina de una mujer adulta fue cuidadosamente disecada para exponer el tracto biliar extrahepático, la vesícula biliar, la arteria cística y las ramas de las arterias hepáticas. La disposición anatómica fue documentada fotográficamente desde puntos de vista complementarios. Resultados. La arteria cística se originó en el origen de la arteria hepática media en lugar de originarse de la arteria hepática derecha. Cruzó anteriormente al conducto hepático común antes de proceder hacia la vesícula biliar. La arteria hepática media estaba posicionada a la izquierda del conducto hepático común y continuó hacia el segmento hepático IV, mientras que la arteria hepática derecha pasó posteriormente al conducto. Conclusión. Esta configuración es quirúrgicamente relevante porque un vaso destinado a la vesícula biliar comparte su origen con una rama de la arteria hepática que continúa hacia el segmento IV. El reconocimiento del origen proximal y la continuación hepática distal de estos vasos puede reducir el riesgo de identificación incorrecta de vasos, hemorragia, ligadura inadvertida de la arteria hepática y lesión biliar durante procedimientos hepatobiliares.

Palabras clave: Arteria Cística. Arteria Hepática Media. Segmento Hepático IV. Conducto Hepático Común. Triángulo Hepatocístico. Variación Anatómica. Colecistectomía.

1 INTRODUCTION

The cystic artery is the principal arterial supply to the gallbladder and is one of the key vascular structures identified during cholecystectomy. In the usual arrangement, it arises from the right hepatic artery and courses through the hepatocystic triangle. Nevertheless, its origin, number, course, and relationship with the biliary tract are highly variable. Large reviews and recent meta-analyses indicate that the right hepatic artery remains the predominant source, while origins from other hepatic branches, including the middle hepatic artery, are uncommon (ANDALL *et al.*, 2016; TRIANTAFYLLOU *et al.*, 2025a).

These variations have direct clinical implications. Arteries may cross major bile ducts, arise outside the expected operative field, or remain continuous with branches supplying hepatic parenchyma. Such patterns can complicate intraoperative identification and increase the risk of hemorrhage, unintended vascular ligation, or bile duct injury (HUGH; KELLY; LI, 1992; ABDALLA; PIERRE; ELLIS, 2013).

The middle hepatic artery is generally defined as an arterial branch supplying hepatic segment IV, although its origin and contribution are variable. Recent evidence-based anatomical synthesis emphasizes that recognition of this artery is relevant in hepatopancreatobiliary surgery, transplantation, and interventional procedures (TRIANTAFYLLOU *et al.*, 2025b). A cystic artery arising from the middle hepatic artery has been reported only rarely; a recent clinical case documented this configuration during laparoscopic cholecystectomy and highlighted the need to preserve the segment IV arterial supply (PERDIKAKIS *et al.*, 2024).

The present study describes a cadaveric arterial configuration in which the cystic artery arose at the origin of the middle hepatic artery, crossed anterior to the common hepatic duct, and proceeded toward the gallbladder. The middle hepatic artery remained to the left of the common hepatic duct and continued toward hepatic segment IV, while the right hepatic artery passed posterior to the duct. The aim is to characterize this arrangement and discuss its surgical relevance.

2 MATERIALS AND METHODS

2.1 CADAVERIC SPECIMEN

The variation was identified during anatomical dissection of the hepatobiliary region of an adult female human cadaver preserved in formalin at the Laboratory of Human Anatomy,

School of Health Sciences, Amazonas State University (Universidade do Estado do Amazonas - UEA), Manaus, Amazonas, Brazil.

2.2 ANATOMICAL DISSECTION

The hepatobiliary region was carefully dissected to expose the gallbladder, cystic duct, common hepatic duct, common bile duct, proper hepatic artery, right hepatic artery, middle hepatic artery, and cystic artery. Perivascular connective tissue was removed while preserving the natural topographical relationships between arterial and biliary structures. The arterial branches were followed proximally and distally to establish their anatomical continuity and distribution.

Particular attention was directed to the origin of the cystic artery, its relationship with the middle hepatic artery, its course in relation to the common hepatic duct, and the continuation of the middle hepatic artery toward hepatic segment IV.

2.3 PHOTOGRAPHIC DOCUMENTATION

The anatomical arrangement was documented under direct illumination using high-resolution photography from complementary viewpoints. The image series preserved the in situ orientation of the liver, gallbladder, extrahepatic biliary tract, and hepatic arterial branches. Representative views were selected to demonstrate the general hepatobiliary topography and the vascular relationships around the common hepatic duct. No anatomical structures were digitally altered.

2.4 ETHICAL CONSIDERATIONS

The study was conducted in accordance with institutional and national ethical standards applicable to research involving human anatomical specimens. The research involving the cadaveric material was approved by the Research Ethics Committee of the Universidade do Estado do Amazonas under CAAE 83194024.9.0000.5016. The specimen was presented without identifying information.

3 ANATOMICAL FINDINGS

3.1 HEPATIC ARTERIAL ARRANGEMENT

Dissection revealed a distinct middle hepatic artery in the hepatobiliary region. The vessel continued superiorly toward hepatic segment IV. The right hepatic artery followed a separate course posterior to the common hepatic duct.

3.2 ORIGIN OF THE CYSTIC ARTERY

The principal finding was the origin of the cystic artery at the origin of the middle hepatic artery. Rather than arising independently from the right hepatic artery, the cystic artery originated in direct association with a hepatic arterial branch that remained identifiable beyond this point and continued toward segment IV.

3.3 RELATIONSHIP WITH THE COMMON HEPATIC DUCT

The common hepatic duct represented the central topographical landmark of the observed vascular arrangement. The right hepatic artery passed posterior to the common hepatic duct, the middle hepatic artery was located to the left of the duct, and the cystic artery crossed anterior to the duct before proceeding toward the gallbladder. These structures therefore formed a distinctive three-dimensional arterial relationship around the extrahepatic biliary tract.

3.4 COURSE TOWARD THE GALLBLADDER

After crossing anterior to the common hepatic duct, the cystic artery continued toward the gallbladder. Direct dissection and photographic documentation from multiple perspectives confirmed continuity of the vessel from its origin to the gallbladder.

4 DISCUSSION

The present specimen demonstrates an uncommon cystic arterial configuration characterized by origin of the cystic artery at the origin of the middle hepatic artery and continuation of the latter toward hepatic segment IV. This finding differs from the usual arrangement, in which the cystic artery most commonly arises from the right hepatic artery. In a review of more than 9,800 cases, Andall *et al.* (2016) reported the right hepatic artery as the typical origin in approximately four fifths of cases. A more recent systematic review with

meta-analysis similarly identified the right hepatic artery as the predominant source and listed the middle hepatic artery among the less frequent origins (TRIANTAFYLLOU *et al.*, 2025a).

The specific association between the cystic and middle hepatic arteries is particularly relevant because the middle hepatic artery supplies segment IV. The evidence-based review by Triantafyllou *et al.* (2025b) emphasizes that the vessel is variably defined and underreported, yet its preservation may be important in hepatobiliary surgery and transplantation. In the present specimen, the arterial branch continued clearly toward segment IV after the cystic artery origin, reinforcing that a vessel encountered near the gallbladder may be anatomically linked to hepatic parenchymal perfusion.

A clinically comparable pattern was reported by Perdikakis *et al.* (2024), who described a cystic artery arising from a robust middle hepatic artery during laparoscopic cholecystectomy. Their report emphasized protection of the middle hepatic artery during dissection. The present cadaveric observation adds direct three-dimensional anatomical documentation of a similar variant, including its relationship with the common hepatic duct.

The anterior crossing of the cystic artery over the common hepatic duct represents an additional surgically important feature. Andall *et al.* (2016) documented cystic arteries anterior to the common hepatic duct among clinically relevant variants. When an artery courses over a major bile duct, vascular injury may cause hemorrhage, while attempts at hemostasis may further increase the risk of inadvertent ductal injury if the anatomy is not clearly established.

Safe cholecystectomy depends on accurate identification of both the cystic duct and cystic artery and on exclusion of structures that continue toward the liver. The critical view of safety was developed to reduce misidentification injuries during laparoscopic cholecystectomy (STRASBERG; HERTL; SOPER, 1995). The present configuration reinforces this principle: the trajectory of an artery toward the gallbladder alone is insufficient to establish that the vessel can be safely divided when an associated hepatic branch continues toward segment IV.

The region of the hepatocystic triangle is known for substantial anatomical variability. Postmortem studies have demonstrated additional arterial structures within this area, and laparoscopic observations have long emphasized the importance of deliberate arterial identification before ligation (BERGAMASCHI; IGNJATOVIC, 2000; HUGH; KELLY; LI, 1992). From a radiological and interventional perspective, awareness of the present pattern may also be useful during vascular mapping, angiographic interpretation, transarterial procedures, and complex hepatobiliary interventions.

The principal limitation of this report is that it represents a single anatomical specimen and therefore does not allow estimation of prevalence or clinical outcomes. Nevertheless, the combination of direct dissection and photographic documentation provides a clear account of a rare vascular relationship with potential surgical relevance.

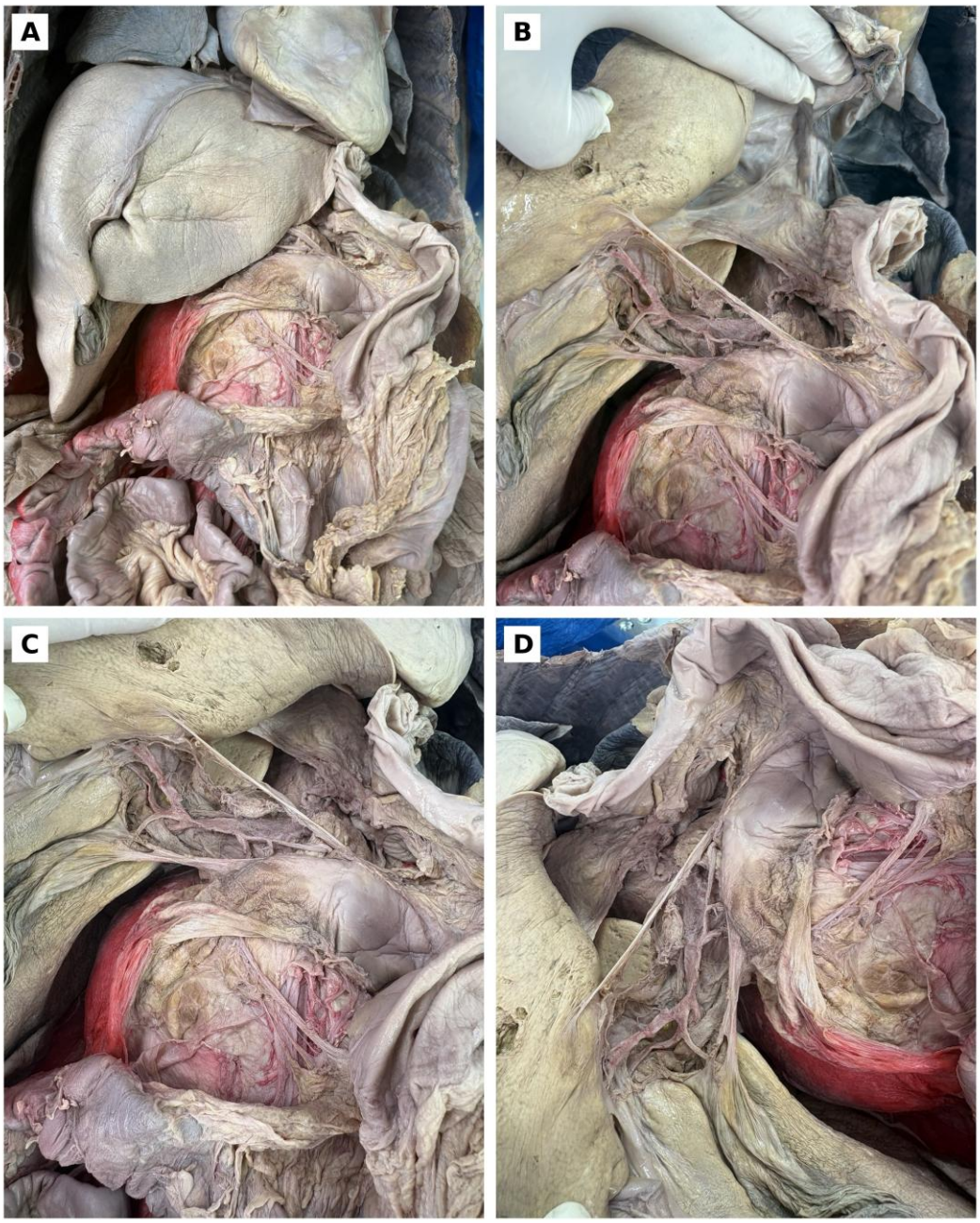
5 CONCLUSION

This study describes an uncommon arterial configuration in a female formalin-preserved cadaver in which the cystic artery arose at the origin of the middle hepatic artery, crossed anterior to the common hepatic duct, and continued toward the gallbladder. The middle hepatic artery remained to the left of the common hepatic duct and continued toward hepatic segment IV, whereas the right hepatic artery passed posterior to the duct.

Recognition of this arrangement is relevant to hepatobiliary surgery because the artery associated with the gallbladder shares its origin with a branch that continues toward hepatic parenchyma. Careful identification of proximal origin, biliary relationships, and distal arterial continuation may reduce the risk of vascular misidentification, hemorrhage, inadvertent hepatic arterial ligation, and bile duct injury.

Figure 1

Multipanel cadaveric documentation of the hepatobiliary region. (A) Panoramic view providing general topographical orientation. (B-C) Closer views of the hepatobiliary region demonstrating the hepatic arterial branches in relation to the extrahepatic biliary tract. (D) Oblique view providing an additional perspective of the vascular relationships



Source: The Authors, 2026.

DECLARATIONS

Ethics approval: approved by the Research Ethics Committee of the Universidade do Estado do Amazonas under CAAE 83194024.9.0000.5016.

Consent to participate: not applicable to the preserved, non-identified anatomical specimen used in this study.

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Data availability: all anatomical observations relevant to this report are presented in the manuscript and associated figure.

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