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Assessing the effect of the critical view of safety criteria on simulated operative decision-making: a pilot study

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Abstract

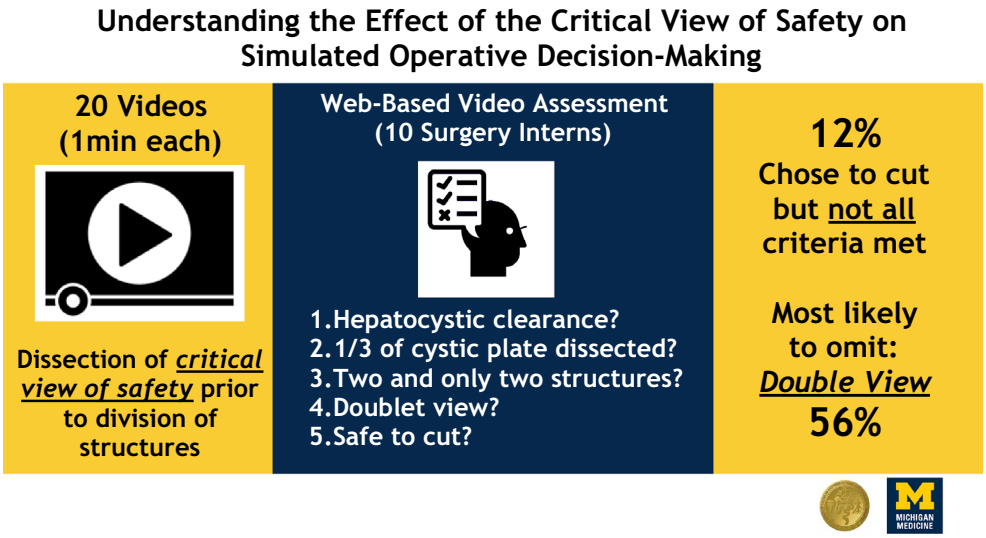
Background Despite well-established criteria for identifying the critical view of safety (CVS) during laparoscopic cholecystectomy, its impact on intraoperative decision-making among trainees is unclear.

Methods General surgery interns ($n = 10$) viewed a training module on the CVS criteria and then independently reviewed 20 cholecystectomy videos lasting 1 min each edited at various points of CVS dissection to include examples of both adequate and inadequate dissections. Participants were asked to identify the following CVS criteria for each video—(1) clearance of fat from the hepatocystic triangle; (2) exposure of the cystic plate; and (3) two and only two structures entering the gallbladder—and then decide if the structures were safe to divide.

Results Inter-rater agreement for each CVS criteria varied: (1) ($k = 0.2510$), (2) ($k = 0.2771$), and (3) ($k = 0.4298$) as did the decision to divide critical structures ($k = 0.371$). Individual mean rate of dividing structures ranged 5–50% and did not correlate with the total number of CVS criteria identified by each participant (Spearman's rho = 0.247, $p = 0.492$). Division of structures with incomplete CVS identification occurred in 15% of cases and was isolated to one participant in the majority of cases (88%). Among these cases, omission of the cystic plate dissection occurred in every instance.

Conclusions Identification of CVS criteria was not uniform with the least amount of agreement on adequate hepatocystic and cystic plate dissection. Individual variation also exists between identification of CVS criteria and likelihood to divide structures. Video-based assessments that include intraoperative decision-making can help assess individual perceptions of safe practices without the risk of harm to the patient.

Graphical abstract



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Keywords Education · Laparoscopic cholecystectomy · Critical view of safety · Video assessment

There are over 750,000 cholecystectomies performed in the United States annually, making it one of the most commonly performed surgical procedures [1]. Laparoscopic techniques have demonstrated to be superior to open surgery with decreased overall complication rates and faster recovery times [2–4]. Despite its advantages, laparoscopic cholecystectomies have been shown to have higher rates of bile duct injury (0.23–0.6%) [5–7] compared to open techniques (0.1–0.2%) [8, 9]. One method for decreasing bile duct injury during laparoscopic cholecystectomy is to establish the critical view of safety (CVS), which was first advocated by Strasberg and Brunt [10]. Establishing the CVS includes clearance of fat and fibrous tissue from the hepatocystic triangle, separation of the lower third of the gallbladder from the liver, exposing the cystic plate, and finally visualizing two and only two structures entering the gallbladder.

Although there is widespread acceptance of the CVS, bile duct injury rates have not changed [5]. This may be due to a knowledge gap regarding the components of the CVS or a perception gap with regard to what constitutes an adequate dissection [11]. Deal et al. created a video-based tutorial on the components of the CVS and demonstrated the ability to educate cohorts of non-surgical volunteers on proper identification of the CVS at the completion of a cholecystectomy using a scoring system [12, 13]. Despite the encouraging results, it is unclear whether trainees agreed on what constituted adequate dissection of each individual CVS criteria and whether it would influence their decision to divide critical structures.

We sought to further examine the effect of using the CVS criteria on safe intraoperative decision-making by assessing how well surgical trainees could identify the CVS criteria when viewing laparoscopic cholecystectomy videos edited at various points of dissection. In addition, we asked trainees whether they felt it was safe to divide the structures identified in the video based on their perceptions of the CVS.

Methods

Video preparation

Following approval from the Institutional Review Board, 20 videos of laparoscopic or robotic cholecystectomies were obtained. Procedures were performed at an academic institution from January 2014 to July 2016. The videos were de-identified and patients were consented to video recording prior to their procedure. Cases were performed by surgeons with a minimum of 5 years of experience with the assistance of a surgical resident. Surgical residents who performed or assisted the case were not included as a participant in this study. Following collection, videos were edited to a 1 min segment that included either complete or incomplete dissection of the CVS. Videos with a complete dissection represented cases in which the very next step involved placement of clips and dividing the cystic duct and cystic artery. Videos with an incomplete dissection involved cases in which the hepatocystic dissection had begun but was well before the cystic duct and artery were divided. Videos were edited using QuickTime (Apple Inc., version 10.4).

Study design and data collected

All incoming surgical interns ($n = 10$) for the 2017–2018 year were asked to watch an educational video on the CVS and then complete a web-based electronic survey. The educational video consisted of a condensed 2 min segment of the video created by Deal et al., which explained the components of the CVS and included operative examples [12]. For the electronic survey, participants viewed 20 prepared videos of cholecystectomy at various points of CVS dissection and were then asked if they identified the following: (1) clearance of fat from the hepatocystic triangle; (2) the lower one-third of the gallbladder is separated from the liver to expose the cystic plate; and (3) two and only two structures entering the gallbladder. In addition, participants were asked whether or not they believed it was safe to divide the structures visible at the conclusion of each video (Fig. 1).

Statistical analysis

Fleiss' kappa was used to assess the level of agreement among the interns on the decision to either divide or not divide the critical the structures in each video [14]. Levels of agreement were determined as follows: above 0.90, almost perfect; 0.80–0.90, strong; 0.60–0.79, moderate; 0.40–0.59, weak; 0.21–0.39, minimal and 0–0.20, no agreement [15]. Spearman's correlation test was used to measure the strength and direction of the correlation between individual mean overall percentage of structures divided and total number of criteria identified in all videos by each participant. All analyses were conducted in STATA15 and a two-sided level of significance was set at $p < 0.05$.

Results

In total, all 10 participants evaluated 20 videos. Participants' overall responses are summarized in Fig. 2. There was considerable variation in inter-rater agreement when

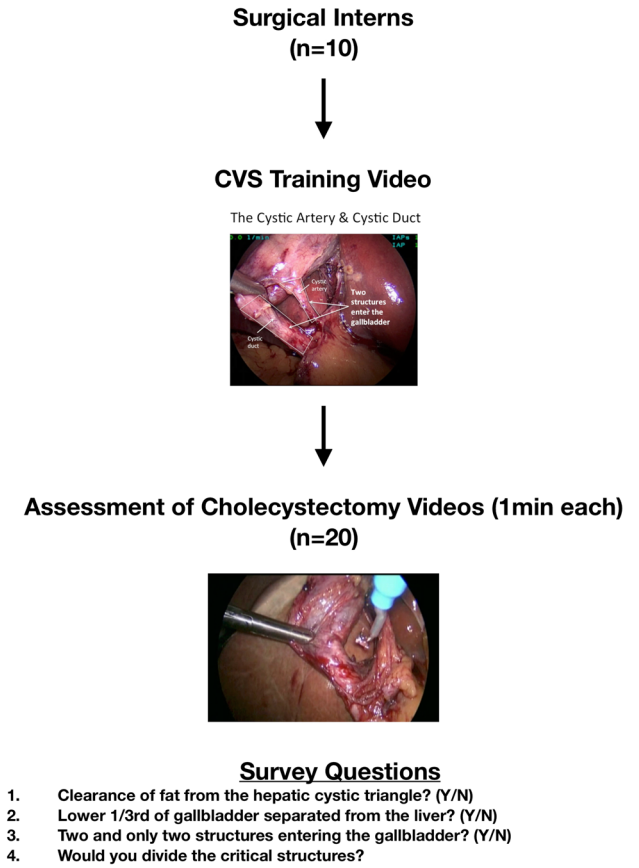

Fig. 1 Study design

participants were asked to identify the specific components of the CVS criteria, with minimal agreement in identifying adequate hepatocystic dissection ($k = 0.2510$) and cystic plate dissection ($k = 0.2771$) and weak agreement when identifying two distinct structures entering the gallbladder ($k = 0.4298$). In addition, there was minimal agreement in the decision to divide critical structures ($k = 0.371$). Overall mean decision to divide critical structures ranged from 5 to 50% among participants and did not correlate with the number of total CVS criteria identified for all videos by each participant (Spearman's rho = 0.247, $p = 0.492$) (Fig. 3).

The association between identification of CVS criteria and decision to divide structures is summarized in Fig. 4. There were eight instances (15%) in which participants chose to divide critical structures and not all CVS criteria were identified. Among these instances, cystic plate dissection was omitted in all cases and the majority (88%) of these decisions were isolated to a single participant (#8).

Discussion

This is a novel pilot study that tests both CVS identification at various points of dissection as well as intraoperative decision-making among surgical trainees. Despite viewing a pretest training module, we identified considerable variation in the identification of CVS criteria with the least amount of agreement in identifying satisfactory hepatocystic dissection and cystic plate dissection. We also discovered that the decision to divide critical structures varied by participant and did not correlate with the total number of criteria they were able to identify in the study. Finally, we were able to identify unsafe practices as participants chose to divide critical structures in 15% of cases when not all criteria were identified. Omission of the cystic plate dissection occurred in all such cases and the majority of these decisions were isolated to a single participant. With these findings, our pilot study demonstrates the value of using video-based assessments to understand a trainee's ability to identify adequate operative dissection as well as make safe operative decisions based without risking harm to patients.

Evaluation of accurate CVS identification has been examined previously. Deal et al. found that faculty experts and crowd-sourced assessments of the CVS correlated

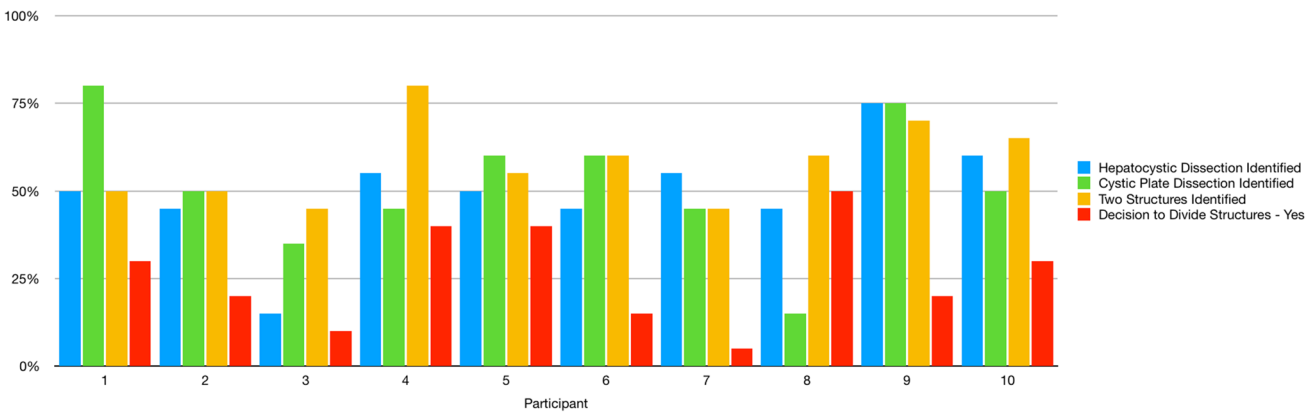

Fig. 2 Summary of responses by participant

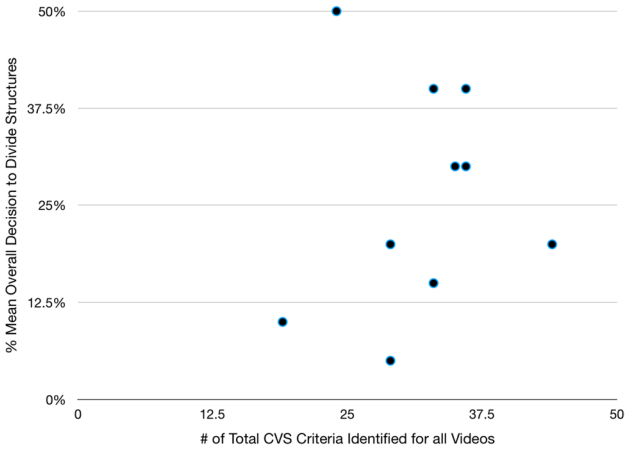

Fig. 3 Association between the total number of CVS criteria identified by each participant and their rate of dividing critical structures

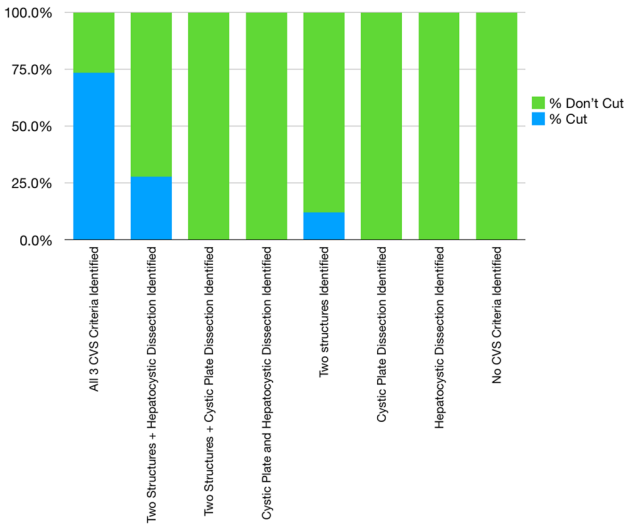

Fig. 4 Summary of CVS criteria identified and decision to divide structures

by simply using a video-based module for training [12]. Although we used an edited version of their training module, we noted minimal to weak agreement among our participants when asked to identify the various components of the CVS. This may be due to several factors. First, the video-based module by Deal et al. had not been tested for reliability or validity and thus may not have been adequate for our trainees. Furthermore, we tested our trainees using only 1 min samples of CVS dissection at various points of the operation, whereas Deal et al. used videos that were stopped just prior to clipping and/or division of structures and thus all of the CVS criteria were included. As a result, we could test our participant's ability to identify CVS criteria based on their perceptions of adequate or satisfactory dissection from complete and incomplete examples. Also, we utilized a survey with binary questions only (i.e., "Is the hepatocystic triangle cleared of the fat and fibrous tissue?"—Yes/No), whereas Deal et al. utilized a graded scoring system (0–2 points) in order to assess a participant's visual perception of the CVS. We chose to use binary questions as we felt that they were more appropriate for assessments that involve decision-making because once structures are divided, the decision cannot be reversed.

Given the morbidity of biliary injury, identifying the CVS should not be considered merely an educational exercise. Nijssen et al. reviewed postoperative video review of patients that had biliary injury following laparoscopic cholecystectomy and found that while the CVS had been documented 80% of the time, it had not actually been adequately achieved in any of the cases [6]. Likewise, Stefanidis et al. found that the CVS criteria were not routinely used by the majority of surgeons participating in a video-based study and one-fourth of those who claimed to obtain the CVS did so inadequately [16]. Our study was able to capture unsafe practices in a simulated setting, as critical structures were divided in 15% of cases in which not all CVS criteria were identified. Interestingly, we found that participants were most likely to divide structures without clear identification of the cystic plate dissection and that many of such cases were isolated to a single participant. Thus, video-based testing of the CVS criteria along with simulated intraoperative decision-making allowed us to assess perceptions of safe practices among trainees without harm to patients and also identify individuals who may need additional education for improvement.

The impact of perception gaps on surgical safety has been evaluated by Way et al., who noted that errors leading to laparoscopic bile duct injuries stemmed principally from misperception and not errors of skill, knowledge, or judgement [11]. Thus, one would have to rely on operative experiences that resulted in harm in order to gain the necessary insight to address perception gaps. For this reason, we advocate for video-based modules that assess for a wide range of operative scenarios that assess both perceptions of CVS along with safe decision-making.

Strategies to implement the use of CVS criteria intraoperatively have also been reported. Chen et al. demonstrated that a comprehensive lecture on safe cholecystectomy along with implementation of an intraoperative "time-out" resulted in significant improvement in identifying the CVS among surgical residents [17]. Although intraoperative use of the CVS criteria provides an opportunity for critical evaluation of the CVS dissection, it lacks the ability to evaluate for perception gaps in identification or safe decision-making without the risk of harm to patients. In our study, we were able to assess perception gaps in safe practices by using a variety of video-based scenarios, thereby avoiding risk to patients.

We recognize that there a number of limitations to our study. First, we studied a small number of participants ($n = 10$) at a single-center academic institution. We chose to limit the study to incoming surgical interns in order to reduce the likelihood of bias due to prior surgical experience, since presumably none of the participants would have performed a laparoscopic cholecystectomy independently as a medical student. In addition, we provided all of the participants with a standardized video to explain the importance of the CVS in preventing iatrogenic injury of the common bile duct as well as provide video-based examples of the anatomic criteria. Nevertheless, we also recognize that the video-based teaching module that we provided for our participants had not been tested for reliability or validity as a method for multimedia tutorial development. This may be the reason why we found minimal to weak inter-rater agreement for each CVS criteria. In addition, videos assessed by our participants were only 1 min in length, which may have limited the participant from additional visual information that could have improved their assessment of the CVS. Although a longer sampling of the video may have given the participant more information to properly discern whether all components of the CVS were satisfied, our goal was to blind the participant to the next steps of the operation in order to simulate a true operative decision-making experience.

Conclusions

In this novel pilot study evaluating the identification of CVS criteria at various points of dissection, participants were least likely to agree upon what constituted an adequate hepatocystic or cystic plate dissection and the decision to divide critical structures varied by individual. Unsafe practices were identified as participants chose to divide structures without identifying all CVS criteria. Cystic plate dissection was most commonly omitted among such cases. Video-based assessments that include simulated intraoperative decision-making can help assess individual perception gaps in safe practices without the risk of patient harm.

Compliance with ethical standards

Disclosures Dr. Oliver Varban receives salary support from Blue Cross/Blue Shield of Michigan for leadership and participation in quality improvement initiatives within the Michigan Bariatric Surgery Collaborative. Adam Niemann, Niki Matusko, and Dr. Gurjit Sandhu have no conflicts of interest or financial ties to disclose.

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