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Microsurgical training for students: presentation of a model and preliminary results

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ABSTRACT

Microsurgery is a form of surgery performed with the assistance of a magnifying device such as a microscope or loupe. It is not considered a distinct specialty but a competency required for different surgical specialties. The study presents an undergraduate training model designed in the authors' institution and is directed towards medical students in their clinical years. It consists of 30 practical learning hours of how to conduct various microsurgical procedures. These took place during 15 three-hour classes (2 h under the microscope per lesson), held once a week. The simulation model used in this training was a chicken thigh and instrumentation consisted of surgical training microscopes and professional microinstruments. Effectiveness of the training was assessed through the observation of acquired skills and the so called "6-stiches test". Other simulation models used in microsurgical training and other methods of evaluating the acquired proficiency were discussed. The results show that the proposed 30 h of undergraduate, facultative microsurgical training is effective in ensuring participating students acquire basic and advanced microsurgical skills, competence and confidence. The curriculum was designed to allow students to participate in training during the evening, away from other duties, so as not to burden them too much.
Keywords: microsurgical training; practice based learning; undergraduate surgical curriculum.

INTRODUCTION

Microsurgery is a specific form of surgery performed with the assistance of a magnifying device such as a microscope or loupe. It is not considered a distinct specialty but a competency that is required for different surgical specialties. The range of basic technical skills taught was limited to undertaking vascular and nerve anastomoses; thus, the course is relatively narrow and possible to master after a limited amount of training. This does not mean that acquiring these skills is enough to be a microsurgeon, but that they are essential in microsurgery. Depending on their particular specialty, any given surgeon must be familiar with the technique of preparing tissue, elevation of flaps, exploring nerves, bone fixation or tendon suture when it is required i.e., at finger replantation. Nevertheless, the fundamental proficiency of this skill, crucial for the success of microsurgical operations, remains to be in the confident performance of vascular micro-anastomoses. Microsurgical skills can be acquired through participation in courses organized by various institutions and directed towards residents of various surgical disciplines such as plastic-, neuro- or hand surgery, ophthalmology or laryngology. These courses differ with regard to simulation modalities, duration and methods of evaluating proficiency. In most courses, surgical microscopes or high-magnification loupes are used to magnify the operative field but the use of simpler devices such as philatelist's loupes and smartphones were also reported [1, 2, 3].

Simulation models used for microsurgical training

There are a variety of simulation models used for training microsurgical skills. They are essentially divided into 4 categories: inanimate models (synthetic materials), animal cadaveric models, human cadaveric models and live animal models. The most popular model for the initial training is a rubber glove stretched over a cup, as was used in our course. Trainees are asked to place simple interrupted sutures on a straight incision made in the glove. It is a simple but useful model to learn how to use micro-instruments (needle holder, forceps) while retaining control of hand tremors and tying surgical knots. In the authors' institution, this model has also been used for assessing whether microsurgical skills have been acquired and is referred to as the "6-stiches test" (Fig. 1). Other possible inanimate models include surgical gauze (trainee attempts to pull thread between the "eyes" of the gauze), beads (crossing the suture through small holes in beads) and polyethylene mini-tubes which imitate blood vessels [1].

The most popular animal cadaveric model, and the one we chose, is a chicken thigh [4]. It represents a simulation model with a moderate-fidelity and an easily-accessible neurovascular bundle consisting of a femoral artery, veins and nerves – all structures which have a diameter of 1–2 mm. Another animal cadaveric model is a chicken wing, in which brachial vessels are prepared and used for anastomosing. The average diameter of the artery is 1.7 mm and vein 1.2 mm. Less popular tissues include the pig trotter (fore- or hind limb) or pig heart, in which coronary arteries are used for training [5]. All these models allow trainees to perform arterial, venous and nerve anastomoses. They are cheap, easily accessible and closely resemble clinical practice with regard to the size of microstructures and tissue consistency. Specialized laboratories are not required for this type of dissection and training.

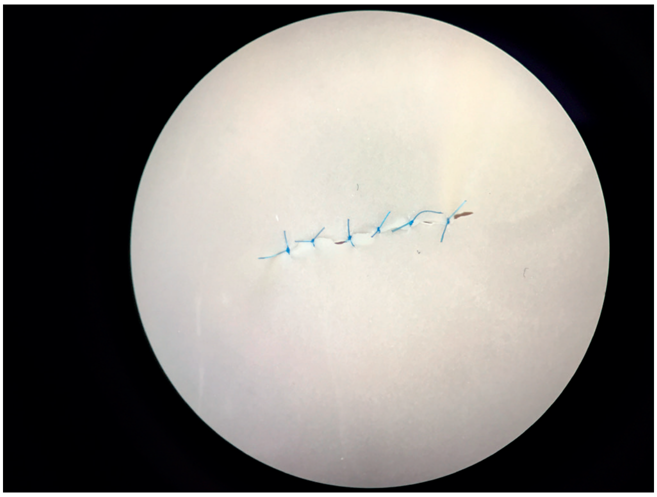

FIGURE 1. Interrupted sutures placed on a rubber glove stretched over a cup

Human cadaveric models are less commonly used for teaching microsurgical skills for obvious reasons. Training on human cadaveric models requires access to a special laboratory, dedicated to working with human cadaveric parts. Thus, it is much more expensive. Although this model reflects anatomy encountered on the operating field (high-fidelity model), there is no evidence that it is associated with a quicker acquisition of microsurgical proficiency when compared with work on animal tissues [1].

Simulation with the use of live animal models (rat aorta or femoral artery, rabbit's ear veins) is considered the gold standard for advanced microsurgical training. It offers natural conditions for preparing living, vascularized tissues and anastomosing real vessels with flowing blood. This allows a unique opportunity to control the patency and tightness of vascular anastomoses [5, 6]. Over and above these unquestioned advantages, this training is associated with several flaws, including less accessibility, higher costs and ethical issues. It requires meeting many preconditions such as having a special lab, access to living animals, skills in animal anaesthesia and moreover, euthanizing the animal after the completion of exercises, and proper utilization of remains. Experiments and training with the use of live animals are governed by special, relatively demanding regulations which must be met. For this reason, microsurgical courses using live animal models are offered only by professional companies in selected countries and thus, availability is limited. Moreover, there isn't convincing evidence that this model is necessary as an intermediate step between the animal cadaveric model and clinical microsurgical practice [5].

Organization of microsurgical training

The duration of a typical microsurgical course varies 1–5 days, which gives 6–40 working hours under the microscope [2, 3]. For various, mainly logistical reasons, the training is organized in a continuous (massed) manner and after completion of the course only some of the participants have the opportunity to develop the acquired skills at home. It is obvious that non-practiced skills are slowly forgotten, and this process is quicker if the time of training was shorter. Microsurgical training is organized almost exclusively in a post-graduate setting, usually for residents of various surgical specialities. The undergraduate training model presented by here is directed towards students in their clinical years. It presents a new approach in teaching surgery during medical studies, extending significantly beyond the standard curriculum.

The objective of this article was to present a training model which has been established and practiced in the authors' institution.

METHODS

The idea of a microsurgical curriculum for students of the medical faculty was first discussed in 2016. The program of the course had been developed based on information from the literature. The training presented in this study consisted of 2-hour practical sessions being held once a week, over 15 weeks. This interval learning model was shown to be more effective in the acquisition and maintenance of microsurgical skills, when compared to massed training [4]. However, it is only possible to conduct this type of training in a very specific setting where participants stay on site and can regularly attend sessions. In the case of stationary studies, this seems to be the optimal setting.

The consent of the Didactic Board of the Pomeranian Medical University in Szczecin was obtained for setting up the microsurgical laboratory followed by an agreement for financial funding. The room was adapted to this purpose and the necessary equipment was purchased, including:

- 6 training microscopes (Optek, Prymus, Ziebice, Poland). One of these microscopes is equipped with visual track which allows for a direct presentation of the operation on a monitor,
- 6 boxes of microsurgical instruments (S&T, Warsaw, Poland), comprising 10 items: forceps, needle-holders and scissors, and 12 vessel-approximators,
- micro-sutures 8/0 and 9/0.

After equipping the laboratory, the authors began recruiting students willing to participate in the course. Two groups comprising of 6 participants were recruited in November 2017.

RESULTS

Classes were held in the evening, once a week for each group. They were run and supervised by 3 surgeons (the authors of this article) and lasted 3 h on average, 2 of which were spent at work under the microscope. The curriculum is shown in Table 1. As a 1st step, the students were familiarised with the surgical microscope, microsurgical instruments, proper posture, methods

TABLE 1. Microsurgical curriculum program

Week of training	Hours of training	Tasks performed in class	Number of anastomoses per person
1	2	introduction to the program familiarization with the microscope and instruments placing sutures on a rubber glove	-
2	4	preparation of structures on a chicken thigh introduction of the technique of nerve suture chicken femoral nerve suture	1
3	6	chicken femoral nerve suture introduction of the technique of microvascular suture	2
4	8	chicken femoral nerve suture chicken femoral artery anastomosis	2
5	10	1st "6-stiches test" on a rubber glove chicken femoral artery anastomosis	2
6	12	chicken femoral nerve and artery anastomosis	2
7	14	end-to-side arterial anastomosis	1
8	16	chicken femoral artery anastomosis introduction of the technique of vein suture	2
9	18	2nd "6-stiches test" artery anastomosis with vein conduit	2
10	20	chicken femoral nerve suture artery anastomosis with vein conduit	3
11	22	chicken femoral nerve suture artery anastomosis with vein conduit (2)	3
12	24	3rd "6-stiches test" repair of femoral nerve defect with vein conduit	2
13	26	chicken femoral artery anastomosis (test) repair of femoral nerve defect with vein conduit (2)	3
14	28	whole chicken femoral vascular bundle repair: artery, vein and nerve	3
15	30	chicken femoral artery anastomosis (test) chicken femoral artery and vein anastomosis	3
Total	30		31

to avoid hand tremor and microsurgical technique. They then practiced placing sutures on a latex glove stretched over a cup (Fig. 1). For the 2nd class, students brought fresh chicken thighs. First, they were instructed on how to prepare the femoral neurovascular bundle in this model (Fig. 2). After placing it under the microscope, they started with femoral nerve repair. In the 3rd class, the group was introduced to the technique of microvascular anastomosis, and participants performed a suture on the chicken's femoral artery (Fig. 3). In the next classes the participants followed the program (Tab. 1) by performing more complex and demanding microsurgical procedures.

FIGURE 2. Fresh chicken thigh with exposed femoral neurovascular bundle

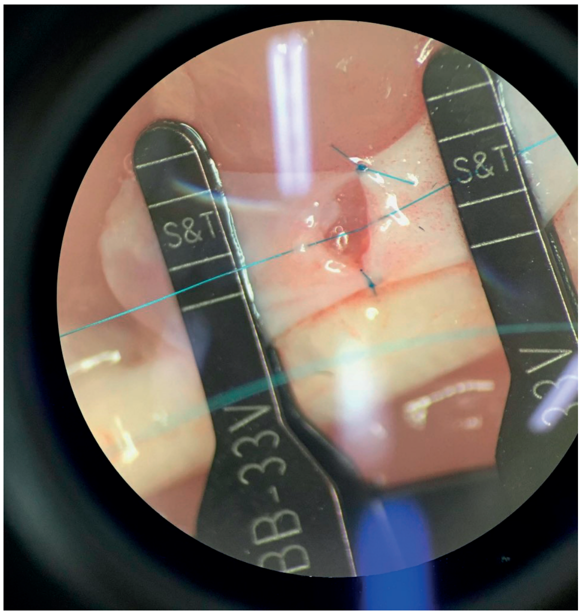

FIGURE 3. Anastomosing of a chicken's femoral artery

Assessment of acquired skills

After the completion of 10 hours' training, the 1st assessment task was conducted. This was a simple, "6-stitches test", consisting of placing 6 sutures of 8/0 on a latex glove stretched over a cup, with 1 mm spacing and with 3 runs for tying one knot. The time it took to complete the task was measured and recorded for each student. During the whole 30-hour curriculum, 3 subsequent assessment tests were performed and the following results were obtained:

– during the 1st test, the median time required to complete the task was 12:10 (12 min 10 s; range 10:54–17:19);

– the 2nd test performed after 18 h of training showed a significant improvement (median 6:40) in the time required to complete the task;

– at the 3rd test, following 24 h of training, the median time was 6:41, which was ½ of the baseline time of the exercise.

After 30 h of training under the microscope and performing 31 anastomoses, the faculty decided that all participants had reached an advanced level of microsurgical skills and had completed undergraduate microsurgical training.

DISCUSSION

The microsurgical curriculum for students of clinical years represents a unique program and the authors are yet to find anything similar presented in the literature. We see the following advantages of the introduction of facultative microsurgical training into the surgical curriculum:

– teaches patience and regularity in the aim to achieve manual and mental skills,

– provides the privilege of achieving unique surgical skills attainable by only a few surgeons,

– allows students to actively participate in highly-specialistic surgical procedures,

– the above arguments incline students to choose a surgical discipline as a future speciality,

– allows early identification of individuals particularly talented in microsurgery,

– provides a quicker start in future surgical speciality training.

The first 2 arguments in particular should not be underestimated. The students awareness of acquiring unique surgical skills as a result of hard, intensive and demanding training led to excellent feedback, which reinforced student enthusiasm and self-confidence. They also changed their attitudes towards "conventional" learning methods and preferred a more active and competency-oriented method. There is some evidence that microsurgical training improves the macro-surgical techniques of residents, teaching them how to be patient and to manage frustration [6]. We observed this and other beneficial effects in our students.

Microsurgical training conducted on the basis of the presented model has the added benefit of making students more inclined to choose a surgical discipline as a future specialty. This comes directly from the satisfaction caused by achieving a unique proficiency in a highly specialised competency, normally unattainable for average surgeons.

Another benefit is students assisting in normal microsurgical operations, i.e., hand replantation or microvascular reconstruction. Students assisted in these operations, using the 2nd ocular of the operative microscope. They did not perform vascular and nerve anastomoses by themselves, but they were allowed to place single stitches during nerve repair. The authors believe that the transferability of skills gained through simulation training into real-life settings is the "next step" of microsurgical teaching.

Undergraduate microsurgical training also allows early identification of individuals particularly talented in operating under the microscope. This is dependent on having some unique predispositions, i.e., the ability to concentrate on small details, manipulation with instruments in a very small operating field, good hand-eye coordination or 3D vision [7]. These talents are not common in the human population, but some individuals are particularly gifted at them. Two such people were identified during the 1st course; they presented an excellent predisposition towards operating under the microscope, followed by providing valuable assistance in microsurgical operations.

The results of this study show that 30 h of undergraduate, facultative microsurgical training is effective in acquiring microsurgical skills, competence and confidence for participating students. They achieved good proficiency in microsurgical anastomosing of vessels and nerves. The curriculum's design allowed students to participate in training during the evening, away from other duties, and did not burden them too much.

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