JOURNAL OF Surgical Simulation

Journal of Surgical Simulation (2017) **4,** 48–51
DOI: https://doi.org/10.1102/2051-7726.2017.0010

EDITORIAL

The use of simulation training for robotic-assisted surgery

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Date accepted for publication: 19 October 2017

Abstract

Current use of simulation training in robotic surgery is outlined, focusing on the types of simulators available and the evidence for their use. The ways in which robotic simulation can be utilised to improve training outcomes are identified and developments for future work are suggested.

Keywords: *simulation; robotic; training*

Robotic-assisted surgery (RAS) is one of the latest operative innovations to generate global interest. In the last decade, there has been a rapid increase in the volume of robotic surgery undertaken. The indication and type of surgery suitable for robotic assistance is still increasing rapidly as more institutions acquire these systems.[1] The first surgical robot, PUMA 560, was used to carry out computed tomography-guided neurosurgical biopsies with enhanced precision.[2] This has since led to the development of a generation of new robots for minimally invasive surgery. The most widely used is the *da Vinci* Surgical System (Intuitive Surgical, Mountain View, CA), approved by the US Food and Drug Administration in 2000 for general laparoscopic surgery. This is now established as a safe and feasible technique for most general surgical procedures.

Some of the well-recognised advantages of RAS include 3D visualisation of the operative field, greater surgical accuracy, improved ergonomics, enhanced degrees of freedom, elimination of the fulcrum effect and adjustment of physiological tremor.[3] The benefits of RAS to the patient are yet to be fully determined. Post-operative outcomes are at least equivalent to standard methods, with the exception of operative time in most cases. RAS may serve as an enabling technology, allowing surgeons to provide complex minimally invasive procedures to a broad range of patients.[3] The cost of RAS compared with traditional laparoscopic surgery is generally higher. The robot itself costs $1,390,000 and its disposable supply is approximately $1,500 per procedure.[4] This has led to some surgeons questioning the economic viability of RAS in smaller, less specialised centres. In 2007, the SAGES-MIRA Robotic Surgery Consensus Group identified three major limitations of RAS: cost, lack of outcomes data and training issues.[3] The high cost of RAS may be deemed acceptable if it provides better outcomes or compensates with a reduction in the cost of training.

RAS requires more specific and dedicated training because of the potential difficulties in understanding high magnification, 3D vision, and the precise hand-eye movements needed to compensate for the loss of tactile feedback.[5] The RAS learning phase is intensive, and experienced surgeons must operate on considerable numbers of patients before they adapt. During the training phase, operations can take up to twice as long as traditional surgery. Halsted's method of training should therefore be superseded by dedicated, competency-based RAS training programmes.

Surgical simulation has been used as an effective training tool for every new surgical innovation and may provide an ideal platform for RAS training. It provides a calmer, less pressurised environment for trainees to learn practical skills, and eliminates patient safety concerns during training. Surgical simulators can be broadly classified into four types: bench, live animal, ex vivo and virtual reality (VR). The VR modality simulators currently predominate in RAS training.

Before a simulator can be used for either training or assessment, evidence of its validity is required.[6] Validity is the extent to which a measurement accurately corresponds to the real world. There are several different facets of simulator validity testing; the more aspects of validity proved, the stronger the overall argument.[7] Content validity is the extent to which a simulator reflects the trait or domain it purports to measure.[7] Construct validity is the simulator's ability to differentiate between novice and expert operators.[7] Concurrent validity is the correlation between assessment tool with the gold standard, and predictive validity is the ability of a tool to predict future performance.[7] The ultimate goal of simulation training is to allow skills to transfer to the operating theatre. There remains a clear need to validate robotic simulation exercises before they are implemented into standardised training curricula.

Limited evidence exists to suggest that robotic simulation can be used as a tool to gain all necessary competences for performing RAS on patients. Data do exist to support the idea that simulation helps in earlier acquisition of basic surgical skills in robotic surgery, regardless of previous surgical experience.[8,9] Reports have demonstrated that the learning curve for a novice robotic surgeon appears to be enhanced with simulator training.[10,11] There are five different VR simulator platforms for RAS: the da Vinci Surgical Skills Simulator (dVSSS), Robotic Surgical Simulator (RoSS), Simsurgery Educational Platform (SEP), ProMIS and Mimic dV-Trainer (MdVT). All of these simulators except SEP were shown to have educational impact.[12] All except RoSS have demonstrated face, content and construct validity.[12] The RoSS system has proven face and content validity.[12] All current studies however, report on small sample sizes and at present, there is no evidence to suggest that one simulator is superior to another. No strong evidence exists to prove that skills acquired through VR simulation can be extrapolated to the operating room for robotic surgery. Lallas et al.[13] reported that current VR models are most beneficial for novices without significant robotic experience. This can be applied to training juniors who are being introduced to robotic cases and to educating the experienced surgeon without formal RAS training seeking credentialing or maintenance of certification.[13] VR simulators, however, have less application once a surgeon has gained some outside experience of RAS.[13]

With the rapid growth in RAS, there is a growing need to incorporate formal robotic skills training into surgical training programmes. This is challenging, particularly because of the lack of validated assessment tools as well as clear definitions for achieving competency. Didactic teaching can help incorporate knowledge of the technology, indications, limitations and post-operative management. Once the foundation has been laid, focus can be moved to skills acquisition using simulation.[14-16] Subsequent learning can be tailored according to specialty and complexity of the procedure to adjust for variability in learning curves.[17-19] A review by Bric et al.[20] highlights the ability of VR training to improve basic robotic skills with proficiency-based training. Kiely et al.[10] have recently published their work on a robotic surgery simulation curriculum to teach robotic suturing. Trainees were randomized into RAS simulation participation or non-participation. Significant improvements were noted in the simulator group for the primary endpoint of GOALS (global operative assessment of laparoscopic skills) scoring.[10]

If RAS simulation training curricula are to be widely introduced, it is important to define ways of measuring improvement up to competency. Noureldin et al.[21] describe introducing the dVSSS into the Canadian Objective Structured Clinical Examinations for postgraduate urology trainees. Experts performed the tasks beforehand and the passing score for competency was based on the average of the expert's total scores minus 1 standard deviation.[21] The simulator was able to discriminate between more and less experienced trainees based on this method. Hung et al.[22] have further developed a novel proficiency score for use in a RAS structured learning programme. This step-wise proficiency score has demonstrated construct and concurrent validity.

Once simulator competency has been achieved, the trainee may be introduced to live operating. RAS has a significant advantage over laparoscopic training during this transition period as a result of the concept of dual-console operating. When the dual console is used for training, the mentoring surgeon can hand over control of the instruments to the trainee at any time.[23] This enables a see-and-repeat model of instruction designed to accelerate the learning curve.[23] The dual console enables integrated teaching, cooperation between surgeons with proctoring, and supervision, without adversely affecting operative times or patient outcomes.[24] The dual console has a "give or take" function referring to each instrument in use, the control of which can be given singularly to the learning surgeon. The system also has "swap all" capability, allowing the lead surgeon to gain full control of all the instruments. This allows the learning surgeon to operate the robot in a simplified fashion, with two operating arms, while the trainer controls the third arm for retraction, exposure or pointing.[23] The virtual pointer enables the operator to point and refer to specific anatomic features intraoperatively. This technology can help remove the trainee's perception from the procedure.[23]. Mikhail et al.[25] demonstrated that the utilisation of a dual-console system can increase the likelihood of gaining certification for robotic training by obstetrics and gynaecology residents without a significant increase in the volume of robotic-assisted total laparoscopic hysterectomy cases. The dual console function therefore provides a novel way of training that has not previously been possible to achieve.

RAS training is still in its infancy despite the sporadic advancements in technology. The key factor limiting the value of robotic surgery is its cost-effectiveness. One study, however, conducted by the Roswell Park Cancer Institute to evaluate the cost-effectiveness of skills training using the RoSS system, has showed that it prevented a potential loss of $600,000 in comparison with live animal training.[26] RAS may also become more widely accepted if it enables surgeons to complete more operations than the conventional methods in a given time. A key aspect of this would be to provide training to more surgeons at an earlier career stage. Simulation training has been used effectively in laparoscopic and endoscopic procedures to provide improved cost and time benefit. This can be extended to RAS training with potential to be incorporated into surgical training curricula.[27] Considering that no large RAS simulation studies have been conducted to date, there is still scope for improvement and a greater need for larger, multi-centred trials to evaluate effectiveness. This should be coupled with an assessment of the correlation between RAS VR training and the incidence of surgical complications and patient outcomes.[5] Future focus on RAS simulation may include its utilisation in assessment for re-credentialing of surgeons, advanced procedure-based training, and as a surgical warm-up method before surgical procedures.[20]

Conflict of interest

The authors declare no conflicts of interest

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