

Received: 2024.11.11
Accepted: 2025.02.27
Available online: 2025.03.31
Published: 2025.05.11

Anatomical Challenges in Laparoscopic Cholecystectomy: Five Arterial Branches from a Right Hepatic Caterpillar Hump

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Financial support: None declared
Conflict of interest: None declared

Patient: Male, 49-year-old
Final Diagnosis: Symptomatic cholelithiasis
Symptoms: Biliary colic
Clinical Procedure: —
Specialty: Surgery

Objective: Rare disease
Background:





Caterpillar hump, also referred to as Moynihan's hump, is a right hepatic artery with tortuous course within the Calot's triangle, which carries a major risk of accidental injury and ligation during laparoscopic cholecystectomy. Its already rare incidence (about 3.81%), in association with the typical presence of 1 or 2 cystic arteries, makes our case unique since it involves a caterpillar hump with 5 distinct arterial branches.

Case Report: We report a case of caterpillar hump detected during elective laparoscopic cholecystectomy for symptomatic cholelithiasis in a 49-year-old man. A large vessel-like structure with an uncertain termination was initially identified after the hepatocystic triangle dissection. The structure was eventually discovered to have a helical route and re-enter the liver. Although more than 2 elements entered the gallbladder, which exceeded the 'critical view of safety' requirements, a thorough dissection was performed. The surgery is successfully completed when all branches end up in the gallbladder.

Conclusions: This report summarizes the clinical and surgical importance of the caterpillar hump, highlighting the necessity for precise anatomical knowledge and the implementation of a "culture of safety" to prevent complications. The concept of "structure" in achieving the "critical view of safety" must encompass its variations and anomalies. Therefore, surgeons must be aware of the potential for multiple arterial branches supplying the gallbladder.

Keywords: Laparoscopy • Hepatic Artery • Cholelithiasis • Cholecystectomy • Anatomy

Full-text PDF: <https://www.amjcaserep.com/abstract/index/idArt/947240>

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Introduction

The anatomical feature known as “caterpillar hump” or “Moynihan’s hump” is a notable gross anatomical finding of the right hepatic artery (RHA), which exhibits a tortuous course along Calot’s triangle, typically close to the neck of the gallbladder. This anatomical relationship can lead to formation of a short cystic artery, thereby increasing the risk of an accidental injury or ligation of right hepatic artery, as may be mistakenly regarded as the cystic artery [1]. Its incidence is reported to be between 1.3% and 13.3% [2,3], and according to a recent metanalysis, it was found in 3.81% of 8418 cases [4].

We present a case of a patient undergoing elective laparoscopic cholecystectomy in which an unexpected finding was noted: a caterpillar hump with 5 arterial branches. This peculiarity of multiple branches of an already rare variant makes this case extremely rare, confirms the diversity of the anatomy of the biliary tree, and further enhances knowledge of the morphological features of caterpillar hump.

Case Report

A 49-year-old man with a history of Gilbert syndrome and no other known comorbidity was evaluated in the Emergency Department due to an episode of biliary colic. During the evaluation of the incident, an upper-abdominal ultrasound revealed multiple gallbladder microlithiasis without evident signs of inflammation. Additionally, liver function tests showed derangements. The patient underwent a routine preoperative assessment, which included an MRCP, which showed no additional findings concerning the biliary tree. Two months later, he had an elective laparoscopic cholecystectomy performed using 4 trocars, video recorded and supervised by a second specialist to ensure confirmation of the critical view of safety (CVS) before clipping, in accordance with our department’s standard protocol.

Once the hepatocystic triangle was dissected in the anterior plane, a vessel-like structure was identified adjacent to the gallbladder wall, exhibiting an upward course, an unusually large diameter, and an unclear termination (**Figure 1A**). A second structure presumed to be the cystic duct was also recognized. The gallbladder was partially mobilized away from the cystic plate on the anterior and posterior planes, and a careful clearance of fibrofatty tissues within the triangle was performed to increase visibility of all critical structures. Consequently, an aberrant anatomical variation was observed, as the first structure was noted to re-enter the liver behind the gallbladder fundus. It exhibited a tortuous course, especially when grasping was released, while 5 small branches were observed entering the gallbladder (**Figure 1B, 1C**).

During a short intraoperative time-out, the entire surgical team concluded they were encountering a possible RHA exhibiting a “caterpillar hump” giving rise to multiple fine cystic arteries. There was no doubt about the orientation of all structures involved, as the detachment from the liver bed extended beyond three-fifths, and the entire triangle was cleared. More than 2 structures were present in both planes, which was contrary to the CVS requirements before clipping. However, all of them were directed toward the gallbladder. Each arterial branch, along with the cystic duct, was clipped separately and divided. The patient was discharged 1 day later, with an uneventful postoperative recovery. Two months after discharge, he had fully resumed his regular activities and dietary routine.

Discussion

When one of the most commonly performed operations in the field of general surgery encounters the unpredictable and fascinating diversity of biliary and vascular anatomy, the existing analogies between the revealed anatomical structures and various creatures of the animal kingdom can ignite our imagination. Additionally, during an elective laparoscopic cholecystectomy performed at our hospital, we encountered an unexpected finding: in addition to the well-known variant of the RHA caterpillar hump, there were 5 arterial branches resembling the legs of a caterpillar, which typically has 3 pairs of legs.

According to a systematic review by Marano et al, the artery is located posteriorly to the common hepatic duct in 60% of cases and anteriorly in 40%, forming a single loop in 55% of cases and a double-loop in 45%, respectively [5]. A recent systematic review and metanalysis by Asghar et al found that the posterior hump in relation to the common bile duct (CBD) was 3 times more common than the anterior one [4]. Typically, the cystic artery emerged from the distal limb and was also extremely short when the hump was double looped in 90% of cases [4]. In addition, when a single loop is present, the cystic artery can arise proximally and cross over the RHA before entering the gallbladder [3-6].

According to the Nagpur Classification, as referenced by Rahate et al, caterpillar humps can be categorized as supracystic, paracystic, or infracystic, based on their relationship to the cystic duct. Additionally, each category may be further classified into anterior or posterior humps, depending on the position of the hump relative to the CBD or to the common hepatic duct (CHD). Supracystic and infracystic humps have only 1 long cystic artery, which bifurcates into anterior and posterior branches. In contrast, paracystic humps have shorter anterior and posterior cystic arteries that originate separately [7].

Based on the above classification and the intraoperative images (**Figure 1A-1E**), the caterpillar hump of our patient was

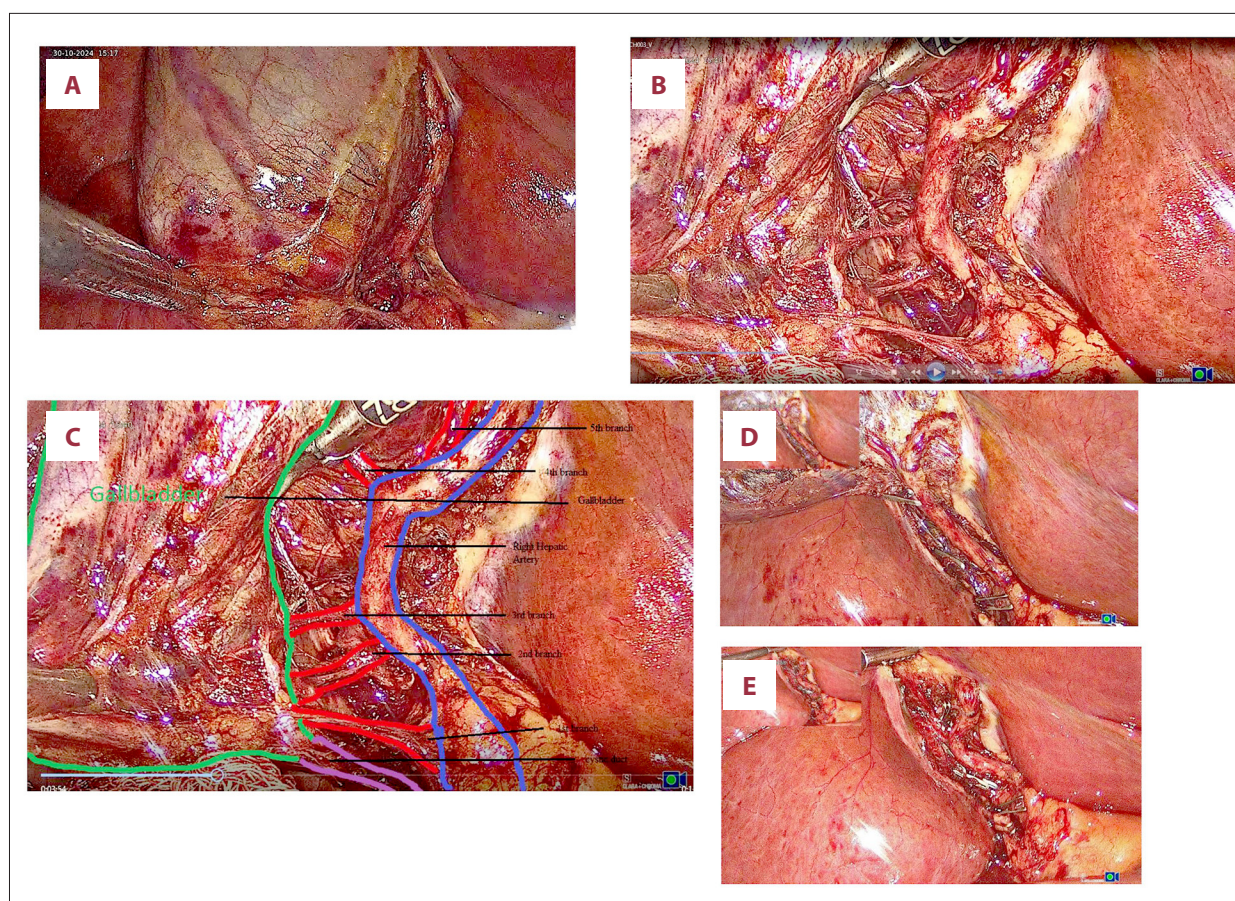


Figure 1. Operative screenshots. (A) An anterior view of the primary steps of dissection through the anterior plane. A vessel-like structure was thought to be a caterpillar hump. (B) An anterior view of the expected critical view of safety. (C) An anterior view of the expected critical view of safety with highlights. (D) The anterior view of the clipped cystic duct and of the 4 out of 5 arteries, with the grasping still in place. The right hepatic artery exhibits a more linear form. (E) The anterior view at the end of the resection reveals a fully visible caterpillar hump.

classified as a supracystic one, and it is an extremely rare variant, on the one hand because it had 5 distinct arterial branches compared to the 'only 1' cystic artery, and on the other hand, because according to Rahate et al, numerous cystic arteries result from a paracystic caterpillar hump [7].

Both intraoperative and postoperative outcomes highlight the clinical and surgical importance of possible RHA damage. Strasberg et al noted that an injury to the right hepatic artery causes right liver infarction in only 10% of cases. Consequently, repair of the vessel is not always feasible or valuable [8]. On the other hand, the ligation, cauterization, or sectioning of the RHA can lead to right liver ischemia, atrophy, and hepatic necrosis or abscess formation [9]. The condition may also lead to stenosis of the CBD as a result of ischemia, which can consequently result in recurrent episodes of cholangitis and potentially progress to cirrhosis [10]. Furthermore, a partial vascular injury may result in the formation of a hepatic artery pseudoaneurysm, which can cause significant and potentially

fatal hemorrhage in the late postoperative period [11]. It is also crucial to recognize that any vascular injury can lead to bleeding during laparoscopy, which can compromise the visibility of the operative field. Attempts to control this bleeding through blind hemostasis or clipping can inadvertently result to CBD injury [12].

A significant concern that emerges is the ambiguity surrounding the terminology used in relation to intraoperative findings. One must consider whether caterpillar hump is merely a variant of abnormal gross anatomy or if it is an abnormal (replaced or accessory) right hepatic artery exhibiting a helical configuration within the triangle. As noted by Marano et al, the incidence of a right accessory hepatic artery originating from the superior mesenteric artery is 18.3%, which is close to the worldwide incidence of the hump, recorded at 6.9% [5]. Asghar et al concluded that anastomosing channels between the proper hepatic artery and the right accessory hepatic artery can form a caterpillar hump on the right hepatic artery [4]. That observation

was based on Andall et al's documentation of a connection between the various abnormal origins of single and double cystic arteries and those multiple anastomoses [13], which suggests that a caterpillar hump is usually a sign of an abnormal right hepatic artery, but not always vice versa.

A secondary consideration pertains to whether intraoperative gallbladder traction during laparoscopic cholecystectomy, which is predicated on the fundamental principles of tension and counter-tension, as well as the dissection and detachment of tissues and major structures, can transiently alter the morphology of the RHA, rendering it less tortuous. In our case, it was clear that the initial, more linear shape of the RHA (**Figure 1D**) transformed into a pronounced curvature following further dissection of the major vessel and ligation of the 5 arterial branches at the end of resection. Consequently, the RHA may be more accurately described as a caterpillar hump (**Figure 1E**). Marano et al noted that the similar incidence of the caterpillar hump observed in both cadaveric and operative groups (6.9% vs 7%) suggests that surgical maneuvers are unlikely to induce significant vascular aberrations [5].

A final concern pertains to the definitiveness of the term "2 and only 2" structures, which is 1 of the 3 criteria of the "critical view of safety" concept. What happens in cases where there are 2 or more arterial branches that all supply the gallbladder, as observed in our patient? Strasberg et al suggested that a significant contributor to bile duct injury is misidentification of the bile duct as either the cystic duct or the artery [14], and described the CVS concept around 30 years ago [8]. The CVS is not always feasible, as in the presence of anatomical variations or in cases of advanced cholecystitis, which can increase surgical difficulty and the associated morbidity [15]. Consequently, CVS appears to have some limitations and it should be integrated into a general culture of safety in cholecystectomy. This integration should include a thorough understanding of intense anatomical structures, the application of appropriate techniques, and education on the possible mistakes and the bail-out strategies in difficult cases [16]. The surgical team needs to be aware of the "culture of safety in cholecystectomy" concept (COSIC) [17,18]. To prevent fatal complications and carry out a safe operation, surgeons facing over 2 structures inside Calot's triangle must fully understand the

RHA anatomy and alterations [4]. Vascular variations of the cystic and right hepatic artery are considered to be an anatomical risk factor for vascular injuries [19].

Understanding surgical anatomy in laparoscopic cholecystectomy is critical for recognizing non-typical structures, as in our case. The proper use of the CVS, as well as knowledge of specific anatomy, assists surgeons in correctly managing these additional structures and preventing serious vascular or biliary injury [20].

After discussion among the members of our department, it was decided that this specific case would be discussed at the next meeting of the Hellenic Task Force on the Typology of Safe Laparoscopic Cholecystectomy (HETALCHO).

Conclusions

When assessing the concept of "structure," one should include its variants and its aberrations. Additionally, the philosophy of safe cholecystectomy is restated as a consequence of operative security control, in particular when it involves multiple components such as a bile vessel and over 2 cystic arteries that enter the gallbladder. Even 5 cystic arteries are possible, and understanding of this variance, as well as meticulous dissection of these structures in the hepatocystic triangle, should coexist nicely with CVS principles. We regard this assumption to be a deeper understanding of the CVS concept, rather than an exception to its principles.

Patient Consent

The patient has provided written informed consent for the publication of this case report, which includes the accompanying images.

Declaration of Figures' Authenticity

All figures submitted have been created by the authors who confirm that the images are original with no duplication and have not been previously published in whole or in part.

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