The Transferability of Generic Minimally Invasive Surgical Skills: Is There Crossover of Core Skills Between Laparoscopy and Arthroscopy?

Kash Akhtar, FRCS (Med), MD,* Kapil Sugand, BSc, MBBS, PgCert, HBE,† Asanka Wijendra, BSc, MBBS,† Muthuswamy Sarvesvaran, BSc, MBBS,† Matthew Sperrin, PhD,‡ Nigel Standfield, FRCS,§ Justin Cobb, FRCS,† and Chinmay Gupte, FRCS, MA, PhD†

*Department of Trauma & Orthopaedics, Barts Health NHS Trust, QMUL, London, United Kingdom; †MSk Lab, Charing Cross Hospital, Imperial College London, London, United Kingdom; ‡Centre for Health Informatics, University of Manchester, Manchester, United Kingdom; and §Postgraduate School of Surgery, London Deanery, London, United Kingdom

OBJECTIVE: The primary objective was observing transferability of minimally invasive surgical skills between virtual reality simulators for laparoscopy and arthroscopy. Secondary objectives were to assess face validity and acceptability.

DESIGN: Prospective single-blinded crossover randomized controlled trial.

SETTING: MSk Laboratory, Imperial College London.

PARTICIPANTS: Student doctors naïve to simulation and minimally invasive techniques.

METHODS: A total of 72 medical students were randomized into 4 groups (2 control groups and 2 training groups), and tested on haptic virtual reality simulators. Group 1 (control; $n = 16$) performed a partial laparoscopic cholecystectomy and Group 2 (control; $n = 16$) performed a diagnostic knee arthroscopy. Both groups then repeated the same task a week later. Group 3 (training; $n = 20$) completed a partial laparoscopic cholecystectomy, followed by an arthroscopic training program, and repeated the laparoscopic cholecystectomy a week later. Group 4 (training; $n = 20$) performed a diagnostic knee arthroscopy, followed by a laparoscopic training program, and then repeated the initial arthroscopic test a week later. The time taken, instrument path length, and speed were recorded for each participant and analyzed.

RESULTS: *Time taken for task:* All 4 cohorts were significantly quicker on their second attempt but the 2 training groups outperformed the 2 control groups, with the laparoscopy-trained group improving the most ($p < 0.05$).
Economy of movement: All cohorts had a significant improvement in left hand path length ($p < 0.01$) but there was no difference for right hand path length.
Left hand speed: Only the 2 training groups showed significant improvement with the laparoscopy-trained group improving the most ($p < 0.05$).
Right hand speed: All cohorts improved significantly with the laparoscopy-trained group improving the most ($p < 0.05$).
Face validity and acceptability were established for both simulators.

CONCLUSION: This study showed that minimally invasive surgical skills learnt on a laparoscopy simulator are transferable to arthroscopy and vice versa, with greater effect after training on the laparoscopy simulator. (J Surg Ed 73:329-338. © 2015 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: skill transferability, virtual reality simulator, arthroscopy, laparoscopy, surgical training

COMPETENCIES: Patient Care, Medical Knowledge, Interpersonal and Communication Skills, Professionalism, Practice-Based Learning and Improvement, Systems-Based Practice

INTRODUCTION

Surgical training has traditionally been an apprenticeship, with the student learning by the side of the master. This educational model, however, is inefficient and requires tens of thousands of

Correspondence: Inquiries to Kapil Sugand, MSk Lab, Charing Cross Hospital, Imperial College London, Level 7 East, Fulham, London W6 8RF, UK; fax: (44) 208-998-1677; e-mail: ks704@ic.ac.uk

Kash Akhtar and Kapil Sugand are the co-authors of this paper.

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hours of service provision in the hope that trainees would receive the necessary clinical exposure. There is no guarantee of the breadth or depth of the surgical experience acquired and the knowledge retained can vary widely, even between individuals trained in the same institution.

There has been a major change in postgraduate medical education over recent years with significant reductions in working hours.[1,2] In the United States, the Accreditation Council for Graduate Medical Education has restricted junior surgical residents and interns to a maximum of 16 or 24 hours of continuous duty, respectively, as of 2011, following on from the initial "80-hour working week" proposal previously adopted.[3,4] Similarly, the European Working Time Directive[3] has also imposed working time restrictions resulting in significant reductions in surgical training time from more than 30,000 hours to approximately 6000 hours.[3,5] This reduction is particularly important for surgical specialties where complication rates and patient outcomes have been directly correlated to case volume.[6-8]

The Institute of Medicine has estimated that approximately 100,000 patients die annually in the United States because of potentially avoidable iatrogenic incidents.[9] There has therefore been an increasing emphasis on patient safety with the goal of achieving competency-based medical training. Simulation has been proposed as a means of vicariously achieving competency in technical skills without compromising patient safety. It allows the repeated practice and acquisition of procedural skills in a risk-free environment and can help shorten the learning curve. Virtual reality (VR) simulation has been introduced into many surgical specialties, with a particular focus on minimally invasive surgical skills.[10-13] There has been a great deal of research into VR simulators and it has been shown repeatedly that simulator performance corresponds with surgical experience (construct validity). These skills have been demonstrated to transfer to the operating room and to significantly reduce the number of errors made in live surgery. VR simulation facilitates standardized training, provides excellent feedback, and allows trainees to progress at their own pace. It also has no consumable products and does not have the storage and ethical issues associated with the use of animals and cadavers. VR simulators facilitate the practice of generic minimally invasive surgical skills such as bimanual dexterity, triangulation, hand-eye coordination, and the manipulation of instruments in a 3-dimensional space while viewing a 2-dimensional screen.

General surgery and orthopedic surgery are the 2 largest surgical specialties and junior doctors invariably encounter these in the early years of surgical training. VR laparoscopy simulators have become increasingly available over recent years, whereas VR arthroscopy simulators are relatively recent introductions. The basic skills required for endoscopic surgery are remarkably similar irrespective of the surgical specialty or anatomical area involved. However, there is no evidence as to whether there is any crossover or transferability of core skills between laparoscopy and arthroscopy.

AIM

The primary objective was to observe any transferability of generic minimally invasive surgical skills between VR simulators for laparoscopy and arthroscopy using objective performance metrics. Secondary objectives were to assess the face validity and acceptability of these surgical VR simulators.

Null Hypothesis

There is no transferability of skills between laparoscopic and arthroscopic VR simulators.

METHODOLOGY

Groups

A total of 72 medical student volunteers were recruited and randomized into 4 groups. There were 2 control groups: Group 1 (*laparoscopic controls*; $n = 16$) and Group 2 (*arthroscopic controls*; $n = 16$) and 2 training groups: Group 3 (*laparoscopic test*, *arthroscopic training*; $n = 21$) and Group 4 (*arthroscopic test, laparoscopic training*; $n = 21$). The LapMentor VR laparoscopy simulator (Fig. 1) and the ArthroMentor VR arthroscopy simulator (Fig. 2) were used (Simbionix, Cleveland, OH). Criteria consisted of the following.

Inclusion Criteria	Exclusion Criteria
Undergraduates only	Postgraduate trainees
No past experience of VR simulation, laparoscopic or arthroscopic surgery	Past experience of VR simulation, laparoscopic or arthroscopic surgery

Group 1 (*laparoscopic controls*) performed a partial laparoscopic cholecystectomy once and Group 2 (*arthroscopic controls*) performed a diagnostic knee arthroscopy once. Both groups then repeated the same task a week later with no training in between (Table 1). Group 3 (*laparoscopic test, arthroscopic training*) performed a partial laparoscopic cholecystectomy, followed by arthroscopy simulation training, and then repeated the partial laparoscopic cholecystectomy a week later. Group 4 (*arthroscopic test, laparoscopic training*) performed a diagnostic knee arthroscopy once, followed by laparoscopy simulation training, and then repeated the diagnostic knee arthroscopy a week later.

PROCEDURE

All participants viewed instructional videos introducing the VR simulators and demonstrating the relevant procedural steps for each task. The subjects were given 1 minute each to orientate and familiarize themselves with the equipment before performing the baseline test. Each subject was tested individually with a member of faculty available to manage any technical problems but no