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The Role of Simulation in Microsurgical Training

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Simulation has been established as an integral part of microsurgical training. The aim of this study was to assess and categorize the various simulation models in relation to the complexity of the microsurgical skill being taught and analyze the assessment methods commonly employed in microsurgical simulation training.

Numerous courses have been established using simulation models. These models can be categorized, according to the level of complexity of the skill being taught, into basic, intermediate, and advanced.

Microsurgical simulation training should be assessed using validated assessment methods. Assessment methods vary significantly from subjective expert opinions to self-assessment questionnaires and validated global rating scales. The appropriate assessment method should carefully be chosen based on the simulation modality.

Simulation models should be validated, and a model with appropriate fidelity should be chosen according to the microsurgical skill being taught. Assessment should move from traditional simple subjective evaluations of trainee performance to validated tools. Future studies should assess the transferability of skills gained during simulation training to the real-life setting. (J Surg Ed ■:■■■-■■■. © 2017 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

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COMPETENCIES: Medical Knowledge, Practice Based Learning and Improvement

INTRODUCTION

The combination of an ever-reducing allocation of time in workplace training with a highly demanding skill that has high stakes in the case of error has led to the establishment of simulation as an integral part of microsurgical training. Mastering this skill cannot be achieved through observation alone as it requires a significant amount of dexterity and must be practised regularly.[1] Many courses have been developed worldwide[2-4] that usually last 1 to 2 weeks[5] to provide an intense workshop during which the trainees can familiarize themselves with the techniques before applying them to the clinical setting. These courses vary in complexity and cost to the trainee depending on the mode of the simulation used. Many courses use various different modes in a stepwise progression as trainees advance their skills.[1] The training implication and opportunity gained from attending such a course has gained such a significance that many institutions consider it a condition before practicing in a clinical setting,[6] and in some instances, as an eligibility requirement for obtaining a place in a training program.[3] Studies have demonstrated that the competency of novices improves to a level comparable to that of experts after intensive repetition of anastomoses over a relatively short space of time which is inversely proportional to the previous experience of the trainee.[7] This shows a steep learning curve in microsurgical technical skills acquisition that can be overcome using the application of extensive focussed practise.[5,7]

When discussing the use of simulation for training purposes, it is important to consider both the validity and the fidelity of the method used. These concepts refer to the appropriateness of the model in preparing the trainee to perform the technique in the clinical setting and the accurateness of the method employed in portraying a realistic model.[1,8]

The aim of this study was to assess and categorize the various simulation models in relation to the complexity of the microsurgical skill being taught and analyze the assessment methods commonly employed in microsurgical simulation training.

METHODS

A pubmed literature search was conducted using a combination of the terms "microsurgery" or "microsurgical" and "simulation." All papers in English language up to June

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2017 were reviewed by the 3 authors independently, and all articles discussing models of microsurgical simulation training or assessment of microsurgical simulation training were included in the study. Articles discussing clinical microsurgical practice were excluded from the study.

SIMULATION MODELS

Discussion of the different simulation models is best done in relation to validity and fidelity. Validity has a number of components and classifications that should be applied accordingly: face, content, construct, concurrent, and predictive validity.[1,8] Face validity describes how realistic a model is compared to the actual setting. Content validity refers to how appropriate the task is at allowing the trainee to reach the desired objective, and as such will vary according to the complexity of the model that the simulation training is based on.[8] The ability of the simulation model to accurately assess performance is known as construct validity. Arguably, the 2 most important aspects of validity in relation to microsurgical simulation are predictive and concurrent validity, that is, the ability of the simulation model to predict future performance at the task and the comparison with models that assess a similar outcome. However, these are perhaps the most difficult to assess.[1] Various studies have shown that construct validity is reliably seen in many models used for microsurgical simulation training.[3,9,10] As mentioned previously, predictive validity is challenging to measure. In a systematic review by Dumestre et al.,[11] the only model successfully establishing this was the rat femoral artery that is widely recognized as being the benchmark in microsurgical simulation.[1,11]

Fidelity is defined as the ability of the practice scenario to recreate the real-life setting and is therefore synonymous with face validity. Using this definition to describe simulation models, low-fidelity models tend to use nonliving material such as silicone tubing, medium-fidelity models use cadaveric animal or human tissue, and high-fidelity models are performed on live animal tissue such as a rat femoral artery or vas deferens. Fidelity, as applied to simulation training, can be further categorized into engineering and psychological fidelity,[8] the former describing the similarity to the physical properties of the task, whereas the latter describing the similarities to the psychological application of the task in a real clinical setting. The simulation environment does not recreate the stress or fatigue of the clinical application of microsurgery accurately, and as such, the only way to achieve accurate transferability into the operating theater is by improving engineering and psychological fidelity. Engineering fidelity in microsurgical training is therefore more pertinent in acquisition of basic technical skills, and psychological fidelity is associated more significantly with transferability. To improve psychological fidelity, the model must recreate the psychological cues of performing the skill on a real patient, such as performing an anastomosis on a silicone tube placed within cadaveric tissue.[8,12] Then again, this speculation has not been formally validated in the field of microsurgery

Although high-fidelity simulations can create a very realistic representation of real clinical microsurgical practice on humans, using high-fidelity models such as live animals is expensive, associated with various ethical issues, and requires the acquisition of special licenses that can be difficult to obtain.[13,14] In addition, it does not follow that low-fidelity models have low overall validity or vice versa. A systematic review of 9 validated microsurgical models by Dumestre et al.[11] showed that construct and concurrent validity were high irrespective of model fidelity and content validity that was present in all models except from the use of a diathermy pad. To reduce cost and the use of live animals, it seems therefore appropriate to use low-fidelity simulations to teach elementary basic microsurgical skills. To achieve content validity for advanced and complex simulated microsurgical tasks such as flap raising and super-microsurgery, though, high-fidelity simulation models are required.

Below, we describe the various simulation models according to the level of complexity of skills simulated and categorize them into basic, intermediate, and advanced. This categorization is summarized in Table 1.

BASIC MODELS

Basic models are usually low-fidelity simulations of simple tasks, such as simple microsurgical suturing, that allow the learner to become familiarized with the microscope and microsurgical instruments and learn how to tie microsurgical knots. These simulations have low cost, are easy to construct,[15,16] and reduce the number of live animals required to teach the more complex microsurgical techniques. Owing to their low fidelity, though, there is a limit to the level and quality of skill that these models can teach the learner.

INANIMATE PROSTHETIC MATERIALS

Many microsurgical simulation courses use placing of simple interrupted sutures on a straight incision made on a rubber glove as the initial microsurgical task to allow the learner to familiarize with the microsurgical instruments and learn how to perform a simple microsurgical suture.[17-19] Lahiri et al.[20] describe modifications of this model that more closely resemble vessel wall suturing by converting the straight incision to an I-shaped incision, which increases the instability of the edge to be sutured, or by creating 2 double triangles on the rubber glove that creates a narrower unstable edge that demands more dexterity during placement of sutures. Crosby et al.[21] describe how the rubber