The effect of a simple intraprocedural checklist on the task performance of laparoscopic novices

El Boghdady, Michael; Tang, Benjie; Tait, Iain; Alijani, Afshin

Published in:
American Journal of Surgery

DOI:
10.1016/j.amjsurg.2016.07.019

Publication date:
2017

The effect of a simple intra-procedural checklist on the task performance of laparoscopic novices

Authors:

Michael El Boghdady, Benjie Tang, Iain Tait, Afshin Alijani

Affiliation:

Cuschieri Skills Centre, Ninewells Hospital and Medical School, University of Dundee, UK

Corresponding author:

Dr Michael El Boghdady, MBChB, MD, MHPE
Clinical Research Fellow,
Email: m.elboghdady@dundee.ac.uk
michael_boghdady@hotmail.com
Telephone: 00 44 (0)1382 383400
Address: Cuschieri Skills Centre,
Level 5, Ninewells Hospital and Medical School
Dundee, UK
DD1 9SY

Introduction:

A checklist has been defined as a comprehensive list of important actions, or steps to be taken in a specific order. It is also used to reduce errors by compensating for potential limits of human memory and attention. It is not believed that checklists prevent all human error and/or accidents but it can decrease errors if it is systematically followed[1]. The introduction of a Surgical Safety Checklist by the WHO has significantly reduced the morbidity and mortality of surgery[2]. Checklists are infrequently applied during procedures and have been limited to lists of procedural steps as aid memoires[3, 4]. A common standardised format for training and error reduction is post-procedural paper feedback[5], however the main limitation of paper feedback is its retrospective post-procedural nature requiring the information being retrieved from memory, often resulting in the loss of finer aspects to feedback.

We aimed to develop a simple performance based self-administered intra-procedural checklist and to study its effect on the surgical performance of novice surgeons when applied during a standardised laparoscopic task.

Methods:

A standardised intra-procedural checklist was formulated by consensus among master surgeons who ranked the technical factors influencing the laparoscopic task performance via a link to an online questionnaire. Factors that were taken into account for the design of the checklist included: simplicity, to be short and quick to apply repeatedly, generic items which were non-specific to any procedure, and with greater emphasis on items influencing the performance rather than only aid memoires for steps of the tasks. The checklist was piloted on 10 novices during laparoscopic knot tying prior to the commencement of this study. Based on the results of the total number of errors, the power calculation suggested twenty subjects should enable the detection of 20% difference of median total number of errors with 80% power at 5% level.

Following the completion of the pilot study, twenty consented novices from medical students and junior doctors without any previous laparoscopic experience were randomly allocated in two equal groups using an online randomiser software. The control group received a standardised post-procedural paper feedback alone, and the checklist group received the post-procedural paper feedback in addition to the standardised checklist. A beeping sound was used at 20 seconds intervals in order to remind novices to apply the checklist that was displayed beside the laparoscopic monitor at eye level. A standardised paper feedback was applied to both arms of the trial, as the current gold standard, in order to study the effect of the checklist.

Each candidate was given a 10 minutes introductory training to perform the task of double square knots. The task was divided into 4 subtasks: i) creation of a C-shaped configuration of the suture thread for creating the first double throw, ii) configuration of the first double throw, iii) creation of a reverse C-shaped configuration for creating the second double throw, iv) configuration of the reverse double throw.

Every participant performed the laparoscopic task on a synthetic material in five separate stages. The duration of every stage was 3 minutes, and was followed by a 3 minutes rest. The tasks were in a Laparoscopic Endo trainer (26348 SZABO-BERCI-SACKIER laparoscopic trainer) using 2 needle holders (26173KAF, KOH Macro Needle Holder, 5mm diameter, 3cm

length, Karl Storz) and a telescope (26003BA, Hopkins ®, 30 degree, 10mm diameter, 31 cm length, Karl Storz)

Novices were randomised by using an online randomiser. Unedited video recordings were analysed by the Human Reliability Technique[6]. The unedited videos were analysed for surgical task performance by the main assessor who was blind to the categorisations of the arms.

Endpoints were total number of errors during each task, error frequency also known as error probability for each task (total number of errors per total number of knots), error types, and number of completed knots. Non-parametric Mann–Whitney U and Wilcoxon tests were used for statistical analysis. Comparative data were presented as median (IQR).

Results:

Fourteen master surgeons ranked the technical factors influencing the laparoscopic task performance via an online questionnaire. This revealed the following order from the most to the least important: 1-Exposure, 2-Bi-manual coordination, 3-Degree of force, 4- Direction of force, 5-Following the steps of the task and 6- Speed (Figure 1).

Exposure was the highest ranked factor, however, it was excluded in this study due to the standardization of the obtained optical view. In addition, direction of force was excluded because it could not be taught to novices with no previous laparoscopic experience. A pilot study on 10 novices revealed that 'speed' was practically the most important factor that improved their performance, therefore it was ordered first on the checklist. The components of the checklist were worded as shown in figure 2.

Twenty laparoscopic novices were included in this study. Eight were males and 18 were right handed (Figure 3). 2341 errors were detected in 141 tasks and 408 subtasks during the 5 stages. There were 1422/2341 errors (60.75 %) in the control group (those who received paper feedback only); as compared to 919/2341 errors (39.25%) in the checklist group (those who received both the checklist and paper feedback). During the first stage, the errors were not significantly different between the two groups. The checklist group committed significantly fewer errors as compared to the control group during all the later 4 stages ($p<0.01$) (Figure 4).

The checklist group had an enhanced learning curve as the last 4 stages showed significant fewer errors compared to the first stage ($p<0.05$). The control group showed no improvement. Error probability was significantly higher in the control group compared to the checklist group [median (IQR) 32.6 (25.89) vs 11.7 (10.72) ($p<0.01$)].

Individual error types during each step of the laparoscopic task were identified. The checklist group performed better with fewer errors for all the error types. While, there was no significant difference in each of 'the lack of supination', 'tissue bite' and 'out of vision'; the differences in all the rest of error types were highly statistically significant ($p<0.01$) (Table 1). Number of completed knots was not statistically different between the 2 groups.

Discussion:

Our simple performance based intra-procedural checklist appears to have a significant accelerating effect on the acquisition of technical skills when applied by novices during a standardised lab-based laparoscopic task. This is the first study to look at a surgical checklist that is simple to be applied, mainly performance based, and used during surgery.

The introduction of a Surgical Safety Checklist by the WHO has significantly reduced the morbidity and mortality of surgery[2]. The 19 items surgical checklist ensures that essential information such as patient identity, the type of procedure, its risks and other patient factors are brought to the team's attention. This synchronization of essential information is accompanied by an introduction of all team members by name and role in the operating theatre. The WHO surgical checklist may prevent avoidable human error, however, it is only limited to pre-and post-procedural evaluation.

There are only few previous studies that have looked at the effect of checklists during routine surgical procedures. Intra-procedural checklist has been loosely defined by different authors. Robb WB *et al* studied the effect of an intraoperative surgical aid memoire on the conversion rates from laparoscopic to open cholecystectomy[3]. In this study, the checklist was used as an indirect measure of error reduction, limited to parts of a specific procedure (cholecystectomy) and was only used as aid memoire for procedural steps. Ziewacz JE *et al* studied the design, development, and implementation of an algorithm for intraoperative neuro-monitoring changes[4]. It highlighted the specific roles of the anaesthetist, surgeon, and neuro-monitoring personnel during neuro-spinal procedures and the clinical efficacy of this remains unknown.

The performance of laparoscopic surgery is often more difficult for novices when compared to open procedures. There are potentially several reasons for this, which may include poor image quality and its magnification, difficulty with depth perception[7] and the need to interpret the 2D image into 3D in laparoscopic surgery. The fulcrum effect of the laparoscopic instrument[8], lack of haptic feedback[9], and unfamiliarity with the angular view might also make laparoscopic surgery more difficult than open.

Our checklist is short and simple, made of four factors making it easy to remember and quick to apply by novices repeatedly. The simplicity of the checklist minimizes its potential interference as a distraction during the procedure. Performing the procedure in a step wise fashion in a correct order has been the focus of previous studies. Our checklist included this important factor but critically also included additional factors influencing the task performance itself. The checklist is based on generic factors which makes it applicable to most surgical procedures. The application of a mainly performance based checklist will result in error reduction rather than error correction, i.e. minimizes the occurrence of errors. It is the authors' opinion that experts tend to apply our simple four point checklist at regular intervals often unknowingly, however, it takes time and practice for the novices to be able to apply these points automatically when appropriate.

Novices tend to operate at the same rate throughout all stages of the procedure regardless of its difficulty. It is generally advisable for novices to operate at slower rate to reduce errors, particularly in high risk zones of the procedure. Reminding the novices to slow down through the application of the checklist will have the desired effect as shown in this study.

During the intensive concentration required for performing laparoscopic tasks, novices often ignore their non-dominant hand at the expense of the dominant one. A typical scenario arises when a novice surgeon fails to adequately retract the tissue using the instrument in the non-dominant hand resulting in poor exposure for the dissection performed through the instrument in their dominant one. Reminding the novice to use both hands optimally has the potential advantage of making the surgeons operate bimanually.

An important independent factor for the performance in laparoscopic surgery is the degree of force applied to the tissue using the instrument, with too little force often resulting in repeating the steps, or too much force giving rise to errors with consequence, such as bleeding or tissue tear. The novices need guidance throughout the procedure over time to understand the appropriate degree of force required to achieve the task. For a novice, it is safer to be gentle in order to minimize any errors with consequence.

The checklist group performed better in five out of eight error types. Although the link between the individual error types and the checklist components was not the focus of this study, there appears to be a relationship between the individual checklist items and certain error types. For example, being asked to be gentle resulted in committing fewer errors defined as ''inappropriate degree of force'' and ''wrong direction of force''. There were significant improvements in the checklist group for '' inappropriate instrument positioning'' and the ''inappropriate grip of suture material''. This could have been corrected by the two components of the checklist, ''slowing down'' and ''using both hands together''. Being asked to follow the steps could be resulted in committing fewer ''missed steps''.

Although novices were asked to perform the tasks slowly, they managed to successfully complete the same number of knots with fewer errors. As in general, the accuracy of a movement tends to decrease when its speed increases above a threshold[10]. Our interpretation is that slowing down could give the participants more time for visual feedback[11]. For the sake of standardization, we used a beeping sound to remind novices to apply the checklist.

We envisage that novices will be able to apply the checklist on their own or simply prompted by the trainer after completing the initial standardized training. Because of the non-obtrusive and simple format of the checklist, we envisage that it can also be displayed for viewing by the surgical trainee during live surgery in the operating room. The effect of the checklist on the acquisition of laparoscopic skills in the operating rooms could be the subject of future studies.

Conclusions:

This simple performance based intra-procedural checklist appears to have a significant accelerating effect on the acquisition of technical skills when applied by novices during a standardised lab-based laparoscopic task. Our checklist can be applicable during lab-based training by surgical novices.

Disclosures:

The authors declare no conflict of interests.

Funding:

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Ethical approval:

Approval was granted by local research ethics committee prior to the commencement of this study.

References:

1. Müller, Stig, & Patel, HitendraR H. (2012). Lessons Learned from the Aviation Industry: Surgical Checklists. In H. R. H. Patel & J. V. Joseph (Eds.), Simulation Training in Laparoscopy and Robotic Surgery (pp. 1-6): Springer London.

2. Haynes, Alex B., Weiser, Thomas G., Berry, William R., Lipsitz, Stuart R., Breizat, Abdel-Hadi S., Dellinger, E. Patchen, . . . Gawande, Atul A. (2009). A Surgical Safety Checklist to Reduce Morbidity and Mortality in a Global Population. New England Journal of Medicine, 360(5), 491-499. doi: doi:10.1056/NEJMsa0810119

3. Robb, W. B. (2012). A 10-step intraoperative surgical checklist (ISC) for laparoscopic cholecystectomy-can it really reduce conversion rates to open cholecystectomy? Journal Of Gastrointestinal Surgery: Official Journal Of The Society For Surgery Of The Alimentary Tract, 16(7), 1318. doi: 10.1007/s11605-012-1886-6

4. Ziewacz, J. E. (2012). The design, development, and implementation of a checklist for intraoperative neuromonitoring changes. Neurosurgical Focus, 33(5), E11. doi: 10.3171/2012.9.FOCUS12263

5. Royal College of Surgeons of Edinburgh, from http://www.rcsed.ac.uk/

6. Joice, P., Hanna, G. B., & Cuschieri, A. (1998). Errors enacted during endoscopic surgery--a human reliability analysis. Appl Ergon, 29(6), 409-414.

7. Breedveld P, Stassen HG, Meijer DW et al (1999) Theoretical background and conceptual solution for depth perception and eye–hand coordination problems in laparoscopic surgery. Minim Invasive Ther Allied Technol 8:227–234

8. Gallagher, A. G., McClure, N., McGuigan, J., Ritchie, K., & Sheehy, N. P. (1998). An ergonomic analysis of the fulcrum effect in the acquisition of endoscopic skills. Endoscopy, 30(7), 617-620. doi: 10.1055/s-2007-1001366

9. Van der Meijden, O. A. J., & Schijven, M. P. (2009). The value of haptic feedback in conventional and robot-assisted minimal invasive surgery and virtual reality training: a current review. Surgical Endoscopy, 23(6), 1180-1190. doi: 10.1007/s00464-008-0298-x

10. Zhou, Xiaolei, Cao, Xiang, & Ren, Xiangshi. (2009). Speed-Accuracy Tradeoff in Trajectory-Based Tasks with Temporal Constraint. In T. Gross, J. Gulliksen, P. Kotzé, L. Oestreicher, P. Palanque, R. O. Prates & M. Winckler (Eds.), Human-Computer Interaction – INTERACT 2009: 12th IFIP TC 13 International Conference, Uppsala, Sweden, August 24-28, 2009, Proceedings, Part I (pp. 906-919). Berlin, Heidelberg: Springer Berlin Heidelberg.

11. Meyer, D.E., Smith, J.E.K., and Wright, C.E. (1982). Models for the speed and accuracy of aimed movements. Psychological Review 89:449-482.