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Simulation in robotically assisted surgery and the surgical training landscape

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Introduction

Learning is a stepwise process: from watching to training, first in simulation and then in the field, all the way to performing and then mentoring[1]. Training in robotically assisted surgery (RAS) includes training with virtual reality (VR) simulators, dry- and wet-lab sessions, and one-to-one proctoring. With the expansion in RAS volume and case complexity, it is critical that these core steps of RAS training are developed and mantained.

Simulation-based training

Training on dry- and wet-lab models requires dedicated facilities and trainers, with associated costs[2]. These opportunities should, therefore, be offered to experienced trainees or consultants within specific training pathways to enable them to perfect techniques. Meanwhile, simulation-based training should be widely accessible and commenced at the earliest stages of training to allow trainees to acquire basic platform agnostic skills with a robotic system[3]. The robotic platform lends itself to VR simulated training, with numerous simulators currently available offering both skill-based exercises (like camera use and knot-tying) as well as procedure-based exercises across many surgical specialties (*Fig. 1*). Although the reported correlation between robotic VR simulator performance and intraoperative technical surgical performance supports the use of simulation in RAS training[4], simulation also has a role in maintenance of RAS skills.

VR simulators evaluate various dimensions of task performance, often categorized as efficiency and penalties. Efficiency metrics include the time to complete exercises, economy of motion, and optimal use of the workspace range, reflecting the ability to perform tasks with minimal and precise movements, utilizing the robotic system's range of motion. Penalty metrics reflect potential risks to the patient, and assess control, accuracy, coordination, and appropriate use of surgical tools. Factors that incur penalties include out-of-view instruments, missed targets, drops, and improperly applied energy type. This iterative process of practice and feedback informs a continuous improvement cycle, ensuring that the user incrementally refines their proficiency towards competence. The feedback provided by VR simulators should also stimulate the tailoring of RAS training programmes to specific users or user-groups.

VR simulators should be considered instrumental in standardizing RAS training and defining training milestones. However, uniform assessment of competencies has not been implemented systematically in training programmes across Europe[5,6], likely owing to lack of availability and lack of consensus on competence definitions.

Immersive reality for robotic training

The availability of dual robotic surgeon consoles can greatly enhance single-surgeon training, yet any additional trainees may miss relevant details when watching a two-dimensional screen. A new solution using immersive head-mounted devices (HMDs) has the potential to address the limitations of current robotic training[7]. This system provides several key displays in real-time to an unlimited number of trainees. These include a 360° view of the operating room encompassing the console view of the intracorporeal surgical field, a view of the surgeon's hands in motion (simulating the perspective of sitting at a console), and an external view of the operating table and the robotic arms (*Fig. 2*). During live operations, real-time interaction with the operator is also possible, maximizing the learning experience. The HMD system is maximally effective in delivering an immersive training experience, either *in situ* or even remotely, thus reducing training cost and carbon footprint.

Future directions and challenges

The ongoing exponential advancement in RAS requires matched developments in training methods. RAS training has the potential to transform the whole training landscape, yet surgeons must continue to collaborate with industry to realize this potential. The development and distribution of high-fidelity simulators which foster platform-transferable skills remains limited and requires continued economic resource. The implementation of immersive reality in surgical training offers an exciting and sustainable tool to disseminate effective surgical training to numerous users simultaneously across regions, countries, and continents.

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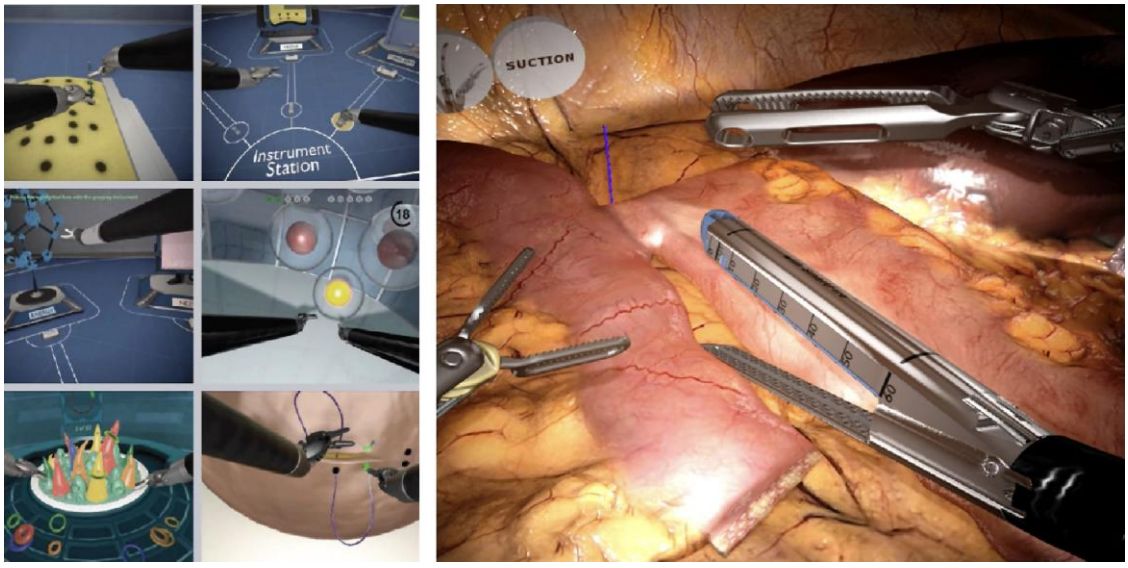


Fig. 1 Example of a virtual reality surgical simulator

The Da Vinci SimNow™ system (Intuitive Surgical, Sunnyvale, CA, USA) provides both skill-based exercises and comprehensive operation simulations across multiple surgical specialties. Copyright © 2024 Intuitive Surgical.

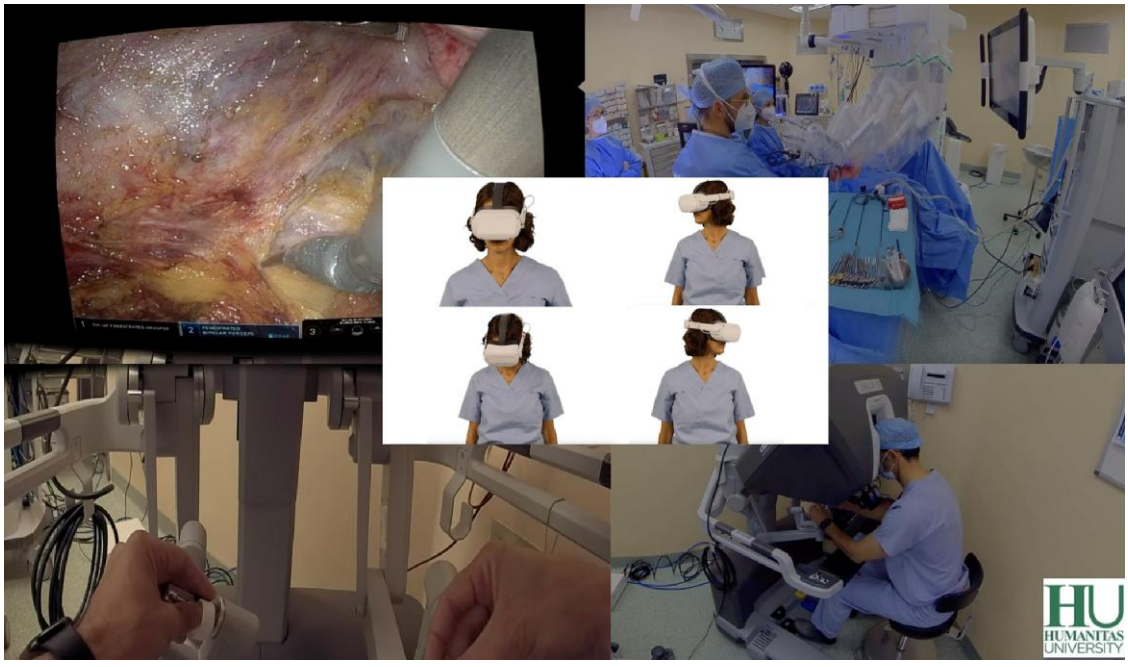


Fig. 2 Bidimensional representation of the 360° immersive space of the surgical field, surgeon's hand movements, and the operating room

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Author contributions

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Disclosure

A.S. has acted as a speaker/consultant for Johnson&Johnson and Stryker. The authors declare no other conflict of interest.

Data availability

Data availability is not applicable to this article as no new data were created or analysed for this work.

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