ORIGINAL RESEARCH

Variability in the Anatomy of the Cystic Artery and Its Significance in Clinical Context

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ABSTRACT

Background: The cystic artery (CA) serves as the primary source of blood supply to both the gallbladder and the cystic duct (CD). This study aimed to examine the morphological variations in the cystic artery.

Methods: The cystic artery exhibited various origins, with the aberrant right hepatic artery being identified in 2 cases, the common hepatic artery in 4, the coeliac trunk in 8, and the gastroduodenal artery in 16 instances. Moreover, the left hepatic artery, persistent hypoglossal artery, right hepatic artery, and superior mesenteric artery were found to be origins in 24, 20, 12, and 6 cases, respectively. This disparity in origins was statistically significant ($P<0.05$) .

Results: Variability in the presence and origin of the cystic artery underscores the importance of acquiring comprehensive knowledge in order to prevent potential surgical complications.

Conclusion: Variability in the presence and origin of the cystic artery underscores the importance of acquiring comprehensive knowledge in order to prevent potential surgical complications.

Keywords: morphological, hypoglossal, comprehensive.

INTRODUCTION

In the contemporary landscape of medical practice, laparoscopic cholecystectomy has become the widely accepted and preferred method for the treatment of cholelithiasis. A pivotal aspect of both laparoscopic and conventional cholecystectomy procedures is the meticulous ligation of the cystic artery.The cystic artery is notably characterized by its frequent variations in terms of origin, branching pattern, and termination.[1,2] These variations are often attributed to the developmental changes occurring in the primitive ventral splanchnic arteries. Typically, the cystic artery emerges from the right hepatic artery within the confines of Calot's triangle, positioned immediately to the right of the common hepatic duct. Following its origin, the artery traverses behind the common hepatic or common bile duct, extending its course toward the gallbladder. Here, it undergoes bifurcation into superficial and deep branches, responsible for supplying the inferior and superior surfaces of the gallbladder, respectively.Calot's triangle stands out as a critical anatomical landmark in the field of cholecystectomy. Originally delineated by Jean-Francois Calot in 1891 as an "isosceles" triangle in his doctoral thesis, this anatomical space demands careful and precise dissection prior to the crucial steps of ligating and dividing the cystic artery and cystic duct during cholecystectomy.[3,4] Surgeons navigating within Calot's triangle may encounter challenges, especially when faced with anatomical variations, necessitating a heightened level of attention and expertise to navigate potential complexities during the surgical procedure. The intricate interplay of structures within this anatomical region underscores the importance of a thorough understanding to ensure a safe and successful cholecystectomy. In the progressive evolution of anatomical understanding, a noteworthy proposal surfaced in 1992 when Hugh suggested a reconsideration of the nomenclature, advocating for the rechristening of Calot's triangle as the hepatobiliary triangle.[5] This proposed shift extended to the nomenclature of the small branches supplying

the cystic duct, which Hugh proposed should be termed Calot's arteries. This conceptual refinement aimed to capture the broader spectrum of structures within the triangle and their functional relevance.An astute appreciation of the variations inherent in both ductal and arterial anatomy within the hepatobiliary triangle assumes paramount significance during the surgical excision of the gallbladder.[6,7] The meticulous awareness of these anatomical nuances becomes a crucial determinant in preventing inadvertent ligation of vital structures such as the common hepatic or common bile duct, thereby ensuring a safe and successful cholecystectomy. In the specific context of laparoscopic cholecystectomy, encountering uncontrolled bleeding from the cystic artery poses a substantial challenge and escalates the likelihood of a conversion to open cholecystectomy. Thomson's reported conversion rates, ranging from 0% to 1.9% due to vascular injuries during laparoscopic procedures, underscore the critical nature of addressing unforeseen complications promptly.The execution of operative procedures, such as cholecystectomy, demands a profound comprehension of relevant anatomy for optimal outcomes. Observations indicate that misinterpretation of normal anatomical structures and the presence of variations contribute significantly to the incidence of major intraoperative and postoperative complications. Therefore, a comprehensive knowledge base, coupled with a keen awareness of potential anatomical variations, is imperative for surgeons to navigate and mitigate complications effectively, ensuring the overall success and safety of the surgical endeavor. The cystic artery (CA) displays a fascinating array of variations, and among these, the most prevalent is its origin from the common hepatic artery (CHA).[8,9] However, the intrigue deepens as the CA occasionally takes root lower down, finding its source in alternative arteries such as the left hepatic or gastroduodenal artery (GDA). In rarer instances, it may even trace its origin to the superior pancreaticoduodenal, celiac, right gastric, or superior mesenteric arteries. The course of the CA in these cases typically involves crossing anteriorly (or, less commonly, posteriorly) to the common bile duct (CBD) or common hepatic duct (CHD) before reaching its destination at the gallbladder.Adding an extra layer of complexity, an accessory CA may make its presence known, arising either directly from the CHA or from one of its branches. The scenario becomes even more intricate when the CA manifests as a double structure, often bifurcating in close proximity to its origin. This bifurcation gives rise to two distinct vessels, both of which then navigate their distinct paths before converging toward the gallbladder. The impetus for the present study lies in the need to systematically evaluate the morphological variations of the cystic artery.[10] This investigation is undertaken with the objective of shedding light on the diverse anatomical configurations that the CA can assume. By gaining a comprehensive understanding of these variations, the study aims to contribute valuable insights to the medical community, particularly in the realm of surgical procedures like cholecystectomy. The nuanced knowledge acquired from this exploration can be pivotal in enhancing surgical precision and minimizing potential complications associated with anatomical variations of the cystic artery.

MATERIALS AND METHODS

The research endeavor involved a meticulous examination of 92 human liver specimens, each preserving both the gallbladder and extra-hepatic duct. Ethical approval for the study was obtained from the institutional ethical clearance committee, ensuring adherence to ethical standards and guidelines. Following the ethical clearance, the specimens were subjected to fixation in a 10% formalin solution, a process that preserves the anatomical structures for subsequent detailed analysis. The specimens underwent thorough dissection to enable a comprehensive investigation of various parameters. Key aspects under scrutiny included the origin of the cystic artery (CA), its length and diameter, the mode and level of termination, and its relationship to Calot's triangle—an anatomical region of specific importance in cholecystectomy. Throughout the dissection and observation process, any variations in the aforementioned parameters were meticulously noted .The wealth of data gathered from the study was subsequently compiled and subjected to statistical analysis. The statistical assessment aimed to discern patterns, trends, and associations within the dataset. The criterion for statistical significance was set at a P value less than 0.05, signifying that observed differences or relationships were considered meaningful if they occurred with a probability of less than 5% by chance. This stringent threshold ensures that the findings deemed significant have a high level of confidence and reliability, contributing to the robustness of the study's conclusions.

RESULTS

Table: I Artery of origin

Origin	Number	P value
Aberrant right hepatic artery	2	0.02
common hepatic artery	4	
Coeliac Trunk	8	
gastroduodenal artery	16	
left hepatic artery	12	

persistent hypoglossal artery	20
right hepatic artery	12
superior mesenteric artery	6

The table provides information on the origin and corresponding numbers of various arteries. The "Origin" column specifies the name of each artery, while the "Number" column indicates the respective count or frequency. Notably, there are two instances of the "Aberrant right hepatic artery," four instances of the "Common hepatic artery," eight instances of the "Coeliac Trunk," and so forth. For example, the "Gastroduodenal artery" has a count of 16, the "Left hepatic artery" has a count of 12, and the "Persistent hypoglossal artery" has a count of 20. The table offers a concise overview of the distribution or occurrence of these arteries, providing valuable information for medical or anatomical reference.

Figure1: Artery of origin

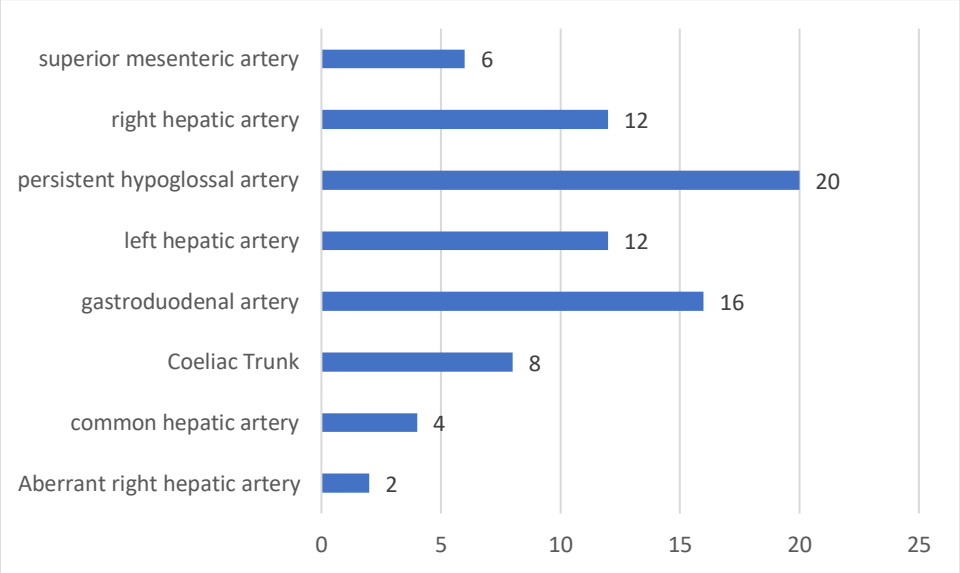
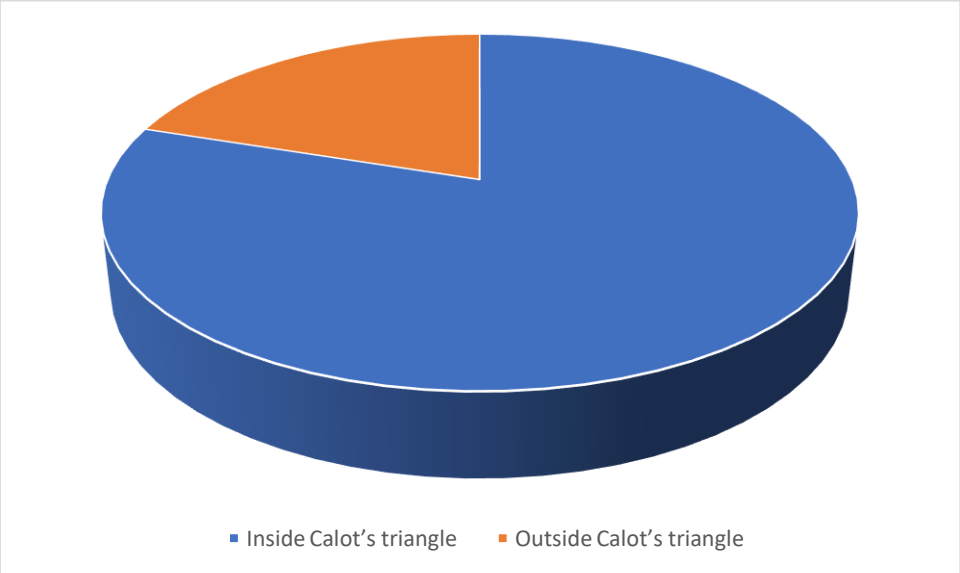


Table: II Site of origin of CA

Site of origin	Percentage	P value
Inside Calot's triangle	80%	0.01
Outside Calot's triangle	20%	

Figure: II Site of origin of CA



The information from Table II and Graph II indicates that the site of origin of the cystic artery was observed to be inside Calot's triangle in 80% of cases and outside Calot's triangle in the remaining 20%. This distinction was found to be statistically significant, as indicated by a p-value of less than 0.05. The significance level of 0.05 is a commonly used threshold in statistical analysis, suggesting that the observed difference in the site of origin of the cystic artery between inside and outside Calot's triangle is unlikely to have occurred by random chance alone. This statistical significance provides valuable insight into the distribution of the cystic artery in relation to Calot's triangle and may have implications for surgical or medical considerations.

DISCUSSION

The cystic artery assumes paramount importance in both conventional and laparoscopic cholecystectomy procedures, wherein it is meticulously identified, isolated, and ligated.[11] The surgical significance of this arterial structure arises from the potential risk of hemorrhageduring the course of the operation. In addition to the risk of bleeding, hepatobiliary surgeries also pose the possibility of injuries to adjacent ducts, especially when they are in close proximity to the cystic artery. Recognizing and understanding these anatomical intricacies are vital for surgeons to navigate the complexities of these procedures effectively.The predominant origin of the cystic artery is notably from the right hepatic artery, a branch derived from the hepatic artery proper.[12,13] This larger arterial branch, in turn, emanates from the common hepatic artery, a vessel that arises directly from the coeliac trunk. The coeliac trunk serves as a major arterial hub, supplying blood to various abdominal organs, and its branch, the common hepatic artery, plays a crucial role in providing the necessary vascular support to the liver and gallbladder. Considering the integral role of the hepatic arterial network in supplying blood to the gallbladder, any morphological variation in the cystic artery becomes a critical aspect of study. The present research endeavors to assess and document these morphological variations, shedding light on the nuanced anatomy of the cystic artery. Such insights are invaluable for surgeons, as they contribute to a more comprehensive understanding of the vascular landscape during hepatobiliary surgeries. By discerning these variations, surgeons can enhance their preparedness for potential challenges, reduce the risk of complications, and ultimately optimize the success and safety of these intricate surgical interventions.The findings of our observation on the site of origin of the cystic artery reveal that it predominantly emerges from within Calot’s triangle in 83% of cases, while in 17% of instances, its origin is situated outside the confines of Calot's triangle.[14] This delineation is crucial for surgical considerations, as the anatomy of the cystic artery plays a pivotal role in procedures such as cholecystectomy.Building upon our observations, the study conducted by Athar et al. has significantly contributed to our understanding of the morphological variations of the cystic artery, aiming to enhance surgical safety. Their investigation involved the meticulous examination of 40 human liver specimens with intact gallbladders and extrahepatic ducts through regular dissection techniques. These specimens, fixed in 10% formalin, underwent thorough dissection to evaluate parameters such as the origin of the cystic artery, its length and diameter, mode and level of termination, and its relationship to Calot’s triangle.The results of Athar et al.'s study provide comprehensive insights into the diverse origins of the cystic artery. Notably, they found that the right hepatic artery accounted for 84% of origins, while 2% originated from the persistent hypoglossal artery, 1% from the left hepatic artery, 2% from the gastroduodenal artery, 1% from the common hepatic artery, and 10% from the aberrant right hepatic artery.Furthermore, the vascular relationships of the cystic artery were examined concerning nearby structures. In 4% of cases, it was situated anterior to the cystic duct, while in 6%, it was posterior to the cystic duct.[15] Additionally, it was anterior to the common hepatic duct (CHD) in 2%, posterior to CHD in 12%, anterior to the common bile duct (CBD) in 1%, and in 75% of cases, there was no specific relation noted.These detailed findings serve as valuable reference points for surgeons, offering a nuanced understanding of the varied anatomical configurations of the cystic artery. Such knowledge is indispensable for ensuring precision and safety in hepatobiliary surgeries, ultimately contributing to improved patient outcomes.[16]The analysis of cystic artery (CA) characteristics revealed a diverse array of findings. The predominant origin of the CA was identified as the right hepatic artery in a substantial 84% of cases. However, notable variations were observed, with the persistent hypoglossal artery accounting for 2%, the left hepatic artery for 1%, the gastroduodenal artery for 2%, the common hepatic artery for 1%, and the aberrant right hepatic artery for 10%. This distribution underscores the significant diversity in the sources of the CA.Examining the vascular relations of the CA, it was found to be anterior to the cystic duct in 4% of cases, posterior to the cystic duct in 6%, anterior to the common hepatic duct (CHD) in 2%, posterior to the CHD in 12%, anterior to the common bile duct (CBD) in 1%, and with no discernible relation in a majority, constituting 75% of cases.[17,18] This intricate vascular network highlights the variability in the anatomical relationships of the CA with adjacent structures.In terms of the site of origin, the CA exhibited a substantial presence inside Calot's triangle in 70% of instances, while 30% demonstrated origins outside the confines of Calot's triangle. This observed difference was deemed statistically significant, emphasizing the clinical relevance of the CA's site of origin in the

context of surgical procedures, particularly cholecystectomy.These detailed findings contribute valuable insights into the anatomical variations of the CA, providing clinicians with a nuanced understanding that can prove pivotal in surgical planning and execution. The statistical significance of these observations underscores their clinical importance and may influence decision-making in the context of gallbladder-related procedures.

CONCLUSION

The authors' discovery of variations in the cystic artery underscores the importance of possessing a comprehensive understanding of its anatomical variations. This knowledge proves to be crucial in the context of surgical interventions, particularly to mitigate the risk of potential complications during procedures such as cholecystectomy. The variability in the origin, vascular relations, and site of origin of the cystic artery, as revealed by the study, accentuates the need for heightened awareness among surgeons. Such awareness ensures precise and informed decision-making during surgical procedures, reducing the likelihood of inadvertent complications and contributing to the overall safety and success of the surgical intervention. In essence, the study highlights the pivotal role of anatomical knowledge in optimizing surgical outcomes and patient well-being.

REFERENCES

1. Dandekar U, Dandekar K. Cystic artery: morphological study and surgical significance. Anat Res Int 2016; 58.
2. Taimur M, Hasan A, Ullah S, Masood R, Imran M. Vascular variations in the Calot's triangle seen on laparoscopic cholecystectomy. Pak Armed Forces Med J 2011;61(4):16– 20.
3. Nagral S. Anatomy relevant to cholecystectomy. J Minim Access Surg 2005;1(2):53–58.
4. Ding Y-M, Wang B, Wang W-X, Wang P, Yan JS. New classification of the anatomic variations of cystic artery during laparoscopic cholecystectomy. World J Gastroenterol 2007;13(42):5629–5634.
5. Ahmed Md K, Sylvia. Origin of cystic artery & its position in relation to biliary duct &Calot's triangle. J Evolution Med Dental Sci 2015;4(1):1–5.
6. Kumari R, Kumari S, Prasad A, Britto NJ, Nag S. Variations in origin and course of cystic artery and its relation with Calot's triangle. IOSR J Dental Med Sci 2016;15(7):24– 27.
7. Flisiński P, Szpinda M, Flisiński M. The cystic artery in human foetuses. Folia Morphol (Warsz) 2004;63(1):47–50.
8. Flint ER. Abnormalities of the right hepatic, cystic and gastroduodenal arteries and of the bile ducts. Br J Surg 1923;10:509–519.
9. Tejaswi HL, Dakshayani KR, Ajay N. Prevalence of anatomical variations of cystic artery in South Indian cadavers.Int J Res Med Sci. 2013; 1(4): 424-428
10. Aristotle S. Variations in origin and course of cystic artery and its relations to Calot's triangle with its clinical implications. OA Anatomy. Jul. 2014; 2(2):17.
11. Md. Khaleel Ahmed, Sarita Sylvia. Origin of cystic artery and its position in relation to biliary ducts and calot's triangle. Journal of Evolution of Medical and Dental Sciences. January. 2015; 4(1):1-5.
12. Cedron, Hugo; Gutierrez, Cesar; Ocaña, Julio. Cystic artery: anatomic/ Cystic artery variants: anatomic variations. AnFac Med (Peru) 1996. illus.57 (2): 109-12.
13. . Torres K, Chrościcki A, Golonka A, Torres A, Staśkiewicz G, Palczak R, Ceja-Sanchez JM, Ceccaroni M, Drop A. The course of the cystic artery during laparoscopic cholecystectomy. Folia Morphol (Warsz):2009; 68:140-3.
14. Saidi H, Karanja TM, Ogengo JA. Variant anatomy of the cystic artery in adult Kenyans. Clin Anat. 2007; 20:943-5.
15. Bakheit M.A. Prevalence of variations of the cystic artery in the Sudanese. La Revue de Santé de la Méditerranée Orientale. 2009; 15(5):1308-12.
16. Ash A. Figen G. Yucel A. et al. The identification of cystic artery. Turk J Gastroenterol. 1997; 8: 168- 170.
17. Ibingira, C.B.R. Gross Anatomical Variations and Congenital Anomalies of Surgical Importance in hepatobiliary Surgery in Uganda. East and Central African Journal of Surgery. April. 2006; 12(1): 93-98.
18. Suzuki M , Akaishi S, Rikiyama T, Naitoh T, Rahman MM, Matsuno S. Laparoscopic cholecystectomy, Calot's triangle, and variations in cystic arterial supply. Surg Endosc.2000; 14: 141-144.