Virtual reality laparoscopic cholecystectomy simulation module: mapping out the essential areas of improvement

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Introduction

Minimally invasive procedures using camera and a screen as means of projection have given birth to Virtual Reality (VR) laparoscopic simulation training, changing the landscape of surgical education. Nowadays, the laparoscopic approach for cholecystectomy is considered the gold standard, this procedure being one of the most widely performed laparoscopic operations[1]. As a result, the VR laparoscopic cholecystectomy training programme is one of the most attractive modules for trainees from variable levels of expertise. Since the first published curriculum[2], several changes have occurred in clinical practice, education and technology that mandate a revision[3].

Methods

Three independent groups performed the module, including four procedural tasks and one full procedure with conventional anatomy on the two most recent versions of the same platform *[Figure 1 and 2]*, namely Lap Mentor II (Simbionix Corporation, Cleveland, Ohio, USA) and Lap Mentor III (Simbionix Corporation, Cleveland, Ohio, USA).

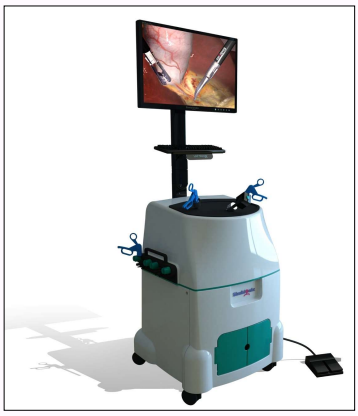

Figure 1. Virtual reality high-fidelity laparoscopic simulator (LAP Mentor II)

Each group kept records of shortcomings and possible improvements, mapped across three areas of interest. The first area consisted of changes in clinical practice that should be reflected in the module; the second one included differences between the two platforms; and the third area focused on suggested modifications of the current software *[Figure 3]*. Items that existed in the lists of no less than two groups were automatically included in the final aggregate, while items that were identified by only one team were thoroughly discussed and were added to the comprehensive list as long as one more group seconded the argument.

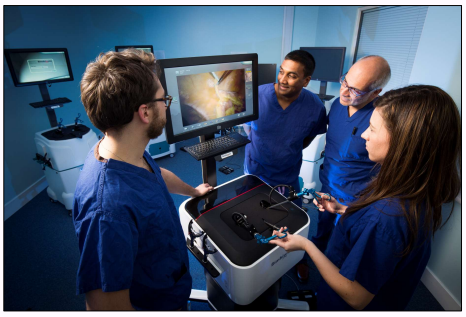

Figure 2. Virtual reality high-fidelity laparoscopic simulator (LAP Mentor III)

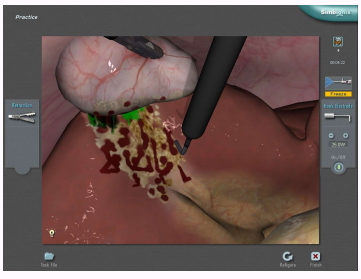

Figure 3. Screen capture of a procedural task from the LAP Mentor II laparoscopic cholecystectomy module: removal of the gallbladder from the liver bed

Results

In total, twenty-five items for improvement were identified *[Table 1]*. The majority of these items belonged to the first (fourteen items) and third (nine items) area of interest. They were related to changes in actual technique of laparoscopic cholecystectomy, use of the diathermy instead of dissection, additional safety parameters that were not included in the previous curriculum, and extra steps for more accurate supervision of trainees' performance, as well as a more realistic depiction of laparoscopic cholecystectomy. In the second area of interest, two items were identified with the potential of improving the curriculum software in order to make it more realistic and accessible to trainees with vision deficiency.

Parameter	Task 1	Task 2	Task 3	Task 4
1st area of interest				
Cautery time without appropriate contact with adhesions to be used as safe cautery indication and replace total cautery time	✓		✓	✓
Addition of "extent of dissection of gallbladder" and use of 1/3 as threshold	✓			✓
Acquisition of photograph of medial and lateral view of CVS	✓			✓
Machine- or assessor-mediated evaluation of CVS	✓			✓
Hinted areas of required dissection to not extend >2cm from the gallbladder	✓			
Calculation of the percentage of clearance should only use this area of 2cm from the gallbladder as denominator	✓			✓
Orderly performance of five subtasks		✓		✓
Appropriate number of clips		✓		✓
Appropriate order of clips' placement		✓		✓
Appropriate distance between clips		✓		✓
Appropriate distance of cutting from the clips of the remnant		✓		✓
Safe use of diathermy should take into consideration the clips of the remnants and not of the specimen				✓
Modifiable level of difficulty (hardness of adhesions)				✓
Requirement to place specimen into retrieving bag				✓
2nd area of interest				
Accurate placement of clips at the exact position where applicator is fired		✓		✓
4-colored hinting to demonstrate adhesions that need to be divided amongst adhesions involved in bleeding			✓	
3rd area of interest				
Appropriate use of hook (hooking and direction)	✓		✓	✓
No clashing of instruments	✓	✓	✓	✓
Instruments kept in view	✓	✓		✓
Minimal crossing of instruments	✓	✓	✓	✓
Hints in forms other than just color	✓		✓	
Scissors to be inserted closed		✓		✓

Table 1. Summary of suggested modifications, mapped across three different areas of relevance

Discussion

Laparoscopic cholecystectomy is indeed one the most commonly performed laparoscopic procedures, with over 750,000 operations per year in the U.S.A. and a similar number in Europe[4]. Introduction of laparoscopic simulation training has offered a strong solution for a series of issues regarding surgical training. Accessibility, safety, repeatability are only some of those. VR simulation training conveyed even more advantages including immersive training, lower cost, asynchronous training and lower cost compared to training on cadavers and laboratory animals[5,6]

In order to modernise the curriculum and prior to revising metrics' thresholds, software should be optimised to reflect the current gold-standard of the operation; these changes will provide a more realistic VR environment to prepare young surgeons for real life surgery and to allow a far more accurate evaluation of their laparoscopic training.

References

1. Hassler KR, Collins JT, Philip K, Jones MW. Laparoscopic Cholecystectomy. StatPearls. Treasure Island (FL) 2022.
2. Aggarwal R, Crochet P, Dias A, Misra A, Ziprin P, Darzi A. Development of a virtual reality training curriculum for laparoscopic cholecystectomy. Br J Surg. 2009;96:1086-93.
3. Fisher AT, Bessoff KE, Khan RI, Touponse GC, Yu MMK, Patil AA, et al. Evidence-based surgery for laparoscopic cholecystectomy. Surg Open Sci. 2022;10:116-3.
4. Russo MW, Wei JT, Thiny MT, Gangarosa LM, Brown A, Ringel Y, Shaheen NJ, Sandler RS. Digestive and liver diseases statistics, 2004. Gastroenterology. 2004;126:1448-53.
5. Hasan LK, Haratian A, Kim M, Bolia IK, Weber AE, Petrigliano FA. Virtual Reality in Orthopedic Surgery Training. Adv Med Educ Pract. 2021;12:1295-301.
6. Portelli M, Bianco SF, Bezzina T, Abela JE. Virtual reality training compared with apprenticeship training in laparoscopic surgery: a meta-analysis. Ann R Coll Surg Engl. 2020;102:672-84.