



Implementation and validation of a competency assessment tool for laparoscopic cholecystectomy

Mickael Chevally¹ · Emilie Liot¹ · Ian Fournier¹ · Ziad Abbassi¹ · Andrea Peloso¹ · Monika E. Hagen¹ · Stefan P. Mönig¹ · Philippe Morel¹ · Christian Toso¹ · Nicolas Buchs¹ · Danilo Miskovic² · Frederic Ris¹ · Minoa K. Jung¹

Received: 7 October 2021 / Accepted: 9 April 2022 / Published online: 15 June 2022
© The Author(s) 2022

Abstract

Background Achieving proficiency in a surgical procedure is a milestone in the career of a trainee. We introduced a competency assessment tool for laparoscopic cholecystectomy in our residency program. Our aim was to assess the inter-rater reliability of this tool.

Methods We included all laparoscopic cholecystectomies performed by residents under the supervision of board certified surgeons. All residents were assessed at the end of the procedure by the supervising surgeon (live reviewer) using our competency assessment tool. Video records of the same procedure were analyzed by two independent reviewers (reviewer A and B), who were blinded to the performing trainee's. The assessment had three parts: a laparoscopic cholecystectomy-specific assessment tool (LCAT), the objective structured assessment of technical skills (OSATS) and a 5-item visual analogue scale (VAS) to address the surgeon's autonomy in each part of the cholecystectomy. We compared the assessment scores of the live supervising surgeon and the video reviewers.

Results We included 15 junior residents who performed 42 laparoscopic cholecystectomies. Scoring results from live and video reviewer were comparable except for the OSATS and VAS part. The score for OSATS by the live reviewer and reviewer B were 3.68 vs. 4.26 respectively ($p=0.04$) and for VAS (5.17 vs. 4.63 respectively ($p=0.03$). The same difference was found between reviewers A and B with OSATS score (3.75 vs. 4.26 respectively ($p=0.001$)) and VAS (5.56 vs. 4.63 respectively; $p=0.004$)).

Conclusion Our competency assessment tool for the evaluation of surgical skills specific to laparoscopic cholecystectomy has been shown to be objective and comparable in-between raters during live procedure or on video material.

Acquisition and improvement of operative skills are central in surgical training. The path from a junior trainee to an independent surgeon involves receiving evaluation and correction from experienced mentors. In most European countries, Australia, and North America, certification in general surgery is based on a minimal required number of procedures without a benchmark of the trainee's autonomy and competence [1]. The American Board of Surgery (ABS) requires six operative performance assessments during

residency that are chosen from 13 interventions. However, there is no requirement to achieve a minimal score. As an exception, the certificate of completion of training (CCT) in general surgery in the United Kingdom requires that three different consultant mentors confirm the trainee's ability to perform three different procedures without supervision [2].

A worrying number of surgeons might finish their training without sufficient surgical skills to perform basic procedures such as laparoscopic cholecystectomy. Furthermore, the legal restriction of working hours [3] clashes with the need to obtain competence and autonomy in different surgeries at the end of a resident's training program. An improvement in the efficiency of the educational system in surgery is required. An objective assessment tool for surgical skills could provide such an improvement so that confidence in an intervention does not rely solely on an individual's perception and self-assessment. We adopted the laparoscopic

✉ Minoa K. Jung
minoa.jung@hcuge.ch

¹ Division of Digestive Surgery, Department of Surgery, Geneva University Hospital and Faculty of Medicine, Rue Gabrielle-Perret-Gentil 4, 1211 Geneva, Switzerland

² Department of Surgery and Cancer, Imperial College, St Mary's Hospital, London, UK

competency assessment tool (CAT) validated in colorectal surgery [4] and modified it for standard cholecystectomy. The essential steps of a laparoscopic colectomy were replaced by those of a laparoscopic cholecystectomy. This study aimed to evaluate the feasibility of implementation of this assessment tool, its objectivity and inter-rater reliability on different supports.

Methods

We included all patients with cholecystectomies fully performed by trainees from our hospital's visceral surgery training program between June 2013 and January 2016. The interventions were performed either in an emergency or an elective setting for uncomplicated symptomatic gallstone disease or acute cholecystitis. Surgery was performed under the supervision of a senior surgeon with board certification. Procedures which were not performed entirely by the trainee or for which the video recording was not available were excluded. If the senior surgeon felt that significant oral guidance was given during the surgery, this was mentioned at the bottom of the assessment sheet and the procedure was excluded from the analysis. We collected the different scores prospectively. Patient's demographic data (age, sex, body mass index [BMI], American Society of Anesthesiologists [ASA] score) and the level of case complexity as rated by the senior surgeon were reported. The senior surgeon who had the role of the live reviewer completed the assessment tool form immediately after the surgery and gave feedback to the trainee. Each procedure was recorded, and the video material was collected at the end of the surgery. Each video received a randomized number and was anonymized for the patient, the live reviewer, and the trainee. One investigator kept a list of matches between the video number and the live assessment form. Two blinded senior surgeons designated as A and B separately reviewed the video recordings of each surgery and filled out the LCAT (except for the cholangiography item which was not shown in the video). The video reviewers did not participate in the live evaluation.

All procedures performed in this study met the ethical standards of the institutional research committee, and the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Institutional Review Board was consulted and informed consent was waived. For this type of study, formal consent was not required.

Assessment tool

Our assessment tool was composed of three parts.

The first part was the Laparoscopic Competency Assessment Tool for laparoscopic cholecystectomy (LCAT) adapted from the CAT in colorectal surgery (4). The CAT

designed for laparoscopic colectomy divides the surgery into four steps: exposure, control of the vessels, mobilisation and resection/anastomosis. In each step reviewers evaluate the use of instruments, manipulation of tissues, complications and end result.

Two senior surgeons (M.J. and F.R.) identified four major steps of a standard laparoscopic cholecystectomy: (1) exposition of the surgical field, (2) dissection of Calot's triangle, (3) cholangiography and (4) resection of the gallbladder (Fig. 1). Each of the steps was subdivided into four tasks that received a rating from 1 to 4 (1 = dangerous, 4 = masterly) (Fig. 1). For each step, an overall score was calculated by averaging the ratings received for the four tasks. Each task corresponds to an essential stage of cholecystectomy that needs to be completed before moving to the next one. The sequence of the assessment items follows the course of a laparoscopic cholecystectomy. The adapted CAT was reviewed and validated by eight senior laparoscopic surgeons in our department. A supplementary video demonstrates the assessment of the different steps including examples of different scoring levels (Supplementary Video). One item was not assessed by the video reviewers (cholangiography interpretation) because it was not captured in the recordings.

The second part was the validated objective structured assessment of technical skills (OSATS) (13) for general surgical skill assessment (Fig. 2).

The third part was a visual analogue scale (VAS) assessment of the capacity of the trainee to perform each step (exposition, Calot's dissection, cholangiography, and resection) without supervision on a scale from 1 (clearly not) to 7 (clearly yes). An overall mean score for the VAS was calculated from the sum of ratings for each step. A global VAS for the autonomy during the laparoscopic cholecystectomy completed the score (Fig. 3). To obtain autonomy for the procedure, a minimum score of 5 on the VAS is required.

Statistical analysis

We compared the means for each step between reviewers using Student's *t* test for categorical data. Statistical significance was assumed when *p* value was inferior to 0.05. Confidence intervals (CI) were set at 95%. For live-reviewed assessment, we calculated a Pearson's correlation coefficient between the operative time and the score for each step. To determine the inter-rater reliability of the assessment tool items, we calculated intraclass correlation coefficients (ICCs) for three ratings: one given during the surgery by the supervisor and two given by the video reviewers. ICC estimates and their 95% confidence intervals were based on a mean-rating ($k=3$), absolute-agreement, two-way random model, single measure. Values inferior to 0.5, between 0.5 and 0.75, between 0.75 and 0.9, and superior to 0.90 were indicative of poor, moderate, good, and excellent reliability

Difficulty of the case: Easy Standard Expert

Exposure							
Trocars introduction		Peritoneal incision at the Calot		Execution		Cystic artery and duct identification	
1.Hazardous	Dangerous technique (not visualized), hazardous or wrong position	1.Uncontrolled	Uncontrolled movements, dangerous	1.Uncontrolled	Perforation (digestive, biliary or vascular), haemorrhages	1.No	Anatomical structures not correctly identified
2.Inadequate	Several attempts, ergonomically poor position	2.Inefficient	Ineffective (several hesitant cuts)	2.Inefficient	Bloody dissection	2.Vaguely	Main structures identified, poor exposure
3.Safe	Safe insertion and ergonomically good position	3.Good	Movements controlled, efficient	3.Good	No digestive, biliary or vascular lesion	3.Good	Main structures identified
4.Masterly	Masterful insertion, ideal position	4.Masterly	Anticipation, perfect movements	4.Masterly	Perfect tissue protection	4.Masterly	Perfectly identified anatomy
Dissection							
Haemostasis control		Cystic artery and cystic duct dissection		Execution with:		Final Result	
1.Hazardous	Dangerous, uncontrolled movements, insufficient exposition	1.Uncontrolled	Uncontrolled movements, insufficient view	1.Damage	Perforation (digestive, biliary or vascular), haemorrhages	1.Uncontrolled	Poorly dissected ducts, lesion of the cystic duct or artery
2.Inadequate	Hesitant and/or jerky movements	2.Inefficient	Several movements, hesitant	2.Near miss	Bloody dissection, too close to major structures	2.Imprecise	Poor preparation
3.Safe	Instrument accurately placed	3.Good	Safe dissection technique	3.No damage	No digestive, biliary or vascular lesion	3.Sure	Good preparation
4.Masterly	Efficient (minimal attempts, ideal position and safety)	4.Masterly	Efficient (minimal attempts and safety)	4.Masterly	Perfect tissue protection	4.Masterly	Perfect preparation
Cholangiography							
Cystic duct incision		Catheter use		Execution		Cholangiography	
1.Hazardous	Total section	1.Hazardous	Uncontrolled movements	1.Uncontrolled	Perforation (digestive, biliary, hepatic, vascular), haemorrhages	1.Hazardous	Unable to perform the cholangiography
2.Inadequate	Repeated attempts	2.Inadequate	Repeated attempts	2.Inefficient	Bloody dissection, too close to major structures, gallbladder perforation	2.Inadequate	Hepatogram or duodenal passage not visible
3.Safe	Correct	3.Safe	Introduction, without leak	3.Good	No digestive, biliary or vascular lesion	3.Safe	Complete hepatogram, duodenal passage
4.Masterly	Perfect	4.Masterly	No leak, efficient	4.Masterly	Perfect tissue protection	4.Masterly	Perfect knowledge of anatomy
Resection							
Use of tissue handlers		Use of the non-dominant hand		Execution with:		Gallbladder resection	
1.Hazardous	Uncontrolled movements, insufficient exposition	1.Hazardous	Left hand does not move	1.Damage	Perforation (digestive, biliary, hepatic, vascular), haemorrhages	1.Wrong plane	Biliary contamination, liver haemorrhage
2.Inadequate	Hesitant and/or jerky movements	2.Inadequate	Lack of anticipation	2.Near miss	Bloody dissection, too close to major structures, gallbladder perforation	2.Inconsistent	Repeatedly wrong tissue plane, able to correct
3.Safe	Instrument accurately placed and engaged	3.Safe	Adequate adjustment to improve exposure	3.No damage	No digestive, biliary or vascular lesion	3.Satisfactory	Correct plan of dissection
4.Masterly	Efficient (ideal position and safety)	4.Masterly	Anticipation and excellent use of the left hand	4.Masterly	Perfect tissue protection	4.Masterly	Correct plan of dissection, efficient

Fig. 1 The laparoscopic competency assessment tool for cholecystectomy with the four key steps of the procedure

Graduation						
	N/E	1	2	3	4	5
Respect for tissue		Unnecessary force on tissue or caused damage by inappropriate use of instruments		Careful handling of tissue but occasionally caused inadvertent damage		Consistently handle tissue appropriately with minimal damage
Time and motion		Many unnecessary moves		Efficient time/motion but some unnecessary moves		Clear economy of movement and maximum efficiency
Instrument handling		Repeatedly makes tentatives or awkward moves with instruments		Competent use of instruments but occasionally appeared stiff		Fluid moves with instruments, perfect use
Knowledge of instruments		Frequently asked for wrong instrument		Knew names of most instruments and used appropriate instrument		Obviously familiar with the instruments and their names
Use of Assistants		Consistently placed assistants poorly or failed to use assistants		Appropriate use of assistants most of time		Strategically used assistants to the best advantage at all time
Flow of Operation		Frequently stopped operating and seemed unsure of next move		Demonstrated some forward planning with reasonable progression of procedure		Obviously planned course of operation with effortless flow from one move to the next
Knowledge of Specific procedure		Deficient knowledge. Needed specific instruction at most steps		Knew all important steps of operation		Demonstrated familiarity with all aspects of operation

Fig. 2 Objective structured assessment of technical skills (OSATS). Graduation from 1 (worst) to 5 (best) for general surgical skills during laparoscopic cholecystectomy

	1	2	3	4	5	6	7
Exposition	Very bad	Bad	Below average	Average	Good	Very good	Excellent
Adequate artery and cystic duct exposure	← Unable to expose themselves		Able to accomplish exposure with hesitation discontinuous advancement			→ Able to expose themselves excellent progression	
Calot's triangle dissection	Very bad	Bad	Below average	Average	Good	Very good	Excellent
Safe dissection of the artery and cystic duct	← Unable to perform dissection		Able to perform dissection with hesitation			→ Able to perform dissection without hesitation, excellent progression	
Cholangiography	Very bad	Bad	Below average	Average	Good	Very good	Excellent
	← Unable to perform cholangiography		Able to perform cholangiography with hesitation, poor fluency			→ Able to perform cholangiography without hesitation, excellent progression	
Resection	Very bad	Bad	Below average	Average	Good	Very good	Excellent
Correct resection of the gallbladder in the correct plane without injury	← Unable to perform dissection		Able to perform with hesitation, poor fluency			→ Able to perform dissection without hesitation, excellent progression	
Autonomy statement	Clearly no	No	Rather no	Not decided	Rather yes	Yes	Clearly yes
This intervention can be carried out autonomously by the trainee	← →						

Fig. 3 Visual analogue scale (VAS) for laparoscopic cholecystectomy for each step and general autonomy statement, rating from 1 (very bad) to 7 (excellent)

respectively [5]. All analyses were performed using the Statistical Package for the Social Sciences software (version 22.0.0, SPSS Inc, Chicago, IL).

Results

We recorded 42 laparoscopic cholecystectomies performed by 15 trainees. Eight trainees had from 1 to 3 years of post-graduate experience and seven trainees from 4 to 6 years of post-graduate experience. 30 procedures were performed by ten trainees (3 laparoscopic cholecystectomy per trainee), 8 procedures by four trainees (2 procedures per trainee) and 4 were performed by one trainee.

All interventions were supervised by one of 15 senior surgeons. The demographic data of the 42 patients are shown in Table 1. No conversion to laparotomy was observed.

Live and video evaluations

The mean score for each step of the competency assessment tool was reported for the live reviewer and the two video reviewers. The most completed items were the autonomy score and Calot's dissection (completed in 42/42 procedures

Table 1 Demographics data

Interventions, <i>N</i>	42
Age in years, mean (\pm SD)	52 (\pm 17)
Female <i>N</i> (%)	32 (75%)
Level of complexity	
Easy <i>N</i> (%)	12 (32%)
Standard <i>N</i> (%)	21 (55%)
Expert, <i>N</i> (%)	5 (13%)
ASA	
I <i>N</i> (%)	9 (22%)
II <i>N</i> (%)	26 (62%)
III <i>N</i> (%)	8 (16%)
BMI, mean (\pm SD)	26.63 (\pm 5.64)
Operative time in minutes, mean (\pm SD)	105 (\pm 35)

SD standard deviation, *ASA* American Society of Anesthesiologists score, *BMI* Body Mass Index

for all reviewers). The mean scores for each step are presented in Table 2.

Differences between reviewers

Scoring results were comparable between the live reviewer and reviewer A. There was no statistically significant

Table 2 Mean scores in each step of the assessment tool from the three reviewers

LCAT step	Reviewer live		Reviewer A		Reviewer B	
	<i>N</i>	Mean (\pm SD)	<i>N</i>	Mean (\pm SD)	<i>N</i>	Mean (\pm SD)
Exposure	42	3.14 (\pm 0.46)	42	3.19 (\pm 0.46)	41	3.11 (\pm 0.61)
Calot dissection	42	3.14 (\pm 0.55)	42	3.07 (\pm 0.48)	42	2.94 (\pm 0.67)
Cholangiography	36	3.32 (\pm 0.53)	39	3.26 (\pm 0.54)	39	3.23 (\pm 0.74)
Resection	42	3.1 (\pm 0.61)	42	3.12 (\pm 0.63)	39	2.9 (\pm 0.69)
OSATS	40	3.68 (\pm 0.88)	42	3.75 (\pm 0.75)	39	4.26 (\pm 0.87)
VAS	39	5.17 (\pm 1.09)	40	5.56 (\pm 0.81)	39	4.63 (\pm 1.16)
Autonomy score	42	4.48 (\pm 1.67)	42	5.05 (\pm 1.52)	42	4.64 (\pm 1.87)

Exposure, Calot Dissection, Cholangiography and Resection steps are rated from 1 to 4, OSATS items from 1 to 5 and VAS items from 1 to 7

SD standard deviation, LCAT Laparoscopic cholecystectomy assessment tool, OSATS objective structured assessment of technical skills, VAS Visual Analog Scale

difference in mean scores between the live reviewer and reviewer A for all the items of the assessment tool. Scores of the live reviewer and reviewer B were significantly different in two items: OSATS (3.68 vs. 4.26 respectively; $p=0.04$) and VAS (5.17 vs. 4.63, $p=0.03$). There was no statistically significant difference in the LCAT.

Scores of reviewer A and reviewer B were significantly different for the same two items: OSATS (3.75 vs. 4.26 respectively; $p=0.001$) and VAS (5.56 vs. 4.63 respectively; $p=0.004$), whereas the LCAT scores were comparable between reviewers A and B.

Inter-rater reliability

For the 27 scored items, the calculated inter-rater reliability coefficients (ICC) were 0.446 to 0.829 (Table 3). For one item (cholangiography interpretation), only one rating was available, so the coefficient could not be computed. 17 of the 27 coefficients showed a good reliability (0.75 to 0.9), 8 showed a moderate reliability (0.5 to 0.75) and 2 (OSATS: knowledge of instruments and OSATS: knowledge of specific procedure) scored a low correlation coefficient (0.45, 95% CI 0.361–0.615 and 0.446, 95% CI 0.248–0.633). Figure 4 shows the ICC for the cholecystectomy-specific part (LCAT) of the assessment tool.

Correlation between operative time and score

The relationship between operative time and score for each item of the assessment tool (LCAT steps, OSATS, VAS and autonomy score) during live review was investigated using Pearson product-moment correlation coefficient. There was no significant correlation between operative time and any other score (Table 4).

Discussion

Surgical education is subject to many constraints such as reduction of trainees' surgical volumes because of the legal limitation of working hours. Every operation performed by a young surgeon is precious and a maximum amount of teaching should be extracted from it. Objective and reliable assessment tools allow to achieve this goal by guiding and, if necessary, correcting each aspect of the intervention. We demonstrated that the implementation of a new assessment tool for laparoscopic cholecystectomy is feasible and the tool appears to be objective.

Over the last 20 years, several tools have been developed to assess general surgical skills [6], skills specific to an intervention or a combination of both [7, 8]. The creation of the LCAT was inspired by a competency assessment tool used in the United Kingdom in the residency training program for right or left laparoscopic colectomies [4]. The assessment is completed at the end of this program to confirm that the surgeon is able to perform the procedure safely. The authors of the tool demonstrated that the higher the score, the better the patient's outcome in terms of postoperative morbidity and the number of harvested lymph nodes. We used this validated assessment tool for a more common procedure, more suitable for the assessment of non-specialized surgeons.

Feedback from a supervisor after an intervention can be infrequent. A national survey was performed in the residency programs in the United States with 998 participants. Concerning postoperative feedback, only a minority of residents reported that senior surgeons reinforced the educational points of a case with them (34%), gave positive feedback (41%), or discussed areas for improvement (37%) upon completion of an operation [9]. Formal written assessment ensures that feedback is given to the trainee

Table 3 Intra-class correlation coefficient for inter-rater reliability between live reviewer and the two video recorded reviewers

	<i>N</i>	ICC	95% CI
Exposure			
Trocars introduction	35	0.805	0.690–0.888
Peritoneal incision	38	0.810	0.702–0.890
Execution	36	0.772	0.628–0.874
Cystic artery and duct identification	36	0.751	0.6–0.862
Dissection			
Hemostasis control	42	0.563	0.362–0.737
Cystic artery and duct dissection	42	0.669	0.515–0.793
Execution	42	0.524	0.332–0.696
Final result	42	0.763	0.551–0.921
Cholangiography			
Cystic duct incision	29	0.805	0.695–0.886
Catheter use	31	0.774	0.638–0.870
Execution	30	0.807	0.702–0.884
Cholangiography	NA	–	–
Resection			
Use of tissue handlers	42	0.776	0.660–0.863
Use of non-dominant hand	41	0.689	0.546–0.805
Execution	41	0.751	0.626–0.846
Gallbladder resection	42	0.829	0.736–0.897
OSATS			
Respect for tissue	42	0.797	0.690–0.877
Time and motion	40	0.821	0.724–0.892
Instrument handling	42	0.753	0.621–0.847
Knowledge of instruments	42	0.45	0.361–0.615
Use of assistants	42	0.684	0.537–0.802
Flow of operation	40	0.683	0.538–0.801
Knowledge of specific procedure	40	0.446	0.248–0.633
VAS			
Exposition	36	0.652	0.497–0.779
Calot's triangle dissection	36	0.744	0.617–0.842
Cholangiography	29	0.787	0.675–0.870
Resection	36	0.662	0.511–0.786
Autonomy statement	42	0.806	0.702–0.882

ICC value < 0.5, between 0.5 and 0.75, between 0.75 and 0.9 and > 0.90 were indicative of poor, moderate, good, and excellent reliability respectively

ICC intra-class correlation coefficient, CI confidence interval, OSATS objective structured assessment of technical skills, VAS Visual Analog Scale

immediately after the surgery. Immediate rating is more accurate than one completed later after the intervention [10]. In our study, all the assessment forms were filled directly after the procedure with full compliance. The form is quick and easy to complete.

Several general scores have been developed and applied to the laparoscopic cholecystectomy. The global operative assessment of laparoscopic surgery (GOALS) consists of

general items rated from 1 to 5 with anchor explanations at the first, third and fifth points. GOALS was first applied for a single step of laparoscopic cholecystectomy, the dissection of the gallbladder from the hepatic bed, and then to the entire procedure [11, 12]. The OSATS is a validated score for general surgical skills that has been used to assess laparoscopic cholecystectomy [13]. Another general and specific assessment for laparoscopic cholecystectomy is the operative performance rating system (OPRS) [6]. It is used by the ABS [1] for the assessment of operative performance during laparoscopic cholecystectomy. The assessment is divided into both general and specific for the procedure items and the VAS ranging from 1 to 7 with anchor explanations for points 1, 4 and 7. A common flaw of these scores is the lack of procedure-specific items. A VAS can be misleading and open to interpretation by the rater. In our assessment tool, we divided the laparoscopic cholecystectomy into 16 steps with anchor explanations for each rating. This allows to standardize the procedure and identify specific areas for improvement. Each step can be corrected to maximize the safety of the patient. An additional element compared to other scores is the inclusion of the peroperative cholangiography. This step may not be systematically performed at all institutions but can be valuable in detecting common bile duct stones or delineating the anatomy of the bile ducts to avoid injuries. This skill should be acquired by any independent surgeon. It therefore seems essential to us to include cholangiography in any assessment tool for laparoscopic cholecystectomy. Objectivity and reliability of the LCAT have been demonstrated in our study as the scoring results were comparable between non-blinded live reviewers and two blinded video reviewers.

Autonomy seems to be the most challenging part to assess. In an American study, all fellowship program directors completed a survey about the residents entering their programs. They reported that 30% of the surgeons could not independently perform a laparoscopic cholecystectomy [14]. In our study, there was no evident consensus about the overall autonomy of trainees. This item showed the widest score range between all the reviewers. The autonomy level assessed by VAS should be used as information for the trainee rather than a threshold to be obtained for independent practice. Overall scores based on all the items and/or successive evaluation by different raters could better assess a trainee's autonomy.

In our study, we compared live assessment scores with the scores given by two blinded video reviewers. Inter-rater reliability was moderate to good for most of the items in the assessment tool. No statistically significant differences in the LCAT part were noted between all three reviewers.

Video assessment simplifies the process as the evaluation is not limited by the rater's availability. It also eliminates sources of bias as the rater is blinded to the trainee's identity.

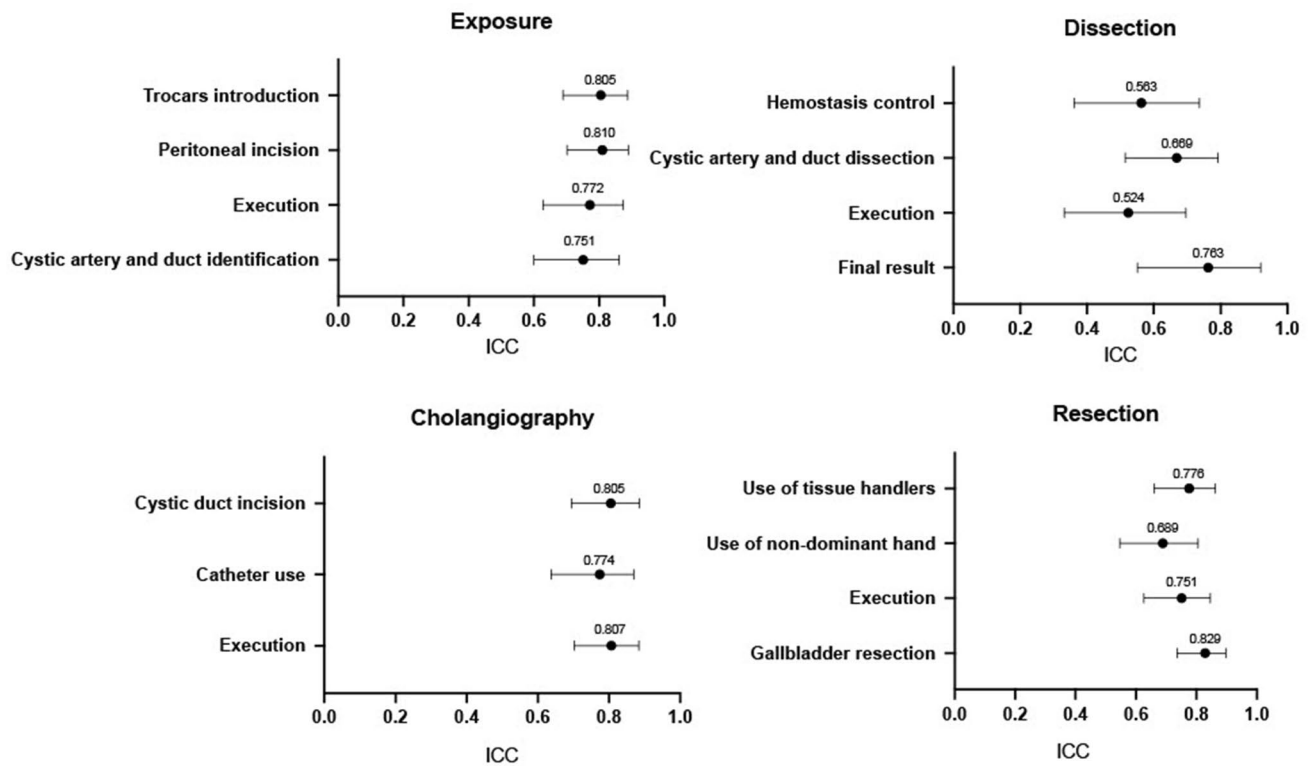


Fig. 4 Intraclass correlation coefficients (ICC) for the four steps of the laparoscopic cholecystectomy assessment tool (LCAT). ICC value < 0.5, between 0.5 and 0.75, between 0.75 and 0.9 and > 0.90 were indicative of poor, moderate, good, and excellent reliability respectively

Table 4 Person correlation coefficient between operative time and score of each step of the assessment score during live-reviewed procedures.

	Pearson correlation coefficient	<i>N</i>	<i>p</i> value
Operative time	1		
Exposure	− 0.108	41	0.5
Calot dissection	− 0.377	42	0.017
Cholangiography	− 0.07	35	0.68
Resection	− 0.128	39	0.43
OSATS	− 0.238	39	0.151
VAS	− 0.233	39	0.166
Autonomy score	− 0.256	42	0.11

In our study, there were two steps the raters disagreed on: the OSATS and the VAS. In the OSATS, the mean score was different between the reviewers and there were two items which showed poor reliability: knowledge of the procedure and use of the instruments. Watching a video recording without intraoperative sound, reviewers could have difficulties to evaluate the flow of the procedure and the accuracy of the trainees' requests for instruments. This could explain the discrepancy between the raters and suggests these items should be omitted during video rating. In the VAS part, the

mean score was different between the reviewers but the individual items showed good inter-rater reliability. The VAS and the OSATS are different compared to the LCAT: not all grades on the scale have an anchor explanation. The VAS has a scale of 1 to 7 but explanations are available only for grades 1, 4 and 7. The choice of a score of 2 or 5 is therefore left to the rater's subjective interpretation. The subjectivity of scoring in the OSATS and the VAS part could explain the differences in score between the raters. The LCAT has a clear explanation for each item leaving less room for interpretation.

The LCAT scoring shows consistency between live and video rating whereas the OSATS and VAS scores differed between reviewers.

Evaluation of laparoscopic cholecystectomy with the LCAT seems to be feasible, more objective and producing results consistent between live and video reviewers.

The operative assessment could improve the patient safety and outcome. Trainees who received feedback from an experienced surgeon after performing a cholecystectomy showed significant improvements in their operative time and efficiency of movement [15]. Giger et al. [16] demonstrated that intraoperative complications were more frequent for surgeons with experience of less than 100 laparoscopic cholecystectomies. These surgeons were classified as at risk

because their patients had the highest likelihood of suffering from surgery-related complications (odds ratio [OR] 1.36; $p=0.0002$). Murphy et al. [17] have shown that postoperative complications after laparoscopic cholecystectomy were more frequent in a non-teaching hospital. These results reinforce the need for control of surgical safety during and at the end of a training program. A successive assessment with the LCAT during the surgeon's training could help identify any unsafe aspect of the procedure.

The laparoscopic cholecystectomy learning curve is not well defined. In their meta-analysis, Reitano et al. [18] found that thresholds for proficiency ranging from 13 to 200 procedures have been proposed. Despite laparoscopic cholecystectomy being a common procedure, there is no consensus on the minimal number of surgeries required for a trainee to become independent. In addition, reaching a certain number of surgeries does not guarantee high quality performance. De Siqueira et al. [19] reported that out of 30 trainees who had attained 50 procedures required for cholecystectomy certification, only 47% had an assessment score valid for independent practice. The LCAT could represent an alternative to evaluate surgical competence.

There are several limitations of this study. We could not exclude a selection bias, as the most challenging cases were performed entirely or at least partially by the senior surgeon and were excluded from the assessment process. In other scores, the level of guidance is a part of the assessment. The criterion of exclusion of not fully independent surgeries also explains the low number of interventions which is another study limitation. However, we found that an assessment score on a procedure done entirely by the trainee better reflects their surgical skills. It forces the trainee to perform the entire surgery under standardized guidance of the mentor and allows safe evaluation of steps with which the trainee may feel less comfortable. The assessment tool helps identify the steps in which there is room for improvement. Another limitation is exclusion of cholangiography assessment from analysis as cholangiography was not performed in every case. Finally, we could not compare assessment scores with patient outcomes as the study was not designed to include patients' postoperative data. A further study comparing assessment scores and patient outcomes is planned.

Conclusion

Surgical education faces new challenges posed by the legal hour restrictions and the resulting reduction of the caseload for specific surgeries. In order to improve surgical training, assessment tools are mandatory to help young surgeons progress with each procedure. We propose the LCAT as a new assessment tool specific for laparoscopic cholecystectomy.

Its implementation was feasible in our residency program. The LCAT seems to be suitable for either live or video review as both resulted in comparable scores in our study. With successive assessments using the same tool, a training program can track the improvement of each resident. An external expert could judge the adequacy of the procedure by analyzing a record of a resident at the end of their training. Further studies are required to assess the capacity of the LCAT to differentiate novice and expert (construct validity) and investigate the correlation between the LCAT score and patients outcomes.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s00464-022-09264-0>.

Funding Open access funding provided by University of Geneva.

Declarations

Disclosures Professor Christian Toso received personal fees from Intuitive Surgical Inc., Ethicon Inc., and Verb Surgical, outside this project. Doctor Minoa K. Jung received personal fees from Intuitive Surgical Inc. and Johnson & Johnson Inc., outside this project. Doctors Mickael Chevally, Emilie Liot, Ziad Abbassi, Andrea Peloso, Ian Fournier, Monika E. Hagen, Stefan P. Mönig, Philippe Morel, Nicolas Buchs, Danilo Miskovic, Frederic Ris have no conflicts of interest or financial ties to disclose.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

1. The American Board of Surgery. Booklet of information-surgery 2019–2020. American Board of Surgery, Philadelphia. <http://www.absurgery.org/xfer/BookletofInfo-Surgery.pdf>. Accessed 10 May 2019
2. Joint Committee on Surgical Training. Certification Guidelines and Checklists 2017. <https://www.jcst.org/quality-assurance/certification-guidelines-and-checklists/>. Accessed 10 May 2019
3. Nasca TJ, Day SH, Amis ES Jr, Force ADHT (2010) The new recommendations on duty hours from the ACGME task force. *N Engl J Med* 363:e3
4. Mackenzie H, Ni M, Miskovic D, Motson RW, Gudgeon M, Khan Z, Longman R, Coleman MG, Hanna GB (2015) Clinical validity of consultant technical skills assessment in the English national training programme for laparoscopic colorectal surgery. *Br J Surg* 102:991–997

5. Koo TK, Li MY (2016) A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *J Chiropr Med* 15:155–163
6. Doyle JD, Webber EM, Sidhu RS (2007) A universal global rating scale for the evaluation of technical skills in the operating room. *Am J Surg* 193:551–555 (**discussion 555**)
7. Hwang H, Lim J, Kinnaird C, Nagy AG, Panton ON, Hodgson AJ, Qayumi KA (2006) Correlating motor performance with surgical error in laparoscopic cholecystectomy. *Surg Endosc* 20:651–655
8. Sarker SK, Chang A, Vincent C, Darzi SA (2006) Development of assessing generic and specific technical skills in laparoscopic surgery. *Am J Surg* 191:238–244
9. Snyder RA, Tarpley MJ, Tarpley JL, Davidson M, Brophy C, Dattilo JB (2012) Teaching in the operating room: results of a national survey. *J Surg Educ* 69:643–649
10. Heneman R, Wexley K (1983) The effects of time delay in rating and amount of information observed on performance rating accuracy. *Acad Manag Ann* 26(4):677–686. <https://doi.org/10.5465/255915>
11. Vassiliou MC, Feldman LS, Andrew CG, Bergman S, Leffondre K, Stanbridge D, Fried GM (2005) A global assessment tool for evaluation of intraoperative laparoscopic skills. *Am J Surg* 190:107–113
12. Gumbs AA, Hogle NJ, Fowler DL (2007) Evaluation of resident laparoscopic performance using global operative assessment of laparoscopic skills. *J Am Coll Surg* 204:308–313
13. Martin JA, Regehr G, Reznick R, MacRae H, Murnaghan J, Hutchison C, Brown M (1997) Objective structured assessment of technical skill (OSATS) for surgical residents. *Br J Surg* 84:273–278
14. Mattar SG, Alseidi AA, Jones DB, Jeyarajah DR, Swanstrom LL, Aye RW, Wexner SD, Martinez JM, Ross SB, Awad MM, Franklin ME, Arregui ME, Schirmer BD, Minter RM (2013) General surgery residency inadequately prepares trainees for fellowship: results of a survey of fellowship program directors. *Ann Surg* 258:440–449
15. Grantcharov TP, Schulze S, Kristiansen VB (2007) The impact of objective assessment and constructive feedback on improvement of laparoscopic performance in the operating room. *Surg Endosc* 21:2240–2243
16. Giger UF, Michel JM, Opitz I, Th Inderbitzin D, Kocher T, Krahenbuhl L, Swiss Association of L, Thoracoscopic Surgery Study G (2006) Risk factors for perioperative complications in patients undergoing laparoscopic cholecystectomy: analysis of 22,953 consecutive cases from the Swiss association of laparoscopic and thoracoscopic surgery database. *J Am Coll Surg* 203:723–728
17. Murphy MM, Ng SC, Simons JP, Csikesz NG, Shah SA, Tseng JF (2010) Predictors of major complications after laparoscopic cholecystectomy: surgeon, hospital, or patient? *J Am Coll Surg* 211:73–80
18. Reitano E, de'Angelis N, Schembari E, Carra MC, Francone E, Gentilli S, La Greca G (2021) Learning curve for laparoscopic cholecystectomy has not been defined: a systematic review. *ANZ J Surg* 91:E554–E560
19. Siqueira DA, Sousa AG, Costa Junior Jde R, Costa RA, Staico R, Tanajura LF, Centemero MP, Feres F, Abizaid AA, Sousa JE (2013) Correlation between plaque composition as assessed by virtual histology and C-reactive protein. *Arq Bras Cardiol* 101:78–86

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.