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# The effect of a performance based intra-procedural checklist on a simulated emergency laparoscopic task in novice surgeons

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**Abstract:**

**Introduction:**

Surgical checklists are in use as means to reduce errors. Checklists are infrequently applied during emergency situations in surgery. We aimed to study the effect of a simple self-administered performance based checklist on the laparoscopic task when applied during an emergency simulated scenario.

**Methods:**

The aviation checklist for unexpected situations is commonly used for simulated training of pilots to handle emergency during flights. This checklist was adopted for use as a standardised performance based checklist during emergency surgical tasks. Thirty consented laparoscopic novices were exposed unexpectedly to a bleeding vessel in a laparoscopic virtual reality simulator as an emergency scenario. The task consisted of using laparoscopic clips to achieve haemostasis. Subjects were randomly allocated into 2 equal groups; those using the checklist that was applied once every 20 seconds (checklist group) and those without (control group).

**Results:**

The checklist group performed significantly better in 5 out of 7 technical factors when compared to the control group: Right instrument path length (m), median [IQR] 1.44 [1.22] vs 2.06 [1.70] (p= 0.029), and right instrument angular path (degree) 312.10 [269.44] vs 541.80 [455.16] (p= 0.014), left instrument path length (m) 1.20 [0.60] vs 2.08 [2.02] (p= 0.004), left instrument angular path (degree) 277.62 [132.11] vs 385.88 [428.42] (p= 0.017). The checklist group committed significantly fewer number of errors in the application of haemostatic clips, 3 vs 28 (p= 0.006).

Although statistically not significant, total blood loss (lit) decreased in the checklist group from 0.83 [1.23] to 0.78 [0.28] (p= 0.724), and total time (sec) from 186.51 [145.69] to 125.14 [101.46] (p=0.165).

**Conclusion:**

The performance based intra-procedural checklist significantly enhanced the surgical task performance of novices in an emergency simulated scenario.

**Keywords:**

Checklist, Laparoscopic, surgery, emergency, training, simulation, task performance.

## Introduction:

A checklist has been defined as a comprehensive list of important actions, or steps to be taken in a specific order. Checklists are used to reduce errors by compensating for potential limits of human memory and attention. It is not believed that checklists prevent all human errors and accidents but checklists can decrease errors if systematically followed[1.]

The introduction of a Surgical Safety Checklist by the WHO has significantly reduced the morbidity and mortality in surgery by reducing human errors through pre-and post-procedural evaluations[2]. Other examples of checklists include the Advanced Trauma Life Support (ATLS) system[3] and anaesthetic crisis management checklist [4,5]. However, there is no study to date that has looked at the effect of a surgical checklist on the task performance during surgical emergency scenarios, laparoscopic or open, as a way of error prevention.

Checklists are applied routinely in aviation industry in operations, technical maintenance and repair, as well as training for pilots, and other personnel. Aviation checklist for unexpected events (DECIDE checklist) (Table 1) is in use for simulated training to prepare aircraft personnel to handle emergencies during flights[1].

We aimed to adopt a self-administered intra-procedural checklist to study its effect on the surgical task performance of novice surgeons when applied during a standardised simulated laparoscopic control of a bleeding vessel.

## Methods:

The DECIDE checklist was shortened into 3 simple components. These included: Detect the problem, choose the safest solution, and then act. These aim to assist the novice to formulate a solution to the problem. This was than combined with a 4-component performance based checklist as detailed in figure1.

Consented 2nd to 5th year medical students with no previous laparoscopic experience were randomly allocated in two equal groups by an online randomiser. The control group received no checklist. The participants were given 10 minutes of introduction to the LapSim virtual reality simulator, then were exposed to unexpected bleeding requiring emergent clipping for haemostasis. The participants were then asked to control the bleeding. A soft beeping sound was used at 20 seconds intervals as a reminder to apply the checklist that was displayed beside the simulator. The control subjects had no such reminder or checklist. The task was considered complete when the bleeding was stopped. The participants were then evaluated on the following metrics:

- Right instrument path length (m): The length of the path swept by the tip of the right instrument as a measure of the economy of movements.
- Left instrument path length (m).
- Right instrument angular path (degree): Pivotal rotation of the right instrument. This is a measurement of how much the participant wiggled the instrument as a measure of the economy of the movements. It does not take into account for axial rotations.
- Left instrument angular path (degree).
- Number of errors in applying haemostatic clips: Number of clips placed incorrectly, or outside designated target areas, in addition to the dropped clips.
- Total task time (sec).

- Blood loss (litres).

The statistical package for the Social Sciences software (version 22, SPSS Chicago, IL, USA) was used. Data was not normally distributed and non-parametric statistics (Mann–Whitney U test) were used for data analysis. Data was presented as Median [IQR]. P value was defined as statistically significant when $P<0.05$.

**Results:**

Thirty novices were randomised into 2 equal groups. Fourteen were males and 2 were left handed. The checklist group performed significantly better in 5 out of 7 technical factors when compared to the control group: Right instrument path length (m),median [IQR] 1.44 [1.22] vs 2.06 [1.70] (p= 0.029), and right instrument angular path (degree) 312.10 [269.44] vs 541.80 [455.16] (p= 0.014),left instrument path length (m) 1.20 [0.60] vs 2.08 [2.02] (p= 0.004), left instrument angular path (degree) 277.62 [132.11] vs 385.88 [428.42] (p= 0.017). The checklist group committed significantly fewer number of errors in the application of haemostatic clips, 3 vs 28 (p= 0.006) (Figure 2).

Although statistically not significant, total blood loss (lit) decreased in the checklist group from 0.83 [1.23] to 0.78 [0.28] (p= 0.724), and total time (sec) from 186.51 [145.69] to 125.14 [101.46] (p=0.165).

**Discussion:**

Our simple performance based intra-procedural checklist has a significant accelerating effect on improving the task performance when applied by novices during a standardised simulated emergency scenario. There are few previous studies that have looked at the effect of checklists during surgical procedures, but these have been limited in use only as aid memoires for the procedural steps[4,5,6,7]. Our study is the first attempt at looking at the effect of a surgical checklist on the laparoscopic task performance as a way of error prevention during emergency scenarios.

Research has shown that limited capacity of human brain can be exceeded when multiple attention demanding tasks are executed simultaneously[8]. The capacity of the human mind is limited in stressful situations as the experience in the aviation industry shows[1]. This task saturation has been causal to accidents, for example, when unexpected events or distractions disturb the routine so that some tasks are overlooked. Surgeons can also suffer from task saturation in emergency scenarios when unexpected events and distractions occur. In an emergency scenario, the surgeon firstly needs to be able to detect and define what the problem is, secondly, to be able to select an appropriate solution to remedy the problem, and thirdly to implement the solution, all executed in a timely manner. This increased demand on mental capacity can result in task saturation, giving rise to a decline in task performance. Our checklist reminds the novice to define the problem, select a solution and execute the action in a timely manner creating a frame for structural thought process. Once the problem is defined and the solution is selected, the checklist helps the novice in executing his/her actions with fewer errors through a series of performance based checklist components (slowing down, using both hands together, being gentle and following the steps).

Our checklist is short and simple, made of seven factors making it easy to remember and quick to apply by novices repeatedly. The simplicity of the checklist minimizes its

interference as a distraction during the procedure. The checklist is based on generic factors which makes it potentially applicable to most surgical procedures. The 4-component section of the checklist was formulated separately by consensus among 14 master surgeons and piloted on 20 surgical novices. The performance based section had shown a significant accelerating effect on the acquisition of technical skills during routine laparoscopic knot tying task. The addition of the 4-component section of the checklist assisted the novice in executing the selected task with fewer errors.

The application of a mainly performance based checklist will result in error reduction rather than error correction, i.e. minimizes the occurrence of errors. Experts tend to apply our simple seven component checklist during emergency situations often unknowingly, however it takes time and practice for the novices to be able to apply these components automatically when appropriate.

Novices tend to operate at the same speed throughout all stages of the surgery regardless of the difficulties. Novices are generally advised to operate at slower rate in high risk zones of the procedure in order to decrease errors. Reminding the novices to slow down through the application of the checklist will have the desired effect of reducing the rate of sensory input from the environment to improve the task performance.

Novices often ignore their non-dominant hand at the expense of the dominant one during laparoscopic tasks when requiring intensive concentration. 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. Reminding the novice to use both hands optimally can improve the task performance.

Another influencing factor for the performance in surgery is the degree of force applied to the tissue using the instrument, as too much force gives 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 error with consequence. This constitutes the third component of the checklist, being gentle.

Although novices were asked to perform the tasks slowly, they managed to successfully complete the same task with fewer errors over the same period of time. Participants performed the task more accurately when they slowed down. This could be because the accuracy of a movement decreases when its speed of execution increases above a threshold[9]. Our interpretation is that slowing down could give the participants more time for visual feedback[10].

The checklist appears to have improved the task performance by improving the economy of movements. It also appears that this improvement has been translated into a significant reduction in the number of errors committed during the application of haemostatic clips. However the extent of the blood loss is an example of the consequence of errors committed during the clip application. Task performance has a more direct relationship with the error itself (e.g. clip application) than its consequences (e.g. blood loss). Often there are other confounding variables that result in the development of consequences and complications when errors are committed.

The emergency scenario of a bleeding vessel was selected for this study because it is a common encounter in clinical environment often requiring quick thinking and rapid corrective actions executed with as few errors as possible. Virtual reality simulator was selected for the purpose of this study because it allowed full participation of complete novices in an emergency surgical task. This would not be ethically and practically possible in a clinical setting. Furthermore, training on a virtual reality simulator has been shown to improve the performance in the operating rooms[11]. One limitation of this study design is that it does not take into account stresses often encountered during live surgery in clinical environment which could be all added factors depreciating surgical performance. A possible future work could be the study of the application of this checklist in more complex surgical scenarios performed by more experienced surgeons.

## Conclusion:

The performance based self-administered intra-procedural checklist significantly enhanced the surgical task performance of novices in an emergency simulated scenario.

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## Conflict of interest:

The authors have no conflict of interest to declare.

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