MINIMALLY INVASIVE AND ROBOTIC SURGERY

Effectiveness of a dedicated robot-assisted surgery training program

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Introduction: *Robot-assisted surgery (RAS) has been integrated into the surgical armamentarium and generated wide-spread interest among practicing, non-robotic surgeons (NRS). While methods for training novice NRS have emerged, the effectiveness of these training programs has endured minimal scrutiny. This study aims to establish effectiveness of the RAS training (RAST) program.*

Materials and methods: *A formal RAST program was established at Roswell Park Cancer Institute (RPCI) in 2008. From July 2010 to October 2012, 43 NRS participated in the program. The 1 to 4 week program included the validated fundamental skills of robotic surgery (FSRS) curriculum, hands-on bedside trouble-shooting training, case observation with an expert robotic surgeon, hands on surgical training (HoST) procedure modules, da Vinci robotic hands-on experience and finally a compulsory animal laboratory utilizing the da Vinci. As part of our quality assurance program, all participants were prospectively evaluated employing a survey. This survey aimed to evaluate the enduring impact of the RAST through time-sensitive interventions that allowed participants to reacclimatize themselves to their prospective practice as independently performing surgeons.*

Results: *The survey responses received from the participating NRS were collected over 27 months, with a response rate of 84%. The average follow up period post-RAST completion was 6 months (2-19). Overall, participants felt that the FSRS curriculum (81%), bedside trouble shooting (7%), and animal laboratory (53%) were beneficial program features that enabled NRS to become adequately acquainted with the basic principles of RAS.*

Approximately 5 weeks after RAST program completion, 64% of surgeons performed robot-assisted surgery. The two most commonly performed procedures were robot-assisted radical prostatectomy and gastrointestinal surgeries where eight surgeons performed independently while 12 performed procedures under the supervision of an expert robotic surgeon. The overall conversion rate to open was reported to be 1.3%.

Conclusions: *A dedicated surgical training program focused on learning key steps of RAS enabled most participants to successfully incorporate and maintain their RAS skills in clinical practice.*

Key Words: robotic, training program, robot-assisted, surgery, effectiveness

Introduction

The evolution of surgical technology has dramatically remodeled the realm of surgical practice. With the potential advantages of this new approach, there is a growing need for trained surgeons who not only have clinical knowledge and surgical skills, but also perform and master these rapidly evolving technologies with sophisticated instruments.[1]

There has been a dramatic rise in the surgical volume performed with robotic assistance in the preceding decade. As many as four out of five radical prostatectomies were performed robotically in the United States last year.[2] Surgeons with formal training

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in either robot-assisted laparoscopic prostatectomy (RALP) or laparoscopic prostatectomy have shown that formal robot-assisted surgery training (RAST) may be beneficial for surgical and pathologic outcomes of robotic-assisted laparoscopic prostatectomy (RALP).[3] The evaluation of a similar teaching program demonstrated that trainees performing the procedure did not negatively affect operative blood loss and positive surgical margin rate, and that trainees were able to adopt the increased efficiency and skills of their mentor.[4]

Simulation-based training (SBT) was introduced to address the training requirements for development of RAS skills. Such training provided an opportunity for a trainee to master the human-machine interface in a patient-safe environment. A variety of SBT platforms have been reported in the past, however they lack conclusive evidence regarding their impact on outcomes of surgeon performance. Additionally, there is a paucity of literature delineating appropriate structure and duration of a postgraduate robot-assisted surgical training program.

In order to address the needs of training surgeons (open and laparoscopic) in RAS skills, a formal RAST program was established at Roswell Park Cancer Institute in 2008.

The prime aim of this program was to provide experienced open and laparoscopic surgeons the technical training required for a smooth transition into RAS by introducing and acclimatizing non-robotic surgeons (NRS) to key components of RAS. In this study we evaluated the impact of our RAST program on NRS and established a methodology to assess the effectiveness of this program in enabling NRS to incorporate this new skill into their clinical practice.

Materials and methods

Study design

This is a descriptive study of all NRS who participated in the RAST program and were prospectively evaluated, over time, to determine the effectiveness of this training program.

Set up

The RAST program was conducted from 1-4 weeks, utilizing various methods to develop RAS skills. These methods include: robotic surgical simulator (RoSS) training, operating room training, and hands-on da Vinci experience, Figure 1.

Robotic surgical simulator (RoSS)

Training on the RoSS formulated the first step of the training program. This training has two components, which help develop and incorporate basic and advanced RAS skills.

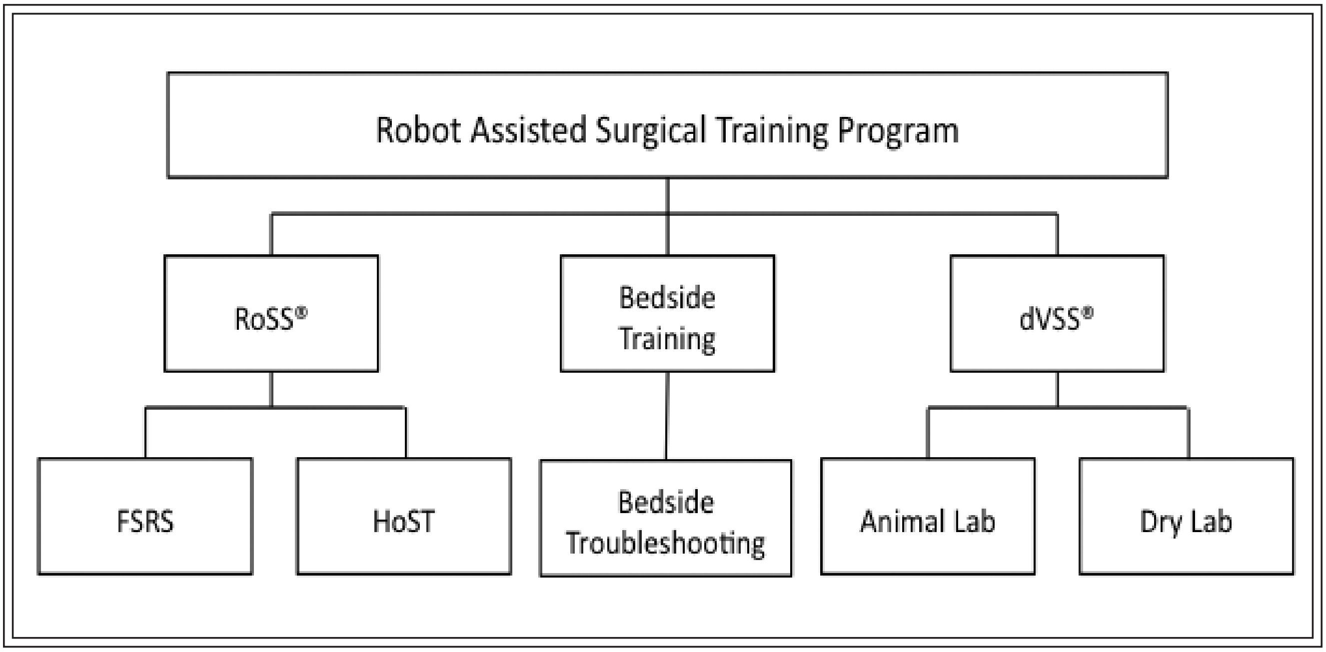

Figure 1. Components of robot-assisted surgical training program at Roswell Park Cancer Institute.
RoSS = robotic surgical simulator; OR = operating room; dVSS = da Vinci surgical system; FSRS = fundamental skills of robotic surgery; HoST = hands-on surgical training.

Fundamental skills of robotic surgery (FSRS) curriculum[5]

The FSRS curriculum is a validated, structured, SBT curriculum, which guides the trainee in overcoming the human-machine interface to develop rudimentary RAS skills. The training provided participants in-vivo virtual operative steps with varying levels of complexity, offering numerous modules aimed at developing motor and cognitive skills for performing RAS. The integrated management system that stores metrics for all users and tasks performed provided immediate feedback to trainees as they completed each task.

Hands on surgical training (HoST) modules

The HoST module provided participants with actual surgical cases integrated with user interaction, guided hand movements, and instructive narrative. Cases include radical prostatectomy, radical cystectomy, radical hysterectomy, and extended pelvic lymph node dissection.

Operating room training

Operating room training comprised of observing live operative cases being performed by experienced RAS faculty as they shared tips and tricks of RAS and displayed the full capabilities and advantages of da Vinci utilization. One-on-one interaction and in-depth case description was complimented by an explanation of procedure-specific anatomy and surgical steps. Additionally, the participants spent time with an experienced RAS nurse, who explained and demonstrated the intricate details of the da Vinci set up and maintenance as well as the docking and undocking process.

Dry and animal laboratory

RPCI has a well-established animal lab facility for research and training purposes. The animal lab is equipped with a da Vinci Robot, exclusively dedicated for teaching and training purposes. Participants were trained in both dry and wet lab settings with a variety of inanimate and animate models for further development of skills. The animal lab procedures were conducted on a porcine model under the guidance and regulations of Institutional Animal Care and Use Committee (IACUC) approved protocols. The procedures were directly supervised by RPCI's expert veterinarians and veterinary technicians. Each participant gained hands-on experience from port placement and robot docking to conducting the entire robot-assisted surgical procedure.

Evaluation of training

All participants of the RAST program were required to fill in pre and post program demographics and feedback questionnaires. Upon successful completion of the program, the participants were prospectively followed via e-mail where they received, completed, and returned the survey. This study-specific survey was designed to determine the effectiveness of the RAST program. The feedback was entered into a database and the pooled results were statistically analyzed. Descriptive statistics such as frequencies and relative frequencies were computed for all categorical variables. Numeric variables were summarized using simple descriptive statistics such as the mean, standard deviation, range, etc.

Results

A total of 43 surgeons participated in the RAST program. The survey responses received from the 36 NRS were collected over 27 months, with a response rate of 84%. The average follow up period since completion of the program was 6 months (2-19). Only 11% of surgeons had performed any RAS before completion of the program. Sixty-one percent of the surgeons were performing RAS in three surgical specialties (urology, gynecology and gastrointestinal surgery). Three surgeons had completed another training program for RAS before embarking on our program, Table 1. Majority of the 36 participants, 33 (92%), completed the course within a 2 week training period.

Overall, participants felt that the FSRS curriculum (81%), bedside trouble shooting (7%), and animal laboratory (53%) were beneficial program features that enabled NRS to become adequately acquainted with the basic principles of RAS. RARP and gastrointestinal

TABLE 1. **Details of participants**

Total number, n	43
Total respondents, n (%)	36 (84)
Previous robotic experience, n (%)	
Yes	4 (11)
No	32 (89)
Prior simulator experience, n (%)	
Yes	3 (8)
No	33 (92)
Time since RAST completion, mean (range)	6 months (2-19)

TABLE 2. **Details of post robot-assisted surgery training evaluation**

Time from training to first case, mean (range)	5 weeks (1-24)
Level of performance, n (%)	
Independent	8 (22)
With supervision	12 (33)
Part of the procedure	03 (8)
Not performed	12 (33)
Procedure performed, n (%)	
Urological	14 (61)
Gynecological	05 (22)
Gastrointestinal	04 (17)
Number of cases since completion of RAST program, mean (range)	6.6 cases (1-50)
Conversion rate to open, n (%)	2 (1.3)
Most beneficial part of RAST program, n (%)	
RoSS (FSRS + HoST)	29 (81)
Bed side training	07 (19)
OR observation	19 (53)
da Vinci (dry lab)	23 (64)
da Vinci (animal lab)	21 (58)
Most beneficial part of RoSS training, n (%)	
FSRS curriclum	29 (81)
HoST module	12(33)
How difficult did you find the robotic surgery after RoSS, n (%)	
Easy	13 (36)
Somewhat difficult	18 (50)
Difficult	05 (14)
Very difficult	0
Confidence level at RAS capabilities after RAST program, mean (range)	7.7 (5-9) on likert scale

surgeries were the two most commonly performed procedures after completion of the RAST program. Eight surgeons had performed the procedures independently; whereas 12 performed them under proctorship/supervision of another experienced robotic surgeon. Sixty-four percent of NRS performed RAS approximately 5 weeks (1-24) after completion of the RAST program. Three cases were converted to open by the surgeons after completion of training. These were due to a difficult bladder neck and post transurethral resection of prostate in two patients respectively and in one patient with a large gynecologic tumor. Most of the participants felt more confident in their RAS capabilities (1-10) after completing the RAST program (mean 7.7, median 8, range 5-9), Table 2.

Discussion

Increasing complexity of surgical techniques necessitates an effective training program to safely implement such new advances. A well-structured training program proves advantageous for both surgeons and patients in terms of conversion rates, complications, and mortality rates.[6] However when it comes to robot-assisted surgery, a different set of skills is needed to master the human-machine interface of a robotic surgical system. Unfortunately cost remains to be the biggest limiting factor in terms of training program limitations.[7]

In this study we determined the effectiveness of a dedicated multimodality training program for NRS, in achieving the desirable operative standards for safe RAS. The participants in our program successfully performed a RAS procedure within 5 weeks of completion of their training. Only one surgeon considered additional training after the RAST program. All the participants felt confident after completion of the FSRS curriculum with regards to performing basic tenants of RAS. Most of the participants considered the RoSS and animal lab training to be most beneficial in development of surgical skills. Our work established that completion of short-term, multi-modality training can eliminate the learning of human-machine interface. Such training programs provide confidence to experienced open and laparoscopic surgeons to execute their expertise at using the da Vinci and pass beyond the human-machine interface limitations. Based on the current experience we have developed a training pathway for minimally invasive surgical skills development at our academic institution, Figure 2. This training program incorporates the use of a validated simulation-based training and teaching instrument.[8-10] Along with SBT, the program also provides hands on experience with the da Vinci surgical robot, incorporating both dry and wet lab sessions. These components are amalgamated so that the transition of skills developed on modules on the RoSS is followed by such tasks on the da Vinci. The basic skills development is followed by HoST training in specific procedures to robot-based inanimate models, thus replicating and practicing procedure-specific skills from the RoSS to the da Vinci. The final day of training provides a test of true robot-assisted operative experience, utilizing an animal laboratory facility.

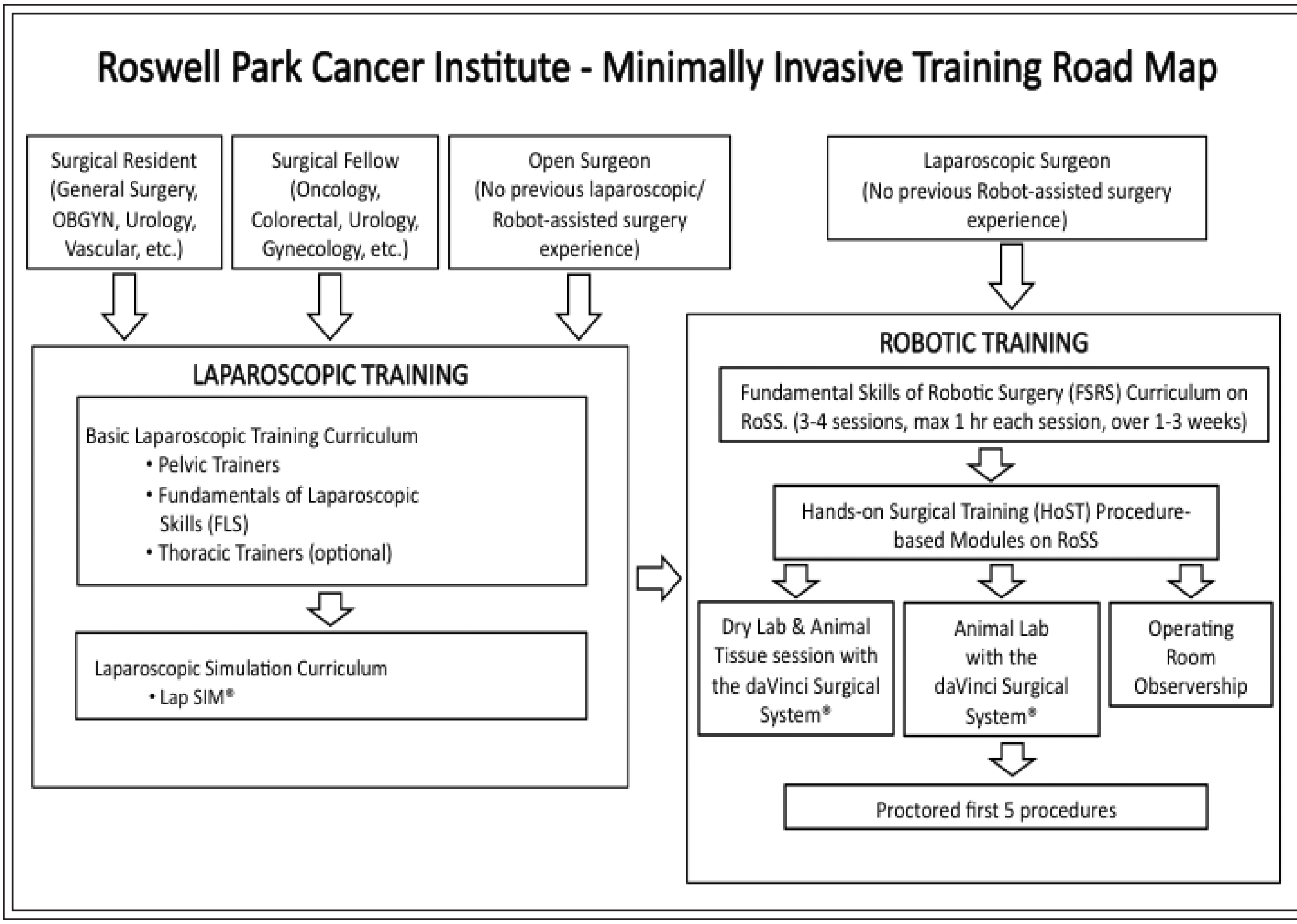

Figure 2. Minimally invasive training road map.

Similar efforts at designing a structured robotics training program at several institutions have been documented. A 5 day mini fellowship at the University of California, Irvine enabled most of its participants to successfully incorporate and maintain RALP in their clinical practice.[11] This program had many features akin to our own, being strongly grounded in skills-based activities. Short-term impact of the mini fellowship training program analyzed at the same institution demonstrated that 19 out of the 20 participants were performing RAS within 14 months of the program.[12] Similarly, the Vattikuti Urology Institute formulated a stepwise program that produced results comparable to the best published data on prostate cancer outcome. This program similarly utilized hands on training and a direct mentor-trainee relationship to allow trainees to master RAS.[13]

Studies assert that simulators can reduce the learning curve and improve patient safety, allowing trainees to develop skills without any danger to patients.[14,15] SBT is time efficient and cost-effective, and their validity has been well established throughout the literature.[16] Several randomized control trials have shown that surgical simulation can improve surgical performance.[17-19] Simulators have the ability of distinguishing a novice from an expert, which is invaluable in assessing trainee skill and improvement. They have proven to be a fundamental component of a RAST program and help in the integration of robotics into surgical practice. A study of more than 500 surgical residents found the majority accepted and appreciated simulators for surgical training and, if available, would utilize them on a regular basis.[20]

SBT in RAS has been hypothesized to improve the learning curve and lead to cost-reduction in robotic surgeries based on operative times. Steinberg et al showed that the operative costs of RALP, ranging from $95,000 to $1,365,000, are directly related to the length of the learning curve.[21] This resulted in an additional $217,000 worth of operative time per year during a trainee's learning curve. A study at our institution showed that loss of care for 73 prostate cancer patients was avoided through training with the use of simulator in the training laboratory.[22] The study also revealed a positive return on investment when utilizing the simulator reflected in preservation of operating room time and robotic equipment. Commonly cited drawbacks of utilizing robotics in surgery include cost of the robotic surgical system, which normally carries a price tag of $1.3-1.7 million, maintenance of the robot, which can cost upwards of $130,000 annually, and the cost of instruments and disposables, which in some institutions approaches $10,000 per attending surgeon.[1,7] Other drawbacks include the aforementioned steep learning curve and poor standardized assessment techniques, as well as education and training of the operating room staff. In consideration of these factors, the ability of teaching centers to offer training programs may be severely impeded by cost. Although cost analysis of the RAST program was not one of the aims of this study, it would be interesting to determine our training expenses in view of the aforementioned findings and direct costs paid by each trainee.

Our study also had some limitations. Primarily, the follow up was not standardized for all participants. Ideally it would have been better to review them all at a specific time after completion of training. This may result in differences among surgeons returning to high-volume or low-volume centers. Secondly, the participants may have some recall bias, especially when asked about the specific components related to the training (i.e. FSRS tasks). Additionally the derived results may not have been implicated over the general population of surgeons as various confounding factors like age, previous surgical experience, and institutional environment including departmental setup, previous robotics experience, and patient volume differed from surgeon to surgeon. Finally, in this study no objective comparison was performed on the skills of the trainees, before and after the RAST program. The newly developed and validated Robotic Skills Assessment Score[23] provides feedback on operator performance and can be used for reporting objective improvements in future studies.

The future aim of our work would be to study the outcome of RAST in view of the aforementioned confounders over a larger number of participants. This study highlights the importance of a comprehensive training program and its educational impact.

Conclusion

A dedicated surgical training program focused on RAS at RPCI enabled most NRS participants to successfully incorporate RAS skills into their clinical practice. ☐

References

1. Grover S, Tan GY, Srivastava A, Leung RA, Tewari AK. Residency training program paradigms for teaching robotic surgical skills to urology residents. *Curr Urol Rep* 2010;11(2):87-92.
2. Phillips C. Tracking the rise of robotic surgery for prostate cancer. *J Natl Cancer Instit* 2011;8(16):4.
3. Kwon EO, Bautista TC, Jung H et al. Impact of robotic training on surgical and pathologic outcomes during robot-assisted laparoscopic radical prostatectomy. *Urology* 2010;76(2):363-368.
4. Schroeck FR, de Sousa CA, Kalman RA et al. Trainees do not negatively impact the institutional learning curve for robotic prostatectomy as characterized by operative time, estimated blood loss, and positive surgical margin rate. *Urology* 2008;71(4):597-601.
5. Stegemann AP, Ahmed K, Syed JR et al. Fundamental skills of robotic surgery: a multi-institutional randomized controlled trial for validation of a simulation-based curriculum. *Urology* 2013; 81(4):767-774.
6. Miskovic D, Wyles SM, Ni M et al. Systematic review on mentoring and simulation in laparoscopic colorectal surgery. *Ann Surg* 2010;252(6):943-951.
7. Lendvay TS, Hannaford B, Satava RM. Future of robotic surgery. *Cancer* 2013;19(2):109-119.
8. Kesavadas T, Stegemann A, Sathyaseelan G et al. Validation of robotic surgery simulator (RoSS). *Stud Health Technol Inform* 2011;163:274-276.
9. Seixas-Mikelus SA, Stegemann AP, Kesavadas T et al. Content validation of a novel robotic surgical simulator. *BJU Int* 2011; 107(7):1130-1135.
10. Seixas-Mikelus SA, Kesavadas T, Srimathveeravalli G et al. Face validation of a novel robotic surgical simulator. *Urology* 2010;76(2):357-360.
11. Gamboa AJ, Santos RT, Sargent ER et al. Long-term impact of a robot assisted laparoscopic prostatectomy mini fellowship training program on postgraduate urological practice patterns. *J Urol* 2009;181(2):778-782.
12. McDougall EM, Corica FA, Chou DS et al. Short-term impact of a robot-assisted laparoscopic prostatectomy 'mini-residency' experience on postgraduate urologists' practice patterns. *Int J Med Robot* 2006;2(1):70-74.
13. Badani KK, Hemal AK, Peabody JO et al. Robotic radical prostatectomy: the Vattikuti Urology Institute training experience. *World J Urol* 2006;24(2):148-151.
14. Grover S, Tan GY, Srivastava A et al. Residency training program paradigms for teaching robotic surgical skills to urology residents. *Curr Urol Rep* 2010;11(2):87-92.
15. Sun LW, Van Meer F, Schmid J et al. Advanced da Vinci Surgical System simulator for surgeon training and operation planning. *Int J Med Robot* 2007;3(3):245-251.
16. Abboudi H, Khan MS, Aboumarzouk O et al. Current status of validation for robotic surgery simulators - a systematic review. *BJU Int* 2013;111(2):194-205.
17. Lendvay TS, Casale P, Sweet R et al. VR robotic surgery: randomized blinded study of the dV-Trainer robotic simulator. *Stud Health Technol Inform* 2008;132:242-244.
18. Seymour NE. VR to OR: a review of the evidence that virtual reality simulation improves operating room performance. *World J Surg* 2008;32(2):182-188.
19. Aggarwal R, Ward J, Balasundaram I et al. Proving the effectiveness of virtual reality simulation for training in laparoscopic surgery. *Ann Surg* 2007;246(5):771-779.
20. Rosenthal R, Gantert WA Hamel C et al. The future of patient safety: surgical trainees accept virtual reality as a new training tool. *Patient Saf Surg* 2008;2:16.
21. Steinberg PL, Merguerian PA, Bihrle W et al. The cost of learning robotic-assisted prostatectomy. *Urology* 2008;72(5):1068-1072.

22. Rehman S, Raza SJ, Stegemann AP et al. Simulation-based robot-assisted surgical training: A health economic evaluation. *Int J Surg* 2013;11(9):841-846.
23. Chowriappa AJ, Shi Y, Raza SJ et al. Development and validation of a composite scoring system for robot-assisted surgical training-the Robotic Skills Assessment Score. *J Surg Res* 2013;185(2):561-569.