600.676 Computer Integrated Surgery II
Critical Review
Group 6: Anand Malpani

1 Publication under review

- Robotic Surgery Training with Commercially Available Simulation Systems in 2011: A Current Review and Practice Pattern Survey from the Society of Urologic Robotic Surgeons by Lallas et. al. [1]
- Current Status of Validation for Robotic Surgery Simulators A Systematic Review by Abboudi et. al. [2]

2 Introduction

Lallas et. al. [1] have attempted to review and evaluate all commercially available VR robotic simulators. For the same, they performed a wide literature search on MEDLINE using all relevant keywords like "robotic surgery simulation", "VR robotic surgery", "validation studies" and the names of the simulation systems. Additionally, they send out a survey regarding the pervasiveness of VR simulators in robotic surgical training to the members of the Endourological Society. They contacted each manufacturer for a price quote for their system too.

Similarly, Abboudi et. al. [2] also performed a broad search in English language literature using MEDLINE, EMBASE, PsychINFO databases with keywords - "robotics", "computer assisted surgery", "computer simulation", "virtual reality", "surgical training", "surgical education". Their goal was to present the first systematic review of all the validation trials for the various VR robotic simulators while exploring their feasibility, reliability, validity, acceptability, educational impact and cost effectiveness. They also reviewed conference abstracts from EAU and AUA for additional literature. References publications in these articles were screened too. They obtained a final set of 19 validation studies for the review.

3 Robotic Surgery VR Simulators

Both the papers focused on the four most common VR robotic simulators (Fig. 1) mentioned below. Abboudi et. al. looked at a laproscopic VR simulator (ProMIS) as well and mentioned another one developed by University of Nebraska at Omaha.

3.1 Robotic Surgical Simulator (RoSS)

This system was developed by Simulated Surgical Systems, Buffalo, NY [4]. It is a standard console system (Fig. 1(a)) constructed to deliver similar functionalities as the daVinci Surgical System Console. As compared to the other VR simulators below, RoSS has a robotic prostatectomy and hysterectomy component. This procedural component is called HOST (Hand On Surgical Training). Herein, the user mimics an actual surgeon's moves during the procedure shown on the console. The trainee can thus, learn a procedure and repeatedly practice it on the console without the need of an actual patient or tissue simulation. Simulated Surgical Systems is planning to add robotic cystectomy, partial nephrectomy as well in the future. Additionally, the system software is capable of measuring objective assessment of performance however there haven't been any studies validating this aspect yet.

3.2 Simsurgery Educational Platform (SEP)

This system was developed by SimSurgery, Norway [5]. Unlike the other VR simulators mentioned, SEP doesn't not have an actual console (Fig. 1(b)). It consists of a monitor, an arm board and a central processing unit (desktop computer). The system lacks capabilities to perform camera control, clutching, etc. due to absence of any components analogous to the usual foot pedals. Even though, the SEP does not contain any procedural components, SimSurgery has simulations for laproscopic cholecystectomy, etc.

(a) RoSS [4]

(b) SEP [3]

(c) ProMIS [8]

(d) dV-Trainer [6]

(e) dVSS [7]

Figure 1: Existing VR Surgical Simulators

3.3 dV-Trainer

This simulator was developed by Mimic Technologies Inc., Seattle, WA [6]. The system is a desktop based console with foot pedals on the floor (Fig. 1(d)). This simulation is the closest one to the actual Endowrist instruments from Intuitive Surgical Inc. A range of training scenarios are available as part of the `MSim` package. Additionally, it is capable of measuring user performance in terms of metrics called `MScore`. There are no procedural components available in the system yet.

3.4 daVinci Skills Simulator (dVSS)

This system was developed by Intuitive Surgical Inc., Sunnyvale, CA [7] who are the manufacturers of the daVinci Surgical System. Intuitive partenered with Mimic Technologies to create this simulator by integrating the MSim with the actual daVinci Si console using a backpack (similar to a desktop computer) which is connected to the console (Fig. 1(e)). As with the dV-Trainer, there are no procedural components.

3.5 Other simulators

ProMIS This system was developed by CAE Healthcare [8]. This is not a robotic VR simulator but a laproscopic one. Also, this is a box trainer form factor system as shown in Fig. 1(c). However, it has a lot of procedural components built for simulation. We won't be discussing this system further. Thus, we would like to add comments by the authors from [2] that this system has been validated by a couple of studies including the sole randomized trial study.

Univeristy of Nebraska, Omaha VR Simulator Authors from [2] also mention this simulator and list out the study performed by the developers to validated the system.

4 Terminology

The authors from both the papers have used terms for validation measurements (criteria) of the simulator quality. They desribe these and are listed below:

Face Validity: the extent to which the examination resembles the situation in the real world.

Content Validity: the extent to which the intended content domain is being measured by the assessment exercise. (e.g. while trying to assess technical skills we may actually be testing knowledge)

Construct Validity: the extent to which a test measures the trait that it purports to measure. (e.g. extent to which a test discriminates between various levels of expertise)

Concurrent Validity: the extent to which the results of the test correlate with the gold standard tests known to measure the same domain

Predictive Validity: the extent to which an assessment will predict future performance.

Feasibility: measure of whether an assessment process is capable of being done or carried out.

Reliability: measure of reproducibility or consistency of performance.

Educational Impact: ability of a training item to improve performance.

5 Comparison

Here, we have compiled comparison results from both the papers with regards to their target reviews.

5.1 Common Simulator Attributes

When comparing the commercially available VR simulators, Lallas et. al. observed certain common attributes among them:

- a stand-alone simulator which is independent of the vision cart and the surgical robot
- a monitor to display the procedure to the user or tutor to critique on the same
- minimal cost of operation as no disposable or consumables were required
- freedom from the operating room environment for training purposes

5.2 VR Simulators

Both the papers have compared the simulators under review with regards to some of their properties or validations which have been tabulated below:

Simulator	RoSS	SEP	dV-Trainer	dVSS
Endowrist Manipulation	✔	✔	✔	✔
Camera, Clutching, Fourth Arm	✔	✗	✔	✔
Energy Dissection	✔	✗	✔	✔
Face Validation	✔	✔	✔	✔
Content Validation	✔	✔	✔	✔
Construct Validation	✗	✔	✔	✔
Procedural Components	✔	?	✗	✗
Cost	120,000	62,000	158,000	89,000 (without console)

Note:

- There is no study yet that has performed the construct validation for RoSS
- HOST is the procedural component present in RoSS
- SimSurgery has laproscopic procedural components for simulators

5.3 VR Simulators Survey [1]

Here are some of the questions asked in the survey which was posted to all the members of the Endourological Society.

- Demographics: sex, age, discipline of surgery, experience
- What is their knowledge about robotic surgery simulation?
- Do they have access to a VR robotic surgical simulator?
- If access,
  - Which type of simulator?
  - How is it being used in the educational curriculum?
  - What was the source for the funds used to purchase it?
- What would be a reasonable cost for a VR simulator for robotic surgery training?
- What would be their role in training?
- What is the largest obstacle in training that can be addressed using simulation?

Though the survey was sent out to the entire society of endourologists (approx. 1200) only 65 responses were received by the authors. These were some of the observations from the responses:

- Looking at the demographics, there was a fair representation of the society:
  - majority were males
  - more than 40% had more than 15 years of experience
  - more than 75% were involved in surgical training with either a resident or fellow under them
- more than 90% surgeons considered VR simulation to play an expanding or advanced role in training
- however, only around 25% had access to a simulator at their institute
- majority of those who has access had a dVSS (even though it was released recently!)
- more than 80% felt that the cost of the simulators is unreasonable

5.4 Validation Studies [2]

The authors here noted that there was a lack of standardization of metrics for measuring simulator quality across the different platforms. For example, there is no agreement on the scale for measuring the face validation, where a “very close / somewhat close” scale is used for RoSS, but, a visual analog scale is used in the case of dVSS. Similarly, there is no definition of the expertise and who should be called “novice” and “experts”. Thus, the validity performed using such notions would not be able to compare the simulator platforms. Owing to this, there have been on head-to-head comparative studies between the different simulators.

All the studies were able to validate the face, content and construct validity of the platforms, however, all of them were small in size. Thus, there is a need to perform large scale studies to get more trusted validations. Additionally, there was a wide variability and inconsistency in the statistical methods used for evaluation of the data. Other parameters of measurement of simulation like feasibility, reliability, cost effectiveness have not been evaluated by any of the studies.

5.5 Issues with VR robotic simulators

There were some observations with regards to the features lacking in the current simulators that were mentioned in both the articles. Firstly, one of the goals of VR robotic simulation is procedural, where a trainee can perform an operation to proficiency before actually touching the patient. HOST in RoSS is one such example of procedural component present in the simulator but there is still a lot of scope for this. There are wide applications for such a utility like observing the surgery as performed by another surgeon, or using anatomic characteristics to create a virtual road-map for a specific surgery. Due to the lack of such a feature, we cannot be sure that the current tasks are leading to improvement of the trainee’s performance in the real-world setting.

Secondly, the other aspect of VR robotic simulation that needs to be worked upon is the cost of such a training media. The costs get even magnified with the inclusion of the annual service maintenance plan. Also, most of the times the cost of such an equipment is departmental and thus is limited. Surgeons are content with the current training curricula and would not consider investing funds in something which is definitely poorer in validation as compared to real tissue practice. Thus, simulation would not get incorporated into the curriculum at most institutes unless the cost is brought down.

6 Limitations

Authors from both the papers mention that there were limitations to the review and list some reasons. Mostly these are due to the paucity of relevant literature. For example, there are no head-to-head comparison studies for simulators to provide a measure or comparison between the different platforms. Due to the lack of standardization of metrics of simulation quality, an analytical review by pooling results from the different studies was not feasible. Validation studies dealing with feasibility, cost effectiveness, reliability have not been done yet. Owing to the cost and limitations of the simulation to introductory skills, incorporation of robotic VR simulation in the surgical training curriculum is still not proven.

7 Conclusions

Both the papers have performed an extensive literature survey using most of the available resources. It has been attempted to cover all the aspects related to VR robotic simulation existing in the literature while listing the different simulators and their validation studies. Abboudi et. al. have performed a first of a kind review of the validation studies in VR simulation. Both the papers have done an excellent job of explaining the different simulation platforms and their validations. Finally, both papers also conclude with the need for a reasonable price for simulators as well as the need for large scale multi-institutional validation studies and head-to-head comparison studies.

References

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