Original article

Virtual reality simulator for training urologists on transurethral prostatectomy

ZHU He, ZHANG Yi, LIU Jin-shun, WANG Gang, YU Cheng-fan and NA Yan-qun

Keywords: prostate; transurethral prostatectomy; computer simulation; continuing medical education; surgical skill training

Background A virtual reality simulator provides a novel training model for improving surgical skills in a variety of fields. They can simulate a variety of surgical scenarios to improve the overall skills required for endoscopic operations, and also record the operative process of trainees in real-time and allow for objective evaluation. At present, some simulators for transurethral resection of the prostate (TURP) are available. The utility of virtual reality simulators in training of transurethral prostatectomy was investigated.

Methods Thirty-eight urologists were randomly selected to take part in a simulation based training of TURP using the TURPSim™ system. Pre and post-training global rate scale (GRS) scores and objective parameters recorded by the simulator were assessed. Then, questionnaires were filled out.

Results Compared with baseline levels, the GRS scores of trainees increased (18.0±4.0 vs. 12.4±4.2, \(P<0.001\)), while the rate of capsule resection (26.3%±0.6% vs. 21.2%±0.4%, \(P<0.001\)), amount of blood loss ((125.8±86.3) ml vs. (83.7±41.6) ml, \(P<0.001\)), external sphincter injury (3.6±2.9 vs. 2.0±2.0, \(P<0.001\)) decreased significantly after training. Most trainees were satisfied with the simulator based training and believed that the simulator accurately mimicked actual surgical procedures and could help improve their surgical skills.

Conclusions As a new method of training on transurethral prostatectomy skills, training of TURP using a virtual simulator can help urologists improve their surgical skills and safety. Therefore, the application of the TURPSim™ system in education and training of urologic surgery is warranted.

The virtual reality simulator provides a novel training model for improving surgical skills in a variety of fields. Apart from training of basic operation skills, a virtual reality simulator can also simulate a variety of surgical scenarios to improve the overall skills required for endoscopic operation. More importantly, with the use of the computer, simulators can record the operative process of trainees in real-time and allow for objective evaluation. At present, some simulators for transurethral resection of the prostate (TURP) are available. Scholars have previously evaluated the surface validity, content validity, and structural validity of these simulators and concluded that the actual surgical experience was closely related to the performance of the simulator. In the current study, we introduced the TURPSim™ simulator and investigated its effectiveness and role in TURP training.

METHODS

Virtual reality simulator

TURPSim™ simulator (Simbionix, Israel) was used in the current study. This simulator is composed of a transformed electric resectoscope, foot pedal, monitor, ordinary desktop computer terminal, and a feedback system. With high accuracy, the simulator mimics endoscopic morphology and anatomy of the prostate.

Manipulation of the virtual electric resectoscope can produce movement of the simulated scope and resection ring, and allows the user to carry out procedures, such as resection and coagulation, and complete full TURP procedures (Figure 1). The simulator software includes modules in a variety of difficulty levels (easy 1–3, medium 1–3, and difficult 1, 2). At the end of each module, the simulator can provide a list of reports about the operation parameters, including the rate of prostate gland resected and capsule resected, amount of blood loss, accuracy of coagulation, and injury of external sphincter, verumontanum, bladder neck, and ureteral orifice (Figure 2).

Trainees

Thirty-eight from 124 urologists who participated in 9 training courses between September 2010 and December 2011 were randomly selected to participate in the current study. All trainees were male and over 30 years of age having over five years experience in urological surgery.

DOI: 10.3760/cma.j.issn.0366-6999.20121674

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Experimental design

Prior to training, a questionnaire was used to collect information on each trainee, including the duration of practice in urologic surgery, experience in computer games, experience with the urologic endoscope simulator, the degree of TURP manipulation, number of TURP cases performed independently, and the number of cases performed per month in their hospital. Trainees performed the complete TURP procedure on the TURPSimTM six times. Only the initial and final simulations were evaluated. For each attempt, operating time was limited to 10 minutes. The training module was set to the level of easy-2, and global rating scale (GRS) scoring was identified for each trainee by one fixed observer. After operation, objective evaluation was obtained from the simulator. After training, every trainee was required to provide feedback regarding their experience with the simulator.

GRS scoring

The GRS was based on the Global Rating Index for Technical Skills (GRITS) and the Objective Structured Assessment of Technical Skill (OSATS), and comprised of five evaluation items, each of which were divided into five grades from 1 to 5, each one represents one score. The total score was obtained by adding related scores, and was used for evaluating the surgical skill of each trainee (Table 1).

Statistical analysis

Statistical analysis was performed with SPSS software (version 13; SPSS, Chicago, USA). A significance level of 0.05 was adopted. Data with a normal distribution were presented as mean ± standard deviation (SD) and were tested statistically using a paired t test. Data with a skewed distribution were presented as median (quartile), and were analyzed statistically by a Mann-Whitney U test and Wilcoxon signed rank test.

RESULTS

Results of questionnaires

Based on pre-training questionnaires, the trainees had over 5-year experience in urological surgery, and had

<table>
<thead>
<tr>
<th>Items</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tissue injury</td>
<td>Injury to the sphincter, verumontanum, the capsule of prostate, etc.</td>
<td>Between 1 and 3</td>
<td>Occasional injury to the sphincter, verumontanum, the capsule of prostate, etc.</td>
<td>Between 3 and 5</td>
<td>No injury to the sphincter, verumontanum, capsule of the prostate, etc.</td>
</tr>
<tr>
<td>Movements and time</td>
<td>Many unnecessary movements</td>
<td>Between 1 and 3</td>
<td>Smooth manipulation with some unnecessary movements</td>
<td>Between 3 and 5</td>
<td>Smooth manipulation without unnecessary movements</td>
</tr>
<tr>
<td>Instrument application</td>
<td>Unidentified application of instruments with stiff and awkward motion</td>
<td>Between 1 and 3</td>
<td>Identified application of instruments with occasional stiff and awkward motion</td>
<td>Between 3 and 5</td>
<td>Smooth application of instruments without stiff or awkward motion</td>
</tr>
<tr>
<td>Surgical process</td>
<td>Unfamiliar with the next step and often stopped operation to acquire help</td>
<td>Between 1 and 3</td>
<td>Had some prospective thought about the surgical process</td>
<td>Between 3 and 5</td>
<td>Surgical procedure is consistent with planned surgical procedure</td>
</tr>
<tr>
<td>Surgical details</td>
<td>Lack of knowledge for surgical details and required help during most steps</td>
<td>Between 1 and 3</td>
<td>Understood the important steps in surgery</td>
<td>Between 3 and 5</td>
<td>Familiar with the whole surgical detail</td>
</tr>
</tbody>
</table>
independently performed between 0 and 200 TURP surgeries. Most trainees (80%) had not taken part in simulation based training, and less than half (38.7%) regularly played complicated computer games. After evaluation, most trainees were satisfied with the simulation training (97%), considered that the simulator accurately mimicked surgery (92%), and believed that it could help improve their surgical skills (92%).

Score comparison before and after training
After training, the GRS scores of trainees increased (18.0±4.0 vs. 12.4±4.2, P < 0.001), while the rate of capsule resection (26.3±6.6% vs. 21.2±0.4%, P <0.001), amount of blood loss ((125.8±86.3) ml vs. (83.7±41.6) ml, P <0.001), external sphincter injury (3.6±2.9 vs. 2.0±2.0, P <0.001), and verumontanum injury (1.1±1.1 vs. 0.5±0.6, P=0.001) decreased significantly after training. Although the rate of prostate gland resected increased slightly after training, the change failed to reach statistical significance (Table 2).

<table>
<thead>
<tr>
<th>Items</th>
<th>Initial evaluation</th>
<th>Final evaluation</th>
<th>P values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of trainees</td>
<td>38</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>GRS scores</td>
<td>12.4±4.2</td>
<td>18.0±4.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Rate of prostatectomy (%)</td>
<td>88.5±9.0</td>
<td>89.1±6.6</td>
<td>0.628</td>
</tr>
<tr>
<td>Rate of capsule resection (%)</td>
<td>26.3±6.6</td>
<td>21.2±4.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Amount of blood loss (ml)</td>
<td>125.8±86.3</td>
<td>83.7±41.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Injury of external sphincter</td>
<td>3.6±2.9</td>
<td>2.0±2.0</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

DISCUSSION

Training on endoscopic skills in urological surgery appeared together with the emergence of the endoscope.6 As one of the earliest endoscopic surgeries, TURP has been taught for years by senior doctors, while junior physicians gradually learned the procedure by intermittent observation. Later, the emergence of a teaching endoscope allowed trainees to directly observe the surgery, while the combined use of a monitor allowed many people to simultaneously observe the procedure in the operating room. More recently, live surgery broadcast systems made it possible for numerous individuals to communicate with the operator through the audio-visual system. Although the scale of training is continually expanding, TURP surgery can only be performed by a single operator, meanwhile trainees have little chance to carry out actual procedures. Therefore, the learning curve of traditional surgical training is relatively steep and there are significant differences in surgical outcomes and safety between novice and experienced surgeons. The rates of total complications during surgery range from 3.1% to 18%.7 In order to improve the clinical safety, the need for a surgical training outside the operating room has been increasingly emphasized. Indeed, many surgeons acquire skills by performing surgical procedures on live animals or cadavers. For instance, some scholars taught cutting and vaporization procedures on pig chordae tendineae of in vitro animal tissue models and managed to improve the basic operating skills.8 While training in this manner is similar to actual surgery in terms of tissue texture and bleeding, problems of ethics, access, sources, equipment, anesthesia, treatment, efficiency, and anatomical differences remain. In addition, the repeatability of training is largely limited, providing a significant drawback in terms of large-scale training.9,10

Recently, more and more virtual reality systems are used for medical diagnosis and therapeutics.11,12 Similarly, training courses also are developed using virtual reality simulators.13 Sets of training modes of varying difficulties were developed, including in vitro simulation, animal or cadaver in vivo simulation, and clinical practice, including cystoscopy,14,15 ureteroscopy,16,17 percutaneous nephrolithotomy,18 laparoscopy,19,20 and even robotic surgery.21 TURP simulation training using the Uro Trainer simulator from the Karl Storz, Germany2 and the UW TURP simulator from the University of Washington have been reported.12,22 Results of these earlier investigations showed satisfactory results in terms of surface, content, and structural validity. TURPSim™ is a virtual reality simulator newly developed by Simbionix Company for TURP training that was not previously evaluated.

In the current study, most trainees were satisfied with the simulation based training and believed that the simulator accurately mimicked the surgical procedure and could help improve their surgical skills. After training, operation parameters representing the trainees’ dexterity of TURP increased significantly from baseline, while parameters representing surgical safety, including the rate of capsule resection, amount of blood loss, and external sphincter injury decreased significantly. Although the rate of prostate gland resection increased slightly after training, the change was not statistically significant. It is possibly because the trainees in the current study paid more attention to safety, as supported by a decrease in parameters representing surgical safety. Therefore, the more careful manipulation during the resection resulted in an insignificant increase in the rate of gland resection within an unchanged operating time. As a result, both the subjective feelings of the trainees and the increased objective parameters show that training with the simulator can increase the surgical skills of urologists, and simultaneously improve surgical safety, both important factors in TURP training.

In summary, the emergence of a virtual reality simulator has led to a new approach for improving TURP surgery skills. In this study, we found that the proficiency and safety of TURP surgery increased significantly after simulation training of TURP using the TURPSim™ virtual reality simulator. Therefore, we believe that virtual reality simulation of TURP can increase the surgical skills of urologists and help urologists increase surgical safety while ensuring a positive surgical outcome. In addition, since the computer is used to create a complete virtual environment, a simulator may provide an unlimited number of simulation surgeries without additional cost.
This novel training technology may bridge theory with true clinical practice, and may play an important role in promoting safe and effective endoscopic skills.

REFERENCES


(Received August 19, 2012)
Edited by SUN Jing