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ORIGINAL ARTICLE

There is a worldwide shortfall of simulation platforms for minimally invasive surgery

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Abstract

Background: The need for simulation in minimally invasive surgery (MIS) has been established. Uptake of simulator training remains poor however. This study quantifies the global availability of simulation equipment, how it is currently used and clinicians' aspirations for the future, including the emerging phenomenon of pre-operative rehearsal/warm-up. **Methods:** An online survey was distributed to 1314 operating clinicians via a global professional media network. **Results:** Two hundred ninety-two responses were received from 145 different cities in 63 countries. Responders were drawn from a range of surgical specialties. Only 34% reported access to a simulator during working hours, falling to 20% outside working hours. Forty-six percent had not used a simulator at all in the last 12 months, and only 19% had used it for more than 6 h in the preceding year. Seventy-nine percent supported the idea that a trainee should demonstrate basic competency on a simulator before operating on patients. Three-quarters think that there is a role for take-home MIS simulators; 86% support the use of MIS simulators for pre-operative warm-up, but only 26% currently do this. **Conclusion:** Worldwide there is great enthusiasm for the integration of simulators into training and surgical practice. Suitable simulation equipment is lacking however. There is strong support for the concept of take-home simulation to address this problem.

Keywords: *simulation; laparoscopy; training; surgical rehearsal; mental rehearsal; patient safety*

Introduction

Minimally Invasive Surgery Simulation

Minimally invasive surgery (MIS) was first performed on humans in 1910 by Hans Christian Jacobaeus from Sweden.[1] Jacobaeus immediately recognized the importance of practicing these skills in a simulated environment, away from patients, and suggested this in his early reports.[1] Unfortunately, this advice was not heeded and it remains the case that most trainee surgeons develop their skills by practicing on patients.[2] This situation is increasingly seen as unacceptable by both the surgical profession and the general public.[3]

Formalized learning by simulation was pioneered by the military, with the 1929 Link aviation simulator.[4] It took 60 years for the medical profession to catch up, when Gaba and DeAnda instigated simulation training for anaesthetists using automated manikins.[5] MIS simulators became commercially available in the mid-1990s, taking the form of virtual reality, physical box simulators and hybrid systems.[6]

The evidence for the efficacy and validity of a range of different simulators has gradually grown.[7–9] Skills learnt in a simulated environment are now known to translate to improved performance in the operating room.[10]

Two recent reports have highlighted that surgeons' access to simulation equipment is currently very limited.[11,12] Moreover, with increasing pressure on training time as a result of working time restrictions[13] and cost as an ever present barrier to the availability of simulation hardware,[7] there is growing enthusiasm for the concept of affordable take-home simulation equipment.[14–17] In addition to skills acquisition, MIS simulators also have roles in skills assessment,[18–20] professional revalidation[21] and development of new techniques,[22] with the ultimate aim of improving patient safety.[3]

Pre-operative Rehearsal/Warm-Up

Formal pre-operative rehearsal/warm-up is gaining greater recognition as an important part of surgical practice.[23]

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Almost all other performance-centred professions have some form of pre-performance preparation, either formally or informally. Few athletes or musicians for example take to the sports field or stage without warming up beforehand.[24] There is emerging evidence that formalizing the rehearsal process can improve performance in the operating theatre,[25] and that MIS simulators have a role to play in this.[26] We note that there is not yet consensus in the literature on the terminology for this process and here we use warm-up and rehearsal interchangeably.

This study assesses the global availability of simulation equipment, how it is used, and clinicians' aspirations for the future, including the emerging phenomenon of pre-operative rehearsal/warm-up. It utilizes a novel means of engaging with the world's surgical and obstetrics and gynaecology communities through the growing phenomena of professional media.

Materials and methods

Survey Generation and Distribution

An online survey was generated (SurveyGizmo.com, Survey Gizmo, Boulder, CO, USA) and distributed to a global audience of surgeons and obstetrics and gynaecology practitioners via the LinkedIn.com professional media network (LinkedIn Corporation, Santa Monica, CA, USA). The survey was sent to the 1314 surgeons and obstetrics and gynaecology clinicians in the first author's Linked In (LinkedIn, Mountain View, CA, USA) contact web.

Data Analysis

Raw survey results were downloaded from SurveyGizmo.com in .xls format and interrogated in Microsoft Excel (Microsoft Excel 2011, Microsoft Corporation, Seattle, WA, USA).

Results

Responses were received from 292 operating clinicians (22% response rate) in 145 different cities from 63 countries (Figure 1). The male to female split was 84% male, 16% female. Participants were general surgeons (41%), paediatric surgeons (26%), obstetricians and gynaecologists (18%), urologists (6%), orthopaedic surgeons (2%) and 7% from other surgical specialties. The responders were an experienced and active group: 65% were attending physicians/consultants and 35% were from training grades. Sixty-three percent reported performing >50 MIS procedures per year, and 38% regularly undertook >100 MIS cases each year.

Worldwide, access to MIS simulation equipment is very poor. Only 34% of responders have regular access to a simulator during standard working hours, falling to 20% outside working hours. Two recent studies from the United Kingdom have classified access to simulation in the same manner. Table 1 shows how these worldwide figures compare with the UK results.

Not only is there poor access to simulators, but the number of hours spent using them is very low. Only 19% had used an MIS simulator for more than 6 h in the whole of the preceding year; 46% had not used one at all in the last 12 months (Figure 2). Factors limiting the use of simulators included limited access to simulators outside normal working hours (43%), lack of time in the working week (37%) and insufficient instruments or disposable training materials

Figure 1 Map demonstrating the geographic distribution of the responders.

Table 1 Comparison with UK studies on the availability of MIS simulators[11,12]

	Access to a simulator during the working week (%)	Access to a simulator outside normal working hours (%)
This study: global cohort	34	20
Milburn et al: UK trainees (2012)	42	16
Brennan et al: members of the Royal College of Surgeons, Edinburgh (2014)	47	–

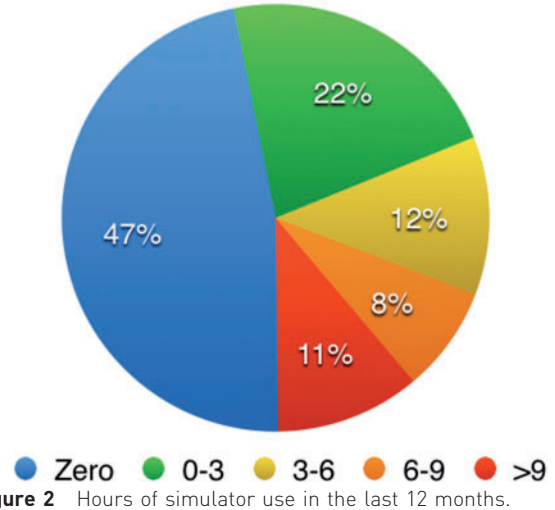

Figure 2 Hours of simulator use in the last 12 months.

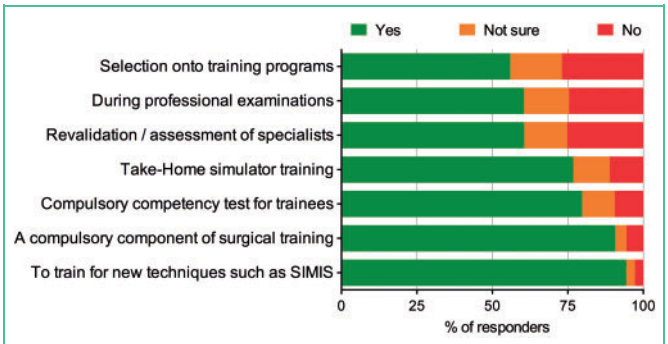

Figure 3 Opinions on the future role of simulators in surgical education and training.

(25%). Fourteen percent stated that they felt there was no incentive to undertake simulation practice.

Despite the lack of availability and lack of use, there was strong support for increased integration of simulators into surgical practice. Ninety-four percent supported simulator use to train for new techniques such as single-incision MIS (SiMIS), 91% felt simulator training should be a compulsory part of surgical training programs and 80% favoured compulsory skills testing on a simulator before trainees operated on patients. Simulators to aid professional revalidation as part of professional examinations and for selection onto training programs was also supported by 61%, 60% and 56%, respectively (Figure 3).

One proposed way to address the poor access to MIS simulators is to provide compact, portable and affordable take-home simulation equipment. The use of such take-home MIS simulators was supported by 77% of responders worldwide (Figure 3). There is enthusiasm to undertake more MIS, with 80% planning to perform operations for which they currently use an open technique by MIS. The evidence presented here suggests that simulators will play a large part in facilitating this increased uptake of MIS.

Pre-operative Rehearsal/Warm-Up

The survey asked two groups of questions about pre-operative rehearsal/warm-up: (1) what they currently do and (2) what they think surgeons should do. We have classified pre-operative rehearsal into four types: informal and formal, mental and physical. Examples of each type are: informal mental, e.g. thinking through the steps of a procedure; formal mental, e.g. revising the operative steps in a textbook or smart phone application; informal physical such as placing a smaller case at the start of an operating list; and formal physical, e.g. using an MIS simulator to warm up before an operation. Currently, informal mental rehearsal is widely practiced, with the other types much less so. There was enthusiasm to increase uptake in future of all four types of warm-up (Table 2 and Figure 4).

Discussion

This study illustrates that the previously reported lack of access to simulators in the United Kingdom[11,12] is a global problem. There is significant enthusiasm for the use of simulators in surgical practice, for both trainee and trained surgeons. For trainees, there was support for compulsory simulator training and mandatory skills assessment. For trained surgeons, responders felt there was a role for simulators in the development of new techniques, skills

Table 2 Current prevalence and future aspirations for surgical rehearsal/warm-up

	Mental, current prevalence (future aspirations)	Physical, current prevalence (future aspirations)
Informal	95% (98%) (i.e. thinking through the steps of a procedure)	61% (81%) (i.e. placing a smaller case at the start of an operating list)
Formal	63% (91%) (i.e. revising the operative steps on a smart phone application)	26% (86%) (i.e. using an MIS simulator before an operating list)

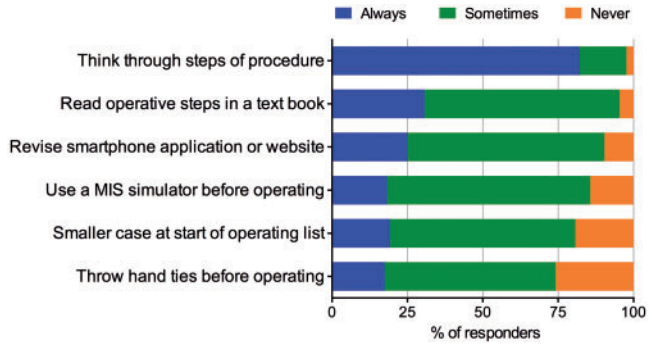

Figure 4 The type of pre-operative rehearsal that the responders felt surgeons should perform.

assessment for revalidation and pre-operative rehearsal/warm-up.

Our response rate of 22% is above the average of 10–15% reported as typical for this type of survey by the online tool we used (SurveyGizmo.com, Boulder, CO, USA). It is likely we could have increased this further by sending a reminder email, but avoided this with a mind to how full clinicians' inboxes become. We recognize that there could be a degree of bias in favour of embracing simulation from our responders, as they may be more predisposed towards embracing this new direction in training compared with those who did not engage with the survey. However, the ever-growing evidence base for the efficacy of simulation training suggests that these findings are likely to be generalizable to the surgical population at large.[7]

The strong support for making simulator use a compulsory part of surgical training is consistent with contemporary medico-political pressures.[3] This is particularly relevant in the era of working time restrictions and the recognition that current surgical trainees are receiving much less operative exposure than previous generations.[13] Procedural simulators do not teach how to complete an operation but they do facilitate translatable psychomotor skills acquisition.[3] This helps the trainee to focus on other challenges, such as the complexities of intra-operative decision making and the subtleties of anatomic and pathologic variation.[10]

There is an important patient safety theme to our findings. Seventy-nine percent favour trainees undertaking a compulsory test of operative skills on a simulator before allowing them to operate on patients. Assessment of surgical knowledge in the form of professional examinations has been compulsory for many years. The surgical community now appears ready to extend this to skills assessment. In the era of constant scrutiny on patient safety and the need to eliminate errors, it is likely that there will also be political pressure to implement this globally. In the United States, such an assessment is compulsory for general surgical training, in the form of the Fundamentals of Laparoscopic Surgery programme (FLS, SAGES, Los Angeles, CA, USA). The cost of this program is considerable, however, which may explain why it has not been widely adopted outside the United States.[27] One proposed solution to the problem of limited access to simulators is low-cost take-home hardware.[16,17] It has been recognized that hardware alone is insufficient, and that objective performance feedback and a curriculum of skills are required for optimal training.[7] A web search for 'laparoscopic simulator' reveals a number of companies now producing such equipment and training materials.

Anecdotally, most surgeons think through the steps of a procedure before an operation. We classify this as informal mental rehearsal and confirm that it is widely practiced. We define four types of pre-operative warm-up and demonstrate that there is a desire to increase their application in the future. There is interesting evidence emerging suggesting a cross-over between physical and mental pre-operative rehearsal. It has been observed that mental preparation results in both better operative decision making and improved technical skills, while physical preparation can facilitate improved cognitive performance as well as better operative technique.[23,28] This survey highlights strong support for the emerging technologies of online and tablet/smart phone applications for formal mental warm-up, one example of which is the TouchSurgery application (Touch Surgery Ltd, London, UK). Previous work has suggested that as little as 15 min of formal physical warm-up is sufficient to demonstrate improved operative performance.[23] Our responders strongly supported the use of MIS simulators to perform this physical pre-operative warm-up.

Compact simulators for use in clinicians' offices or non-clinical areas of operating room complexes are likely to be required to facilitate this.

This study provides a unique international perspective on the current availability and uptake of MIS simulators. While there is enthusiasm for the integration of simulation into surgical training and practice, including pre-operative warm-up, access to simulators is poor. There is strong support for the concept of take-home simulators to address this problem. Ultimately, this is a matter of patient safety, and it is incumbent upon the surgical profession to act.

Conflict of Interest

Partridge RW, Hughes MA, Brennan PM and Hennessey IAM have taken steps to address the poor access to surgical simulation tools highlighted in this study, by designing and manufacturing affordable take-home simulation equipment, instrument tracking software and an online curriculum of skills. They established a company eoSurgical Ltd (eoSurgical.com) in order to achieve this. All authors are shareholders in eoSurgical Ltd.

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