

## Preservation of the cystic artery during laparoscopic cholecystectomy: Current state of the problem

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**Background.** Laparoscopic cholecystectomy remains the standard surgical treatment for gallstone disease; however, injuries to the extrahepatic bile ducts and combined vasculobiliary complications continue to represent a serious clinical problem. In most cases, these complications are associated with erroneous identification of anatomical structures within the hepatocystic triangle. In this context, increasing attention is being paid to the concept of safe cholecystectomy and to organ-preserving elements of surgical technique, including preservation of the cystic artery.

**Aim.** To analyze the current state of the problem of cystic artery preservation during laparoscopic cholecystectomy and to assess the level of evidence of the available data.

**Materials and methods.** A review of domestic and international publications was conducted, focusing on the anatomical variability of the cystic artery, the principles of the Critical View of Safety, methods of its intraoperative control, and vascular complications of laparoscopic cholecystectomy. Recommendations of international professional societies and data from clinical studies were also analyzed.

**Results.** The literature demonstrates a high degree of anatomical variability of the cystic artery, which increases the risk of intraoperative bleeding and misidentification. The Critical View of Safety is recognized as a key element of safe laparoscopic cholecystectomy and as a methodological basis for determining the optimal management of the cystic artery. Despite the availability of studies addressing various methods of intraoperative vascular control, targeted preservation of the main trunk of the cystic artery remains insufficiently investigated. Direct comparative clinical studies based on the “preservation versus division” principle are scarce, and the overall level of evidence is limited.

**Conclusion.** The strategy of preserving the cystic artery during laparoscopic cholecystectomy remains inadequately studied. The absence of standardized protocols and unified patient selection criteria highlights the need for further clinical research, with mandatory adherence to the principles of the Critical View of Safety, in order to improve the safety of surgical treatment.

**Keywords:** laparoscopic cholecystectomy; cystic artery; Critical View of Safety; safe cholecystectomy; vasculobiliary complications.

**Introduction.** Laparoscopic cholecystectomy (LC) currently remains the standard surgical treatment for gallstone disease and chronic calculous cholecystitis [1,2]. Despite the widespread adoption of endovideosurgical technologies and continuous refinement of operative techniques, the most severe complications of LC continue to be injuries to the extrahepatic bile ducts as well as combined vasculobiliary injuries [1,6]. In a significant proportion of cases, these complications are attributable not to technical errors per se, but to erroneous identification of anatomical structures within the hepatocystic triangle [1,7]. In this regard, the concept of safe cholecystectomy has evolved over recent decades primarily toward the standardization of anatomical identification and the minimization of tissue trauma [2,7].

**Anatomical Features and Variability of the Cystic Artery.** In the majority of cases, the cystic artery originates from the right hepatic artery; however, its position, course, and number of branches are characterized by marked anatomical variability [8,9]. Clinical series and morphological studies have described in detail such variants as the presence of a double cystic artery, atypical arterial origin, passage outside the “classical” Calot’s triangle, as well as diverse relationships with the cystic duct, common hepatic duct, and common bile duct [8,9]. These anatomical features are considered common and are regarded as significant

risk factors for intraoperative bleeding and the forced use of hemostatic maneuvers within an anatomically hazardous area [8,11].

The practical significance of this aspect lies in the fact that pronounced anatomical variability of the cystic artery substantially complicates its dissection, particularly in the presence of inflammatory changes, increases the likelihood of erroneous clipping or coagulation of the vessel, and necessitates clear definition of criteria for the technical feasibility of its preservation [8,11]. This is of particular importance when designing and conducting studies focused on organ-preserving elements of laparoscopic cholecystectomy technique.

**Critical view of safety as the basis of safe laparoscopic cholecystectomy.** One of the key milestones in the development of the safe laparoscopic cholecystectomy concept was the introduction of the Critical View of Safety (CVS) principle, proposed by S. Strasberg as an alternative to the infundibular dissection technique [2]. This principle requires fulfillment of a set of conditions under which, prior to clipping or division of any structures, the surgeon can confidently identify only two anatomical structures entering the gallbladder – the cystic duct and the cystic artery. Adherence to these conditions significantly reduces the risk of misidentification and, consequently, of severe iatrogenic injuries [2,4].

Contemporary multisociety guidelines, including documents issued by SAGES and other professional surgical associations, emphasize the CVS principle as the preferred standard for anatomical identification and a cornerstone of the “safe cholecystectomy” culture [7]. At the same time, the use of so-called “bail-out” strategies is recommended in situations where achieving CVS is not feasible due to severe inflammation, dense adhesions, tissue friability with bleeding, or altered anatomy [3,5,7].

Within the context of the present topic, the CVS principle is of fundamental importance because, on the one hand, it establishes uniform criteria for the quality of dissection, without which comparison between cystic artery preservation and division strategies becomes methodologically unsound. On the other hand, it allows for standardization of patient inclusion in clinical studies, by analyzing either only cases in which CVS has been achieved or the feasibility of achieving CVS itself as an independent endpoint [2,4].

**“Difficult” laparoscopic cholecystectomy and bail-out strategies.** Particular attention to the safety of laparoscopic cholecystectomy is given in the Tokyo Guidelines 2018, which provide a detailed description of the operative steps in the management of acute cholecystitis [3]. The authors emphasize the necessity of switching to alternative surgical strategies, including subtotal cholecystectomy and other bail-out approaches, in cases where achieving the Critical View of Safety is not possible [3,5]. This principle is also of fundamental importance for studies focusing on cystic artery preservation, as it underscores that organ-preserving elements of surgical technique are justified exclusively under conditions of controlled and safe dissection. In “difficult” clinical scenarios, the primary priority remains the prevention of severe iatrogenic injuries rather than the preservation of individual anatomical structures.

**Current approaches to cystic artery management during laparoscopic cholecystectomy.** Most traditional laparoscopic cholecystectomy techniques involve clipping and dividing the cystic artery. At the same time, the literature includes comparative studies addressing various methods of hemostasis and vascular control during LC [10,11]. In particular, outcomes of ultrasonic and other energy devices have been evaluated in comparison with conventional cystic artery clipping, and so-called “clipless” LC techniques using harmonic or ultrasonic instruments have been described. Such studies typically assess operative time, intraoperative blood loss, complication rates, and the need for conversion, including in specific patient subgroups, for example those with liver cirrhosis [10].

These studies are relevant to the present work because they demonstrate the variability of approaches to cystic artery management and support the notion that surgical strategy is not limited to mandatory clipping and division of the vessel. Moreover, they help define a set of objective endpoints applicable to comparisons of cystic artery preservation versus division, including blood loss, operative time, frequency of hemostatic maneuvers, and postoperative complications [10,11].

**Cystic artery preservation: evidence from the literature and level of proof.** Studies in which preservation of the main cystic artery is considered a deliberate and intentional surgical strategy are reported far less frequently than publications focused on the Critical View of Safety or anatomical variability [2,4,8]. Nevertheless, there are reports and clinical series describing a practice of abandoning active pursuit and routine division of the cystic artery, instead clipping its branches “as encountered.” In essence, this approach approximates the concept of preserving the main trunk of the cystic artery in a subset of cases and highlights the need to evaluate the clinical outcomes associated with such a strategy [10].

Overall, the current evidence base regarding cystic artery preservation is characterized by a limited number of direct comparative clinical studies, predominance of observational descriptions, and reliance on indirect data derived from CVS principles and the “safe cholecystectomy” concept. It also underscores the need for clear standardization of both operative technique and patient selection criteria, primarily with respect to the feasibility of achieving CVS [2,4,7].

**Vascular complications and the clinical significance of a tissue-sparing strategy.** Although the majority of vascular complications associated with laparoscopic cholecystectomy are limited to intraoperative bleeding, the literature also describes rare but clinically significant events, such as pseudoaneurysm of the cystic artery stump [11,12]. This condition may manifest as gastrointestinal bleeding or hemobilia and typically requires endovascular or surgical intervention [12]. While such reports do not allow a direct demonstration of the superiority of cystic artery preservation over its division, they underscore the clinical importance of meticulous handling of the vessel, appropriate selection of energy sources, and minimization of arterial wall injury, particularly in the setting of inflammation or infected collections.

**Conclusion.** Analysis of the contemporary literature indicates that the safety of laparoscopic cholecystectomy is currently based on adherence to the Critical View of Safety standards and the safe cholecystectomy concept. The cystic artery demonstrates marked anatomical variability, which increases the risk of bleeding and misidentification. Methods of vascular control – including clipping, the use of energy devices, and clipless approaches – have been investigated far more extensively than strategies aimed at preserving the main trunk of the cystic artery. At present, direct comparative data following the “preservation versus division” paradigm remain insufficient; however, the existence of registered clinical studies confirms the relevance of this scientific direction [1-4,7,8].

Accordingly, a comparative evaluation of laparoscopic cholecystectomy with cystic artery preservation versus division, with mandatory standardization of dissection according to the Critical View of Safety principle and appropriate patient selection, represents a logical and timely focus for further clinical research.

Thus, the available evidence suggests that the safety of laparoscopic cholecystectomy is largely determined by strict compliance with the principles of the Critical View of Safety and the safe cholecystectomy concept. Despite well-documented anatomical variability of the cystic artery and the availability of data on various methods of its intraoperative control, the strategy of deliberate preservation of the main cystic artery trunk remains insufficiently studied. The limited number of direct comparative clinical studies, together with the absence of unified patient selection criteria and standardized operative protocols, underscores the need for further investigations in this field. In this context, comparative assessment of laparoscopic cholecystectomy with cystic artery preservation versus division, with obligatory standardization of dissection and achievement of the Critical View of Safety, appears to be a justified and promising direction for clinical research aimed at improving the safety and effectiveness of surgical treatment for gallstone disease.

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