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# The effect of checklists on the surgical performance during laparoscopic cholecystectomy: A systematic review

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## ABSTRACT

**Aims:** Laparoscopic cholecystectomy (LC) is known to be one of the most widely performed general surgical operations. However, it is associated with an increased incidence and severity of complications especially during the period of a surgeon's proficiency-gain curve. Certain complications could be prevented by decreasing the incidence and consequences of surgeon errors. We aimed to systematically review the application of checklists during LC and their effect on the surgical task performance.

**Methods:** A systematic review was performed in compliance with the PRISMA guidelines. A search was performed on PubMed, ScienceDirect and the Cochrane-Library databases. English language articles published to November 2020 were included in this study. The terms included: 'Checklist and laparoscopic cholecystectomy', 'checklist and laparoscopic surgery', 'checklist and cholecystectomy' and checklist and minimally invasive surgery'. MERSQI score was applied for quality assessment. The research protocol was registered with PROSPERO register (CRD42021209118).

**Results:** The systematic search resulted in 8862 citations, of which 23 relevant citations were assessed for eligibility. A final 9 articles (1079 procedures) were included. The endpoints were equipment-related-risk events, numbers and types of adverse events, rate of conversion to open cholecystectomy, team communication and coordination, the number of consequential and inconsequential errors. MERSQI mean score was 10.8 (range 5 to 13). The positive effect of checklists on the performance during LC was supported with 5 high-quality studies.

**Conclusion:** The effect of the checklists application during LC showed a significant improvement of the surgical task performance by decreasing the surgeons' errors. A combination of pre-operative safety and intra-procedural checklists can be the subject of future research for possible application during routine laparoscopic cholecystectomy.

## Introduction

A checklist has been defined as a comprehensive list of important actions, or steps to be followed in a specific order [1]. The checklists are meant to be used in order to reduce human errors by compensating the potential limits of human memory and attention. Checklists do not prevent all human errors and accidents but they can decrease errors if systematically followed [2]. In surgical practice, the introduction of a Surgical Safety Checklist by the WHO has significantly reduced the morbidity and mortality by reducing human errors through pre-and post-procedural evaluations [3].

Laparoscopic cholecystectomy (LC) is known to be one of the most widely performed general surgical operations. However, it is associated with an increased incidence and severity of complications such as bleed-

ing, infection, bile leak, bile duct injury and bowel injury [4]. These complications can result in significant reduction in the quality of life and increase the risk of morbidity of surgical patients [5, 6, 7].

Certain complications of LC could be prevented by decreasing the incidence and consequences of human errors. Therefore, previous studies introduced different types of checklists to be used as a way of improving patients' safety during LC procedures. The checklists were classified as pre-, intra- and post-procedurally applied. Some checklists were used as aid memoires for procedural steps, while some others were mainly performance based.

We aimed to systematically review the literature for the use of checklists during LC procedures and their effect on the surgical task performance. Our purpose is to study the types and nature of checklists that can improve the quality of task performance of this commonest surgical

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procedure and their possible future use in routine practice and surgical training for safer surgery.

## Methods

### Protocol

The research protocol was registered with the PROSPERO register for systematic reviews (CRD42021209118).

A systematic review was performed in compliance with the PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis) and AMSTAR (Assessing the methodological quality of systematic reviews) guidelines [8, 9].

### Search strategy

A search was carried out on PubMed, ScienceDirect and the Cochrane Library databases. English language articles published to November 2020 were included in this study. Search strategy and terms included: 'Checklist and laparoscopic cholecystectomy', 'checklist and laparoscopic surgery', 'checklist and cholecystectomy' and checklist and minimally invasive surgery".

### Inclusion and exclusion criteria

Only publications related to the use of checklist in laparoscopic cholecystectomy procedures were included in this review study. Procedures in surgical training programmes and surgical performance in experimental surgical studies were also included.

Publications related to the use of checklists in specific procedures, other than cholecystectomies, were excluded. Conference abstracts, letters, editorials, commentaries, and publications in non-English language were excluded.

### Procedure

Two authors' inspection of titles, abstracts, and full-text papers comprised the procedure for developing a systematic review, which were systematically reviewed against the inclusion and exclusion criteria. The first author performed the detailed literature search. The final list of citations ( $n = 9$ ) was completed by both authors. Search items were studied from the nature of the article, date of publication, and aim and main findings in relation to the effect of checklist on surgical task performance.

### Grading and analysis

The Medical Education Research Study Quality Instrument (MERSQI) was applied to assess the quality of studies conducted using the checklist [10]. The MERSQI contains 10 items reflecting 6 domains of study quality. This includes study design, sampling, type of data, validity, data analysis, and outcomes. MERSQI maximum score is 18 with a potential range from 5 to 18. 5–8 points were considered to be of low quality, 8–11 with moderate quality and those with  $\geq 12$  points represented high-quality studies. The maximum score for each domain is 3. The overall MERSQI scores of the publications included in the review were shown in [table 1](#).

### Risk of bias within and across studies

Risk of bias was assessed in a blind manner; and the assessments were completed by the two authors, independently. If the assessment scores did not agree, we calculated the mean score of the given scores. We controlled for accumulated risk of bias by calculating and grading the body of evidence of the findings according to MERSQI recommendations.

## Results

### Study selection and characteristics

The results of the systematic search resulted in 8862 citations, of which 23 relevant citations were kept. These were screened and assessed for eligibility. After scanning the titles and abstracts, the full texts of the relevant citations were read for further evaluation. The inclusion and exclusion criteria were applied and the duplicated citations were excluded.

The analysis of the articles and findings in relation to the use of checklists during LC is presented in [Table 1 \[11–19\]](#). This included a summary of the type of studies, evidence grades, the aims, the checklists types and their effect on the surgical performance was presented.

The MERSQI contains 10 items that reflect 6 domains of study quality including study design, sampling, type of data, validity of evaluation instrument, data analysis, and outcomes. The maximum score for each domain is 3 with a potential range from 5 to 18. The MERSQI score represents the mean of two independent assessors' quality estimations of each citation.

### Results of individual studies

The effect of the checklist application on the surgical task performance during LC was scrutinized in 9 studies. Analysis of the quality of 9 studies was performed using MERSQI, the mean was 10.8 scores and the scores ranged from 5 to 13, with 5 high quality, 3 moderate and 1 low quality studies. 9 articles with 1012 procedures were included in this study ([Fig. 1](#)).

Surgeons were recruited at different categories such as trainees and consultants, while few studies stated only "surgeons".

Our review included 5 cohort studies, 3 controlled trials, and 1 recommendation. The checklists were applied pre-procedurally in 3 studies, intra-procedurally in 3 and post-procedurally in 2 studies, while in one study the checklists were based on pre and intra-procedural steps.

The endpoints were different across the studied. These included equipment and instruments related risk sensitive events [14], numbers and types of incidents and adverse events [12,13, 17], rate of conversion to open cholecystectomy [16], team communication and coordination, compliance with directives for patient positioning, placement of proper appliances (e.g., nasogastric tube, Foley catheter), and appropriate administration of medications, accurate identification of anatomical structures during the procedure, post case questionnaire captured team knowledge of case events [15]. In addition to the number of consequential and inconsequential errors analysed by Human Reliability Analysis technique [19]. The effect of checklists application was overall positive based on high evidential value.

The positive effect of checklist application during laparoscopic cholecystectomy was supported with 5 high quality studies:

Sarker et al. [12] : proved that their technical and technological assessment checklist for laparoscopic surgery seemed to have face, concurrent, content, and construct validities and it was envisaged that the checklist can be used in surgical training and appraisal.

Verdaasdonk et al. [13] : Assessments were in form of incidents with the technical equipment, such as the insufflator, the diathermy equipment, monitors, light source, endoscope or suction unit, in addition to time taken to execute the items on the checklist. A checklist was developed and it was proven to be feasible when applied, helping to reduce errors with the laparoscopic equipment in the operating theatre.

Buzink et al. [14]: proved that their checklists reduced the effect on the number of equipment and instruments related risk-sensitive events.

El Boghdady et al. [19]: used a previously developed performance based checklist and studied its effect on surgeons' errors during LC. The self-administered intra-procedural checklist improved the performance of surgical trainees and decreased the number of interventions by the trainer during laparoscopic cholecystectomy.

**Table 1**  
Tabular analysis of the included citations.

AUTHOR (YEAR)	JOURNAL	TYPE OF STUDY	TYPE OF CHECKLIST (NUMBER OF CASES)	OBJECTIVE	FINDINGS	EFFECT OF CHECKLIST	MERSQI SCORES*	Quality
Sarker et al. (2005)	Surgical Endoscopy	Cohort study	Post-procedural checklists of generic and specific technical minor and major events (37 procedures)	To assess generic and specific minor and major error rates in laparoscopic cholecystectomies (LCs) performed by consultant surgeons.	The study demonstrated a migration of surgical technical errors in expert laparoscopic surgeons. The surgeons migrate technically when they execute a high rate of minor errors. When it comes to the major fundamental aspects of the operation, they could adapt and migrate away from performing major technical errors.	Positive	10	Moderate
Sarker et al. (2006)	Journal of the Society of Laparoscopic & Robotic Surgeons	Cohort study	Post-procedural checklists for generic, specific technical, and technological skills for laparoscopic cholecystectomies.(100 procedures)	To develop a structured assessment tool to assess technical and technological skills for laparoscopic procedures .	Technical and technological skills can be measured to assess the performance of laparoscopic surgeons through a checklist. This technical and technological assessment tool for laparoscopic surgery seemed to have validities. The tool had the possibility of being used in surgical training and appraisal.	Positive	12	High
Verdaasdonk et al. (2008)	Surgical Endoscopy	Controlled trial	Mainly Pre-procedural (60 procedures)	To determine the effect of checklists in reducing the number of incidents with technical laparoscopic equipment.	Use of a checklist was feasible and helped to reduce problems with the laparoscopic equipment in the operating theatre.	Positive	13	High
Buzink et al. (2010)	Surgical Endoscopy	Randomised trial	Pre-procedural checklist: Pro/cheQ (45 procedures)	To study the influence of the integrated operating room system and Pro/cheQ, a digital checklist tool, on the number and type of equipment- and instrument related risk sensitive events (RSE) during LC.	Using both an integrated operating room and Pro/cheQ has a stronger reducing effect on the number of RSE than using an integrated OR alone. The Pro/cheQ tool supported the optimal workflow in a natural way and raised the general safety awareness amongst all members of the surgical team.	Positive	13	High
Calland et al. (2011)	The American Surgeon	Randomised controlled trial	Pre-procedural and intra-procedural checklist. (47 procedures)	To evaluate the feasibility of implementing a perioperative safety checklist, and to gain an increased awareness of the challenges and solutions associated with such an effort.	Surgical procedural safety checklists have a positive effect to increase the frequency of team behaviors in the operating room during laparoscopic surgery. It is likely that they can be implemented in a wide range of other medical and procedural settings with similar results.	Positive	13	High
Robb et al. (2012)	Journal of Gastrointestinal Surgery	Cohort study	Intra-procedural (637 procedures)	To document the introduction of a 10-step intraoperative surgical checklist to standardize performance, decision making, and training during LC.	The introduction of the checklist was temporally related to reduced conversion rates to OC. The standardization of LC could potentially lead to an impact, which warrants further attention in prospective, appropriately designed studies.	Positive	10	Moderate
Romain et al. (2012)	Journal of Visceral Surgery	Prospective monocentric cohort study	Pre-operative (62 procedures)	To study if a preoperative checklist for laparoscopy could improve procedure efficiency by reducing lost time due to incidents related to equipment failure/ malfunction.	The preoperative checklist for laparoscopic procedures was feasible and seemed necessary as a primary tool to prevent failure/malfunction in the operation room. The checklist improved the efficacy of operating theatre.	Positive	9.5	Moderate
Connor et al. (2013)	Hepatobiliary	Recommendation based on experts' errors analysis	Intra-procedural to accompany the WHO checklist	To describe a standardized technique for LC that will allow a development of a concept of checklist, the use of which, it is hoped, will decrease the prevalence of bile duct injury.	A standardized approach to LC would allow for the creation of an LC-specific checklist that has the potential to lower the prevalence of bile duct injury.	N/A	5	Low
El Boghdady et al. (2017)	World Journal of Surgery	Cohort study	Intra-procedural (24 procedures)	To study the effect of a previously designed performance-based self-administered intra-procedural checklist on the performance of trainees during elective LC.	The self-administered intra-procedural checklist improved the laparoscopic performance of trainees and decreased the number of interventions by the trainer during LC. The trainees were satisfied using the checklist during LC.	Positive	12.5	High

\*5–8 points were considered to be of low quality, 9–11 with moderate quality and those with 12–18 points represented high-quality studies.

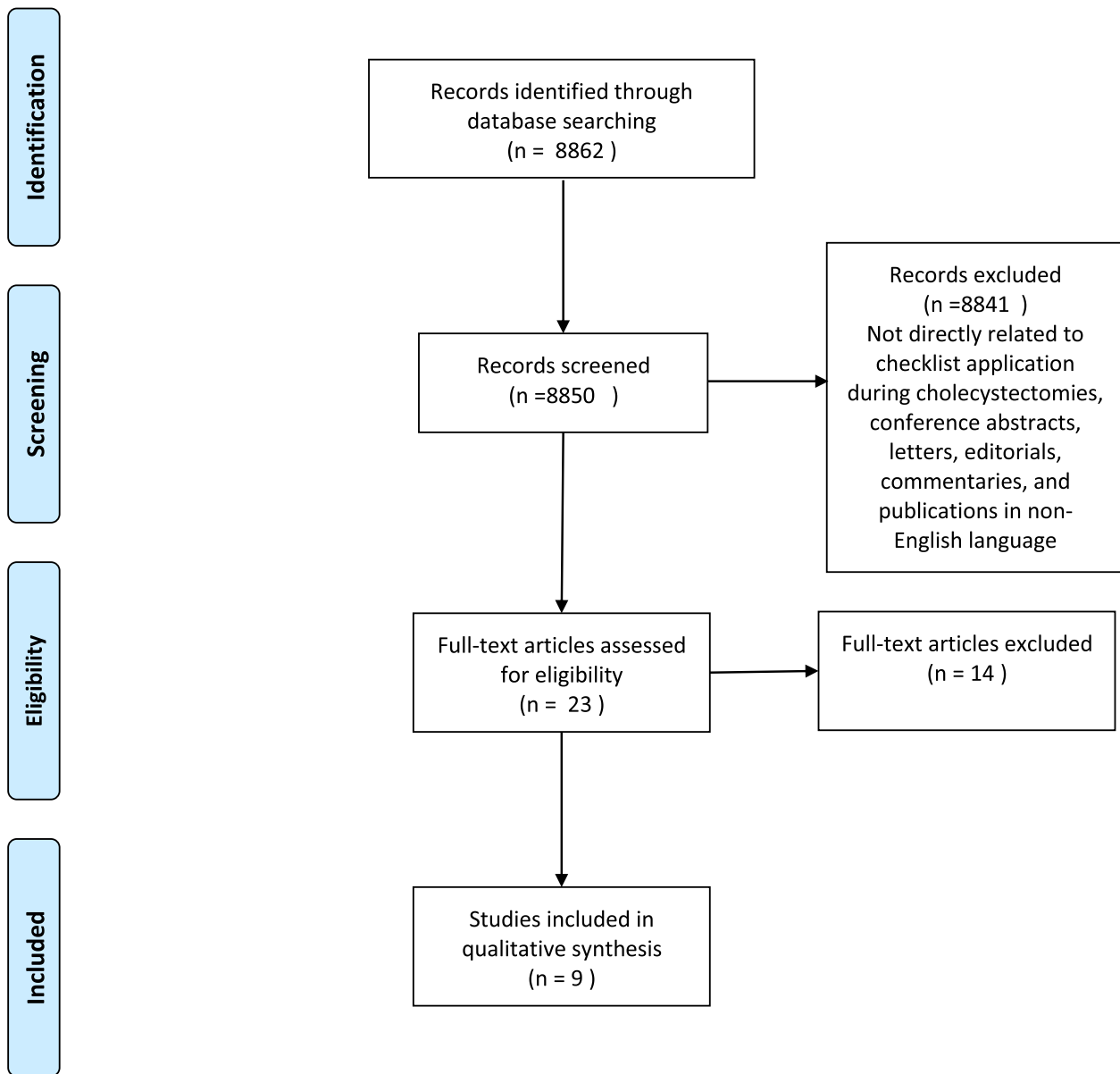


Fig. 1. Cohort diagram of the systematic review.

Calland et al. [15]: used a mix of pre-operative safety and intra-procedural checklists, proving that they had the capacity to increase the frequency of positive team behaviors in the operating theatre during laparoscopic surgery. In addition, the checklists improved the appropriateness of medications' administrations, accuracy of identification of anatomical structures during the procedure and the post case questionnaire captured team knowledge of case events.

#### Risk of bias across studies

The retrieved citations were read in full text for further assessment for eligibility. The risk of bias within studies consisted of the small number of papers. However there was a good number of laparoscopic procedures included in the studies. It was claimed that MERSQI is not limited to intervention studies only, but is appropriate for all quantitative studies. The MERSQI scores of the raters were found almost the same, a mean score was calculated and the quality assessment for the scored citations was applied.

#### Discussion

Our current systematic review presented scientific evidence for a positive effect of the use of checklist on surgical task performance during laparoscopic cholecystectomy procedures. The current incidence of complications and bile duct injury following LC remains unacceptably high. Therefore, we studied checklists use to perform safe LC which proved to reduce the incidence of such complications by decreasing operating theatres' errors.

Key findings of the included studies were a significant decrease in the numbers and types of incidents and adverse events. A technical and technological assessment tool for laparoscopic surgery proved to have face, concurrent, content, and construct validities during LC procedures [12]. A pre-operative checklist was feasible and reduced the number of incidents with technical laparoscopic equipment in theatres [13]. Integrated operating room (OR) system and Pro/cheQ, a digital checklist tool, was studied on the number and type of equipment and instrument related risk sensitive events (RSE) during LC. It was proven that using an integrated OR and Pro/cheQ has a higher reducing effect on the number

of RSE compared to using an integrated OR alone. The Pro/cheQ tool supported the optimal workflow in a natural way and raised the general safety awareness amongst all members of the surgical team [14].

Another pre-operative surgical procedural safety checklist was based on biochemistry and imaging review, functioning appliance (e.g. nasogastric tube, foley's catheter), medications administration (e.g. antibiotics and heparin), Intra-operative trochar check, cystic artery and duct check, clip verification and haemostatis. This had the capacity to increase the frequency of positive team behaviors in the operating theatre during laparoscopic surgery and appropriate administration of medications, accurate identification of anatomical structures during the procedure, post case questionnaire captured team knowledge of case events [15]. In addition, the number of consequential and inconsequential errors analysed by Human Reliability Analysis technique and the number of interventions of the trainers significantly decreased using the performance based intra-procedural checklist that was self-administered at repeated intervals by the trainees [19].

The checklists applied specifically during LC in previous studies were different in nature. The pre-procedural checklists aimed mainly to decrease equipment related events [13, 14]. While the post-procedural checklists studied the technical and technological skills [12], aimed to divide the tasks into procedural steps to be used as aid memoires for the steps [16, 18] and focused on decreasing the performance based errors in surgical trainees [19].

In an analysis of errors enacted by surgical trainees during skills training courses, average number of errors committed by surgical trainees per simulated laparoscopic cholecystectomy was twice that observed during clinical laparoscopic cholecystectomy [20]. Hence, training in skills laboratories is to be considered a prelude to supervised training of clinical operative skills in the operating theatre. A checklist application is then envisaged to improve the acquisition of technical skills and improve the surgical task performance of trainees [1]. Checklists can also be used as a reminder of the procedural steps and guide them through the task to decrease unintended errors.

The performance of laparoscopic surgery is often more difficult for novices and junior trainees when compared to open procedures. There are potentially several reasons for this, which may include difficulty with depth perception and the need to interpret the 2D image into 3D in laparoscopic surgery. It is known that the fulcrum effect of the laparoscopic instrument, lack of haptic feedback, and unfamiliarity with the angular view might make laparoscopic surgery more difficult when compared to open surgery. Therefore, it was envisaged that a checklist can be applied to assist the performance of the surgeons throughout the laparoscopic task [1].

Close supervision with appropriate use of a well-defined and validated checklist during practical sessions of simulation-based surgical training or surgical performance in the operating theatre, will play a major role in surgical training for improving quality of surgical performance of LC. Although the novice trainee will need time and practice to be able to apply a checklist correctly during simulation-based surgical training [21], they have to be considered as an integral part of the training/learning process. The finding in this review has demonstrated the effectiveness and validity of checklist in improving surgical performance during the LC, hence, the well established checklist can be used in surgical training purpose.

The use of checklists in health care is not uncommon. A Surgical Safety Checklist has been developed by The World Health Organization's Patient Safety Programme to improve the safety of surgical care. Its use improved compliance with standards of care by 65% and reduced the death rate after surgery by nearly 50% [22]. Laparoscopic surgery involves the use of sophisticated laparoscopic and energy equipment as well as increased demands on the operating theatre staff for set-up and troubleshooting of equipment. Therefore, different types of checklists have been developed, including a safety checklist in form of preoperative assessments for laparoscopic equipment complexity [23].

The main limitation of our research study was the small number of articles and the different nature of the previously used checklists in literature. In the meantime, this was a precursor to conduct this review in order to study the effect of the previously developed checklists and their effect of the surgical task performance, for possible future routine use.

The development of a new standardised checklist by a combination of more than a checklist can be the subject of future research for possible application in routine LC to reduce surgeons' errors by preventing pre- and intra-procedural adverse events. The checklist focusing on the factors influencing the task performance can be mixed with another one focusing on memorising the steps of the task.

## Conclusion

The effect of the application of checklists during LC showed a significant improvement of the surgical task performance by decreasing surgeons' errors. A combination of pre-operative safety and intra-procedural checklists can be the subject of future research for possible application during routine laparoscopic cholecystectomy.

## Declaration of Competing Interest

The authors declare no conflict of interests.

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