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British Journal of Oral and Maxillofacial Surgery 57 (2019) 616–619

BRITISH Journal of Oral and Maxillofacial Surgery

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Review

Role of live animals in the training of microvascular surgery: a systematic review

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Available online 22 June 2019

Abstract

As training in microvascular surgery often involves the use of live animals, it is important that such a practice is regularly revisited and justified, particularly in the context of emerging training strategies such as virtual simulation. This systematic review was therefore designed to assess the ongoing need for their use over other methods. A search of PubMed and MEDLINE using the major MeSH terms: anastomosis, surgical vascular procedures, microsurgery, and training, yielded 1386 titles from which 153 abstracts were read, 70 papers analysed, and 17 included. Nine of these papers were randomised studies that compared different methods of training. Other publications were included if the use of live animals was assessed or commented upon, or both (8 publications). Only one study randomised trainees to a non-living animal model or a living model, with detailed assessment that included clinical transfer to live surgery. It showed no significant difference in the quality of training, and excellent techniques of assessment. There was much discussion on the advantage of regular training and opportunities to practise without tuition, but there was no clear advantage for the use of live animals. Our review emphasises the lack of evidence regarding the need for live animals in the training of microsurgical or microvascular skills. Although the assumption remains that the use of live rats is essential, there is a clear need for a high-quality, comparative study to justify the continued use of such models given the quality of the alternatives now available.

Keywords: microsurgery; training; vascular surgical procedures; anastomosis

Introduction

Patients rely on the surgical profession to ensure that surgeons maintain an acceptable level of competency, and since the problems with children's cardiac surgery in Bristol between 1985 and 1995,[1] the scrutiny of surgical practice in terms of audit and training has increased. It is universally acknowledged that the paradigm of care by a single surgeon in areas of high complexity is no longer acceptable, and the multidisciplinary approach with regular meetings, audit, and national benchmarking, has rightly become the national standard.

The Bristol experience[1] has clearly shown that in some technically complex procedures, higher levels of competency and training are necessary for the delivery of an acceptable standard of care. Craniofacial and cleft lip and palate surgery, for example, require additional training (fellowships) to that which is standard in oral and maxillofacial surgery (OMFS), owing to the relatively small number of cases, the complexity of the operations, and the importance of high-quality outcomes. The use of microscopes is increasing in all areas of surgery and dentistry, but is now standard in free tissue transfer in OMFS, and every trainee requires training in this competency.

David Soutar, a plastic and reconstructive surgeon at Canniesburn, was the first to show the versatility of the radial forearm free flap as a reconstructive option after the use of ablative techniques to treat oral cancer.[2] It soon became clear within OMFS that free tissue transfer was increasing the role

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https://doi.org/10.1016/j.bjoms.2019.06.003

Table 1
Randomised studies that assess different methods of training in microsurgery.

First author and reference	Year	Institution	Brief description
Low-fidelity compared with high-fidelity randomised trials			
Grober[6]	2004	University of Toronto (Canada)	Low fidelity (LF) model (silicone tubing) cf high fidelity (HF) model (live rat) cf didactic teaching alone showed LF as good as HF
Trignano[7]	2017	Sassari University (Italy)	3-step (latex glove-silicone tube-placenta) cf 2-step (latex-live rat) assessed with SAMS and clinical setting: no difference in scores
Value of using simulation model training to reduce the use of live animals			
Usón[8]	2002	Caceres (Spain)	Practice card shown to reduce use of live animals
Guerreschi[9]	2014	Lille University Hospital	Showed advantage of using a task-trainer simulation program, with a 50% reduction in the use of live animals
Training at regular intervals compared with a single course (massed)			
Moulton[10]	2006	University of Toronto	Distributed training (4 sessions over 4 weeks) was better than massed (1 day)
Schoeff[11]	2017	University of Virginia USA	Interval (3 x 30 min sessions in 1 week) better than massed training (1 x 90 min session)
The value of training and regular practice			
Price[12]	2011	University of Ottawa	Practice in own time on LF model significantly better than no practice
Malik[13]	2017	Guy's and St Thomas Hospital (London UK)	Laboratory microscope (1 hour/week × 4) cf home microscope cf home Apple iPad were compared and shown to be effective training in all 3 methods
Mokhtari[14]	2017	San Francisco/Phoenix USA	LF training before anastomosis of rat aorta cf no training showed much improved results with LF group

cf: compared with.

of primary surgery in head and neck cancer.[3] What was initially a difficult procedure that required new microsurgical and microvascular skills, rapidly became routine in the management of these patients, and thereafter training in these techniques became imperative for surgeons in our specialty.

At this time it was considered essential to complete a 5-day course on end-to-end and end-to-side vein grafts, and free flap transfer (epigastric), using rat femoral vessels. Such a course has been run by OMF surgeons at Liverpool University since 1993.

The use of live animals for surgical training is expensive and warrants ongoing ethical consideration. Emerging technologies such as virtual reality training and computer-aided microsurgical assessment[4,5] mean that adequate tuition may be possible without their use. The aim of this systematic review therefore was to find out whether the use of live animals can still be justified in the training of microsurgical skills.

Methods

Searches of the MEDLINE and PubMed databases using the major MeSH terms: anastomosis, surgical vascular procedures, microsurgery, and training, yielded 1386 titles. Of these, 153 abstracts were read, and 52 papers (drawn from the Liverpool University Library and the British Library) read in detail. A further 34 papers were obtained from this research because it was thought that they might add further useful data or opinion. These were reduced to 17 by the exclusion of work that was not directly related to the value or otherwise of the use of live animals for training.

Two papers reported randomised studies to compare the use of an in-vivo, high-fidelity training model (live rats) and a low-fidelity training model (for example, placenta or silicone tubing) (Table 1).[6,7] Randomised studies that involved training in microsurgery, even without a comparison of high and low-fidelity models, were also included (Table 1),[8–14] as were non-randomised studies that described a course, a new training model, or reviews, if they also included an assessment or comment on the use of live animals (Table 2).[15–22]

Other studies that did not assess or comment on the use of live animals, or compare different techniques for suturing (such as coupling devices), were not included, as were duplicate studies or methods.

Results

Grober et al[6] divided 50 junior surgical residents into 3 training groups: one that used a high-fidelity model (n = 21, live rat vas deferens), one that used a low-fidelity model (n = 19, silicone tubing), and one that was given didactic teaching alone (n = 10). The trainees assigned to the models had only 2 hours of training and were then tested on both the high and low-fidelity models. When assessed, the results immediately after anastomosis of the vas deferens were better in the group assigned to the high-fidelity model, but when the anastomoses were examined after 30 days, the results in the group assigned to the low-fidelity model were better. Their paper concluded as follows: "Surgical skills training on low-fidelity bench models can be as effective as high-fidelity live animal model training for the acquisition of microsurgical skill among novice surgeons".

Table 2
Non-randomised studies and opinions that assess the need for live animals in the training of microsurgery.

First author and reference	Year	Institution	Brief description
Review of validated microsurgical models			
Dumestre[15]	2004	University of Calgary (Canada)	Only 2 studies showed evidence of the use of the rat vessels and concluded that larger studies were required
Microsurgical training courses that do not use live animal models			
Mücke[16]	2013	Munich (Germany)	A comparison of surgeons and medical students who attended a 14-day course
Ali [17]	2018	Barts & the London (UK)	5-day course with chicken thighs as main model
Non-living models claiming equivalence to the use of live animals in microsurgical training			
Steffens[18]	1992	Essen (Germany)	Pig front legs, claimed to reduce the use of live animals
Fanua[19]	2001	Memorial Hospital, Baltimore (USA)	Latex card and Silastic gloves to create tubes to do end-to-end, end-to-side, and grafts, reduced animal use by 50%
Maluf[20]	2014	University of Parana, Rio de Janeiro (Brazil)	Pig's spleen suggested as non-living model capable of replacing the need to use live animals
Rodriguez[21]	2016	Santiago (Chile)	Trainees equivalent to surgeons with chicken-leg model
Camargo[22]	2017	University Sao Paulo (Brazil)	Oxen tongue suggested as a viable alternative to a live model

Trignano et al[7] took 20 residents in plastic and reconstructive surgery and divided them into groups of 10 to do either a standard course using live rats (starting with a latex glove before moving on to the live situation for 5 days), or one that did not use live animals (starting with a latex glove then an endovascular prosthetic tube (size 0.4 – 0.8 mm), before completing the course with a fresh placenta). The quality of the training was evaluated on the last day of the course using the SAMS scoring system,[20] then clinically assessed in the operating room as an assistant for the artery and first vein, and as the operator for the second vein. The SAMS scores were tested with a paired *t* test and, although the overall score for the live animal course was slightly better (8.65 compared with 8.07 scored out of 10), the difference was not significant. The residents were given a questionnaire to measure satisfaction (introductory lectures, time allocated for training, possibility of help by the tutor) and overall, the score (1 extremely unsatisfied – 5 extremely satisfied) given by the non-live animal group was 4.6 whereas that given by the live animal group was 4.1. Although the authors concluded that the use of animals could be reduced, they also made a strong case for training without the use of live animals.

Although further randomised studies have been done to confirm the value of simulation training with low-fidelity models and training at regular intervals and regular practice (Table 1), these points are less controversial, and the need for strong evidence less important.

The review by Dumestre et al[15] made the point well that there is little or weak evidence to confirm the need for the use of live animals in the training of microsurgical skills. We know of only one course that lasts for 5 days and does not use live animals,[17] but there is no evidence to suggest that those attending are at a disadvantage.

A number of papers[18–22] have introduced new non-living training models in microsurgery with an indication that the live model could be discontinued (Table 2). Lannon et al[23] predicted that virtual-reality training models would displace the reliance on the use of live animals for training in microsurgical and microvascular surgery as early as 2001. So far, however, such options remain the exception, although the technique has been suggested as a means to maintain skills.[24] It is clear that whatever the method used, there is a need for simulation training that can be used regularly when formal teaching and instruction has been completed.[25]

Discussion

The use of any animal for research or training must be justified, hence the governmental regulation by the Home Office in the UK. This is even more important if live animals are being used routinely to train surgeons, as is the case with microsurgery. Our main finding has been that there is no substantial evidence to support the continued use of live animals for training in microsurgery or microvascular surgery. We know of only one randomised study that compared the results of trainees and included human practice, and this showed no advantage for the high-fidelity (live animal) model.[7]

Although the evidence is weak (we know of only 2 randomised studies[6,7] that compare the use of live animals with other models for training in microsurgery) (Table 1), there is a trend in other publications to support low-fidelity options (Table 2). The studies listed in Table 2 were included in an attempt to assess opinion regarding training techniques. The discussions and conclusions in additional articles cannot exclude the use of live animals, which is still recommended, but there is a view that the use of low-fidelity models may ensure that appropriate levels of competence are achieved at a much lower cost.

Our review has shown that the value of formal training with practical models is improved when there are opportunities to continue to practise. This was emphasised in the study by Malik et al,[13] who showed the effective use of a home

microscope or Apple iPad over the formal use of a laboratory microscope.

Our searches found only one 5-day training course that was not based on the use of live animals (Table 2).[17] The reduced cost and the confidence gained from completing a course that uses non-living models, enables trainees to continue to develop their skills. The charge for this course is £600 or $790 which, compared with £1500 or $2000 for the standard 5-day rat course, is a considerable saving for UK trainees who often can only claim up to £750 (depending on their deanery).

Most hospitals and units with trainees in microsurgery will not have access to live animals on which to practise. The Munich course[16] (Table 2) lasts for 2 weeks (which could be reduced), but the unit also uses live animals for the completion of training. The reliance on live animals implies that other forms of practical learning may be deficient. We found no vindication for such a view, but instead, the need to move to low-fidelity models for teaching and the need to encourage opportunities to practise.

In conclusion, this review highlights the lack of evidence to justify the continued use of live animals in the training of microsurgical or microvascular skills. With virtual-reality, self-assessment models for basic suturing techniques, and dissection on low-fidelity models such as chicken thighs or placentas, there are excellent alternative training options which, when assessed, have shown equivalent results to those of high-fidelity models. Although the assumption remains that a course using live rats is essential, there is clearly a need for a high-quality comparative study to justify the continued use of live animals when we consider the quality of the alternatives now available.

Ethics statement/confirmation of patients' permission

Not applicable.

Conflict of interest

We have no conflicts of interest.

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