Assessment of Individual Hand Performance in Box Trainers Compared to Virtual Reality Trainers

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Training residents in laparoscopic skills is ideally initiated in an inanimate laboratory with both box trainers and virtual reality trainers. Virtual reality trainers have the ability to score individual hand performance although they are expensive. Here we compared the ability to assess dominant and nondominant hand performance in box trainers with virtual reality trainers. Medical students without laparoscopic experience were utilized in this study (n = 16). Each student performed tasks on the LTS 2000, an inanimate box trainer (placing pegs with both hands and transferring pegs from one hand to another), as well as a task on the MIST-VR, a virtual reality trainer (grasping a virtual object and placing it in a virtual receptable with alternating hands). A surgeon scored students for the inanimate box trainer exercises (time and errors) while the MIST-VR scored students (time, economy of movements, and errors for each hand). Statistical analysis included Pearson correlations. Errors and time for the one-handed tasks on the box trainer did not correlate with errors, time, or economy measured for each hand by the MIST-VR (r = 0.01 to 0.30; P = NS). Total errors on the virtual reality trainer did correlate with errors on transferring pege (r = 0.61; $P < 0.05$). Economy and time of both dominant and nondominant hand from the MIST-VR correlated with time of transferring pegs in the box trainer (r = 0.53 to 0.77; $P < 0.05$). While individual hand assessment by the box trainer during 2-handed tasks was related to assessment by the virtual reality trainer, individual hand assessment during 1-handed tasks did not correlate with the virtual reality trainer. Virtual reality trainers, such as the MIST-VR, allow assessment of individual hand skills which may lead to improved laparoscopic skill acquisition. It is difficult to assess individual hand performance with box trainers alone.

LAPAROSCOPIC TRAINING FOR novice surgeons and residents is best initiated in an inanimate laboratory setting. Performance of minimally invasive surgical procedures requires a different set of manual skills especially when compared to open procedures. Studies have demonstrated that possession of open skills does not guarantee possession of laparoscopic skills.[1] During laparoscopic cases, surgeons must be able to work in 3 dimensions while viewing the operation on a 2-dimensional video monitor. This lack of depth perception handicaps the surgeon. The laparoscopic instruments, which may be longer than those used in conventional surgery, are often hard to adjust for many surgeons. This is particularly important when beginners learn the "fulcrum effect" due to the fixed trocar placement.[2] Different eye-hand coordination is required especially when the camera angles are not appropriate or even "mirror-image." Furthermore, tactile feedback (sensation and perception) in minimally invasive surgery is altered; this requires some type of hands-on experience to obtain the skill needed to operate with this altered tactile input.

This hand-on experience takes an investment on the part of surgical educators. The investment involves both time and money. Time is required to acquire, to set up, and to utilize the devices. While these devices vary in price range, they are vital to the education and instruction of surgical residents. The decrease in time of educating residents in basic laparoscopic skills in the operator room has the potential to eventually offset cost of most of the devices.[3] However, it is imperative for program directors and surgical chairman to allocate appropriately resources for their resident education.

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For this reason, research should be focused on comparing the types of laparoscopic trainers. One such trainer is the Minimally Invasive Surgery Trainer-Virtual Reality (MIST-VR) (Mentice Medical Simulation, Gothenburg, Sweden). The MIST-VR has been validated to help improve resident surgeon skills in laparoscopic procedures.[4] It additionally has the advantage of recording the performance and improvement of individual residents. A disadvantage of the MIST-VR is the use of virtual reality, which does not allow for tactile feedback. The Laparoscopy Training Simulator (LTS 2000, Dome Medical, Albuquerque, NM) is a box trainer that has been utilized to teach basic laparoscopic skills.[5] The LTS 2000 helps recreate the operative environment and allows one to use the same instruments that are utilized in routine laparoscopic cases. This trainer, however, does not automatically record the performance and improvement of the trainee. Methods of metrics have been described for inanimate trainers, but they are often very labor and time intensive.[6]

Unluckily, in some training programs, simple procedures (such as laparoscopic cholecystectomy) have been taught with the residents utilizing both hands on one trocar to assist with the fulcrum effect. This often leads residents to the "bad habit" of being 1-handed laparoscopic surgeons. The focus of the trainers is often, in part, to create a 2-handed laparoscopist. Thus, we decided to examine and compare the ability of the MIST-VR and the LTS 2000 is assessing individual hand performance. The goal of this investigation was to compare the ability to assess dominant and nondominant hand performance. Our hypothesis was that the individual hand performance assessed by the LTS 2000 does not correlate with the individual hand performance assessed with the MIST-VR.

Materials and Methods

Medical student volunteers without laparoscopic experience were utilized in this study. Informed consent was waived by our institutional review board. Each student performed 3 tasks on the LTS 2000. Task 1 was to place 5 pegs with the dominant hand on to the pegboard. Task 2 was to place 5 pegs with the nondominant hand. Task 3 was to transfer 5 pegs from one hand to another and then place them onto the pegboard. A laparascopic surgeon scored students for all the inanimate box trainer exercises. Time and errors were recorded. Errors were defined as dropped pegs or inappropriate transfers.

The same students underwent 1 task on the MIST-VR. The task was to grasp a virtual reality object and place it into a virtual reality receptacle. This task was performed with both the dominant (Task A) and nondominant (Task B) hand. The computer program associated with the MIST-VR scored each student; the time, economy of movements, and errors for each hand.

Statistical analysis included Pearson correlations utilizing GraphPad InStat Version 3.05 (GraphPad Software, San Diego, CA). A *P* value less than 0.05 was considered statistically significant.

Results

A total of 16 first- and second-year medical students were included in this study. Table 1 displays the mean scores and standard deviations for the LTS tasks and MIST tasks. When correlations were calculated, errors and times for the 1-handed tasks on the box trainer (Tasks 1 and 2) did not correlate with errors, times, or economy of movements measured for the respective hand by the MIST-VR (Tasks A and B) as demonstrated in Table 2.

Total errors on the virtual reality trainer (Tasks A and B) did not correlate with errors on transferring pegs (Task 3; $r = 0.61$, $P < 0.05$). In addition, Table 3 displays that economy and time of both dominant (Task A) and nondominant hand (Task B) from the MIST-VR correlated with time of transferring pegs in the box trainer (Task 3).

Discussion

While the 2-handed task by the box trainer was related to assessment by the virtual reality trainer of both dominant and nondominant hands, individual hand assessment did not correlate with the virtual reality trainer. This is particularly important when trying to educate residents to focus on a "weaker" hand. Low scores in 2-handed tasks, performed with the box

TABLE 1. *Mean LTS 2000 and MIST Scores*

LTS 2000 Scores			MIST Scores			
Task	Time (s)	Errors	Task	Time (s)	Economy of Movements	Errors
Task 1	117 ± 35	1.0 ± 1.4	Task A	16 ± 8	3.9 ± 1.8	11 ± 7
Task 2	135 ± 66	0.8 ± 0.9	Task B	25 ± 16	7.2 ± 5.1	13 ± 10
Task 3	293 ± 133	3.8 ± 2.5				

Values expressed as mean ± standard deviation.

TABLE 2. *Correlations Between 1-Handed Tasks and the MIST Task**

	Time	Economy of Movements	Errors
Task 1 vs. Task A	r = 0.18	r = 0.19	r = −0.01
Task 2 vs. Task B	r = 0.30	r = 0.28	r = 0.08

* P = NS for all correlations.

TABLE 3. *Correlations between the 2-Handed Task and the MIST Task**

	Time	Economy of Movements
Task 3 vs. Task A	r = 0.53	r = 0.64
Task 3 vs. Task B	r = 0.72	r = 0.77

* $P < 0.05$ for all correlations.

trainer, may suggest that the residents may need to practice basic skills with their nondominant hand. The MIST-VR does, however, provide a more accurate description of individual hand performance.

Because the successful completion of most complex laparoscopic procedures requires a 2-handed laparoscopic surgeon, these data are particularly important in guiding surgical training programs. The use of inanimate box trainers alone does not provide the necessary data and feedback to the residents on problem areas that need to be improved upon. Although our feeling is that inanimate box trainers are an invaluable part of any resident surgical training program, a virtual reality trainer is needed for proper education and advancement of residents to more complex procedures. The virtual reality trainer, however, should provide data to the educator concerning individual hand performance. These data may help residents develop stronger basic laparoscopic skills. Additionally, it may provide an objective measure of competency to determine when the residents are ready for actual operative experience.[4]

Because the financial constraints of all surgical programs limit the amount of resources that can be spent on education, it is important for educators to assess expensive training devices. The MIST-VR is not an inexpensive device. Thus, its expense needs to be justified especially when purchased along with inanimate box trainers for any laparoscopic training laboratory. This investigation demonstrates that the MIST-VR provides specific information that is not obtainable by the inanimate box trainer. While no basic laparoscopic training laboratory can be complete without inanimate box trainers, the MIST-VR also provides a solution to the need for constant supervision for the documentation of scores with inanimate box trainers. This virtual reality trainer eliminates the time and resources for a "scorer" to be present during practice and training session. Because the schedule of most general surgery residents is limited, the MIST-VR additionally provides a method for residents to be trained and tested on their own time.

Virtual reality trainers, such as the MIST-VR, allow assessment of individual hand skills which may lead to improved and quicker laparoscopic basic skill acquisition. Although box trainers should be included in any basic laparoscopic skills laboratory, assessing individual hand performance with box trainers alone is difficult.

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