CRITICAL VIEW OF SAFETY (CVS) DURING LAPAROSCOPIC CHOLECYSTECTOMY: MODERN APPROACHES TO THE PREVENTION OF BILIARY AND VASCULAR DAMAGE

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ABSTRACT.

Laparoscopic cholecystectomy is the standard treatment for most benign gallbladder diseases. Despite the development of minimally invasive surgery, iatrogenic damage to the extrahepatic bile ducts remains one of the most serious complications. The key reason is the erroneous identification of anatomical structures in the area of the hepatocystic triangle. The Critical View of Safety (CVS) concept offers a standardized way to confirm anatomy before clipping and intersecting the cystic duct and cystic artery. The purpose of this review is to summarize current data on the three criteria of CVS, its role in the prevention of bile duct damage, objective photo and video assessment, intraoperative imaging, and bailout tactics when it is impossible to safely achieve CVS. An analysis of modern publications shows that CVS is associated with a reduced risk of general and severe damage to the bile ducts compared with infundibular technique. However, CVS does not eliminate the risk completely and requires a proper understanding of all three criteria, quality control, and timely termination of dangerous dissection. If it is impossible to obtain a CVS, the priority is to re-evaluate the anatomy, additional imaging, the help of an experienced surgeon and, if necessary, bailout procedures, primarily subtotal cholecystectomy.

Keywords: Critical View of Safety; laparoscopic cholecystectomy; damage to the bile ducts; cystic duct; cystic artery; hepatocystic triangle; subtotal cholecystectomy; intraoperative cholangiography.

INTRODUCTION

Laparoscopic cholecystectomy (LCE) has become the standard of surgical treatment for symptomatic cholecystolithiasis, chronic and acute calculous cholecystitis, and a number of other gallbladder diseases. At the same time, the safety of the operation is determined not only by the minimal invasiveness of access, but above all by the correct identification of anatomical structures.

Iatrogenic bile duct injury (BDI) is a rare but potentially catastrophic complication. Its consequences may include bile flow, biliary peritonitis, strictures, recurrent cholangitis, the need for reconstructive surgery, and long-term follow-up. The modern concept of security has therefore shifted from the search for a "typical anatomy" to evidence-based identification of structures before crossing them.

In the 1990s, S. Strasberg formulated the concept of Critical View of Safety (CVS). Its principle is that before the intersection of the cystic duct and the cystic artery, the surgeon must create conditions to ensure that the hepatocystic triangle is cleared, the lower third of the gallbladder is separated from the liver with visualization of the cystic plate, and only two structures enter the gallbladder.

Currently, CVS is the centerpiece of safe cholecystectomy programs. SAGES and the international expert consensus recommend CVS as the main method of identifying the cystic duct and cystic artery, and also emphasize the need for a surgical pause before clipping, taking into account atypical anatomy and a low threshold for intraoperative imaging.

At the same time, the implementation of CVS remains heterogeneous. Some surgeons do not meet all three criteria, while others subjectively consider CVS achieved, although an independent evaluation of the video shows insufficient visualization. This creates the need for objective documentation and standardized training.

MATERIALS AND METHODS

The work is performed as an analytical review of the literature with a transparent description of the search strategy and the structuring of sections on IMRAD. For systematic reviews of PRISMA 2020, it is recommended that databases, search strategies, inclusion and exclusion criteria, and the data selection and synthesis process be described separately. This work is not claimed to be a registered systematic review or meta-analysis, as independent double screening, a formal assessment of the risk of systematic error of all studies, and a quantitative de novo meta-analysis were not performed.

The search was conducted using PubMed/MEDLINE using combinations of terms: “critical view of safety", “laparoscopic cholecystectomy", “bile duct injury", “cystic duct”, “cystic artery", “safe cholecystectomy", “subtotal cholecystectomy", “intraoperative cholangiography", “indocyanine green", “video assessment”, “photographic documentation". Additionally, SAGES documents and key publications identified by the literature lists were taken into account.

Priority was given to systematic reviews and meta-analyses, international recommendations, multicenter studies, prospective cohort studies, and objective evaluation of surgical video. Current SAGES materials, including recommendations for intraoperative imaging of the common bile duct, were taken into account for clinical recommendations.

RESEARCH METHODOLOGY.

Three mandatory CVS Criteria.

CVS is considered achieved only if three conditions are met simultaneously:

• The hepatocystic triangle is cleared of fat and fibrous tissue so that the anatomical structures are visible.

• The lower third of the gallbladder is separated from the liver to visualize the cystic plate.

• The gallbladder visually includes only two structures — the cystic duct and the cystic artery.

The key principle is not just to visualize the alleged cystic duct, but to obtain evidence that the identified structure is indeed a cystic duct. That is why the infundibular "confluence" of the duct into the neck of the bladder should not be used as the only identification criterion.

CVS and the risk of damage to the bile ducts.

A systematic review by Manatakis et al. It included 150 publications on CVS; a quantitative analysis of 11 studies covered 10,938 operations. CVS was achieved in 92.5% of cases, and CVS-related bile duct damage accounted for 0.09%. The authors concluded that the routine use of CVS reduces the risk of BDI, but does not completely eliminate it, and recommended high-quality visual documentation.

The meta-analysis by Aburayya et al., published in 2025, included 13 studies and 4,837 patients. Compared with the infundibular technique, CVS was associated with a reduction in the overall risk of BDI (RR 0.36; 95% CI 0.18–0.71) and severe BDI (RR 0.28; 95% CI 0.13–0.63). There were no differences in minor BDI, surgery time, conversion, and duration of hospitalization.

Why the damage occurs: identification error.

The main problem that CVS is designed to solve is the erroneous visual interpretation of anatomy. With inflammation, fibrosis, bleeding, gallbladder deformity, or the presence of abnormal vessels, spatial relationships may differ significantly from those expected. Simply following the "usual location" of the cystic duct increases the risk of clipping of the common bile duct or common hepatic duct.

Modern anatomical literature confirms the significant variability of the cystic artery and cystic duct. Therefore, safety should be based on the principle of evidence-based identification, rather than on the assumption of a typical anatomy.

Factors making it difficult to achieve CVS.

Clinical and ultrasound signs associated with the difficulty of achieving CVS include severe inflammation, the emergency nature of the operation, thickening of the gallbladder wall, and an embedded concretion. In a prospective study of 273 patients, CVS was achieved in 238 (87.2%); predictors of failure included age, male gender, higher ASA, positive Murphy's symptom, emergency surgery, wall thickening >3 mm, and an embedded stone.

Photo and video documentation.

The written record "CVS achieved" does not allow independent verification of the quality of the dissection performed. Therefore, photo and video documentation is becoming increasingly important. The double view is considered particularly informative — the anterior and posterior projections, which make it possible to evaluate the hepatocystic triangle, the cystic plate and the two structures entering the gallbladder.

Research has shown that an objective photo assessment of CVS can reveal discrepancies between the declared and actually achieved level of security. In one large study, satisfactory photo CVS was found in only a fraction of operations, and the availability of high-quality documentation was associated with a lower frequency of BDI.

Objective video assessment and training.

The multinational LC-CVS OPSA validation proposed a 6-component evaluation procedure that includes two retraction elements and four CVS components: visualization of the hepatocystic triangle, separation of the gallbladder from the liver, identification of the

cystic artery and cystic duct. This approach allows the use of operational video recordings for a formative and final assessment of students' skills.

Research also shows that surgeons do not always accurately assess the quality of their own CVS. Therefore, a structured independent video assessment can be more useful than a simple self-assessment.

Surgical pause before clipping.

After receiving the CVS, it is advisable to perform a short "critical view pause" before clipping and crossing structures. The surgeon must reconfirm the three criteria of CVS and the absence of obvious atypical anatomy. Such a pause is an element of the security system and is especially important in complex dissection.

Intraoperative visualization.

CVS and intraoperative imaging are not mutually exclusive methods. If the anatomy is questionable, intraoperative cholangiography and other imaging techniques of the biliary tract may be used. In 2025, SAGES published separate recommendations on the use of intraoperative imaging of the common bile duct. In addition, indocyanin-green fluorescence can be used as an additional visualization tool for biliary anatomy, but should not be considered as a substitute for full-fledged anatomical dissection and CVS.

What should I do if CVS cannot be achieved?

The key principle of complex cholecystectomy is that CVS should not be achieved at any cost. With severe inflammation, dense fibrosis, bleeding, or severe deformity, further dissection may become more dangerous than the most alternative surgery.

• stop further dangerous dissection and reassess the anatomy;
• ensure adequate exposure and hemostasis;
• Use intraoperative imaging when in doubt.;
• involve a more experienced surgeon;
• consider a bailout procedure, primarily subtotal cholecystectomy;
• Conversion to an open transaction should be considered as a security tool, not as a failure.

Modern SAGES recommendations, when it is impossible to achieve CVS and it is impossible to safely identify the anatomy using imaging, suggest considering subtotal cholecystectomy as the preferred bailout strategy compared to continuing risky dissection.

Comparison table.

Approach Main Goal Advantage Limitation.

CVS Anatomical Identification Standardizes safety May not be achievable in severe inflammation.

Infundibular technique Identification by the cervical region is technically simpler The risk of mistaken identity in complex anatomy.

Cholangiography Visualization of the biliary tract Clarifies the anatomy /stones Does not replace the correct dissection.

ICG-fluorescence Optical visualization of bile structures X-ray-free additional method Depends on the technique and does not replace CVS.

Subtotal HE Bailout in case of unsafe dissection Reduces the need for dangerous duct discharge, the risk of bile flow and residual problems.

ANALYSIS AND RESULTS.

Modern data supports CVS as the basic principle of a secure LCE. Its main importance lies not in the specific direction of dissection, but in creating verifiable anatomical evidence before crossing structures.

However, the published data must be interpreted taking into account the limitations. Most of the CVS research is observational; definitions of CVS quality and methods for evaluating it vary. Therefore, it cannot be argued that CVS eliminates BDI. It is more correct to talk about reducing the risk, provided that all three criteria are correctly fulfilled.

A separate problem remains the discrepancy between the knowledge of the concept and its actual implementation. Prospective video studies have shown that a high percentage of surgeons are familiar with the term CVS, but a significantly smaller proportion accurately fulfills all three criteria. This confirms the need for structured learning, video selection, and objective assessment.

An important area of development is the integration of CVS with technological visualization methods. ICG fluorescence and intraoperative cholangiography can complement CVS, especially in cases of questionable anatomy. However, none of these methods negates the fundamental requirement not to cross the structure until its anatomical identity has been proven.

Finally, safety should be assessed not only by the ability to perform a standard cholecystectomy, but also by the surgeon's ability to avoid dangerous dissection in time. A bailout procedure is a manifestation of a correct surgical decision, not a technical failure.

CONCLUSION.

The Critical View of Safety should be considered as a central component of the modern system of prevention of damage to the bile ducts during laparoscopic cholecystectomy. A full-fledged CVS requires the fulfillment of all three criteria: purification of the hepatocystic triangle, visualization of the cystic plate, and confirmation of the presence of only two structures entering the gallbladder.

Modern systematic reviews and meta-analyses demonstrate the advantage of CVS in reducing the risk of general and severe BDI compared to infundibular techniques. At the same time, there remain problems of heterogeneity of execution, subjective assessment and the impossibility of CVS in complex inflammation.

The optimal strategy for safe CCE should include: proper exposure, CVS, a brief pause before crossing, photo/video documentation, consideration of atypical anatomy, a low threshold for intraoperative imaging, and a timely transition to bailout tactics. If safe CVS is not possible, continued aggressive dissection is not justified; subtotal cholecystectomy is one of the key strategies for reducing the risk of catastrophic injury.

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