Simulation-Based Bypass Training and Learning Curves—Resident Experience

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Abstract

Introduction Bypass surgery is a challenging operative procedure that requires surgical excellence. Achieving the skills required for vascular surgery is difficult to master in the operating room without intensive microsurgical training. Various models have been developed to provide training to young neurosurgeons and increase dexterity and patient safety. Bypass surgery requires complex microsurgical techniques.

Methods Microanastomosis training was performed on plastic tubes and chicken wings for 2 months. Each microanastomosis was evaluated by a senior author.

Results An improvement in the quality and patency of microanastomosis was observed.

Conclusion Microsurgical simulation training can contribute to the improvement of surgical skills and dexterity.

Keywords
- bypass surgery
- education
- resident
- technique
- training

Introduction

Technological advances in neurosurgery have made it possible to create three-dimensional (3D) models of blood vessels that can be useful in training residents and young neurosurgeons. The development of simulation models can give a realistic neurovascular model. Simulation represents an educational technique in which the trainee interacts with the environment that recreates the same scenario from the real world.[1,2] Simulation training is required before the first neurosurgical vascular operation. While synthetic and virtual reality models are used at the beginning of the training, human and animal cadavers are part of advanced neurovascular training.[3] Based on the results of simulation tests, we can assess surgical dexterity, the validity of the stoma, and the readiness of the specialist for the first operation on a real patient. Therefore, our aim is to highlight the need to introduce simulation bypass training into the curriculum of the neurosurgical program and to show learning curves during training.

Methods

In the first phase of training for microvascular anastomoses, plastic tubes with a diameter of 2 mm and a length of 70 mm were used, while the second phase of training was based on chicken wings purchased from a grocery store.

Microsurgical tools and instruments used for the training are as follows (►**Fig. 1**):

(1) Leica training microscope
(2) Microsurgical scissors

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Fig. 1 Instruments for bypass training.

(3) Forceps
(4) Microsurgical needle holders
(5) Microvascular practice suture needles 10–0

All anastomoses were performed by a junior resident (MJ). ►**Fig. 2** shows a junior resident performing an end-to-side anastomosis.

Each anastomosis was evaluated by the senior author (YK), and the final score consisted of the mean value of the evaluated variables. The various characteristics that were evaluated were (1) time required for complete anastomosis, (2) visual quality of the anastomosis, (3) patency, and (4) strength of the suture. The rating was given for microanastomoses performed on plastic tubes and chicken wings.

Results

A microanastomosis was performed using the end-to-side technique. The first sutures were placed at the 12 and 6 o'clock positions. Sutures were then placed on the front and side of the anastomosis. After complete microanastomosis, a small syringe was inserted into the proximal area of the vessel, and physiological saline was injected through the vessel to test the patency and tightness of the suture. ►**Fig. 3** shows examples of microanastomosis performed during the 2-month training. The average time required for suturing a microanastomosis during the first week of training was 100 minutes. In the last week of the training, it took 29 minutes to suture one anastomosis (►**Fig. 4**).

During training, the senior author (YK), gave better ratings for the visual quality of microanastomosis compared with the initial rating. Also, the patency of the anastomosis at the end of the training with the plastic tube was rated better compared with the anastomosis at the beginning of the training.

Fig. 2 Junior resident performing a microanastomosis on a simulation model.

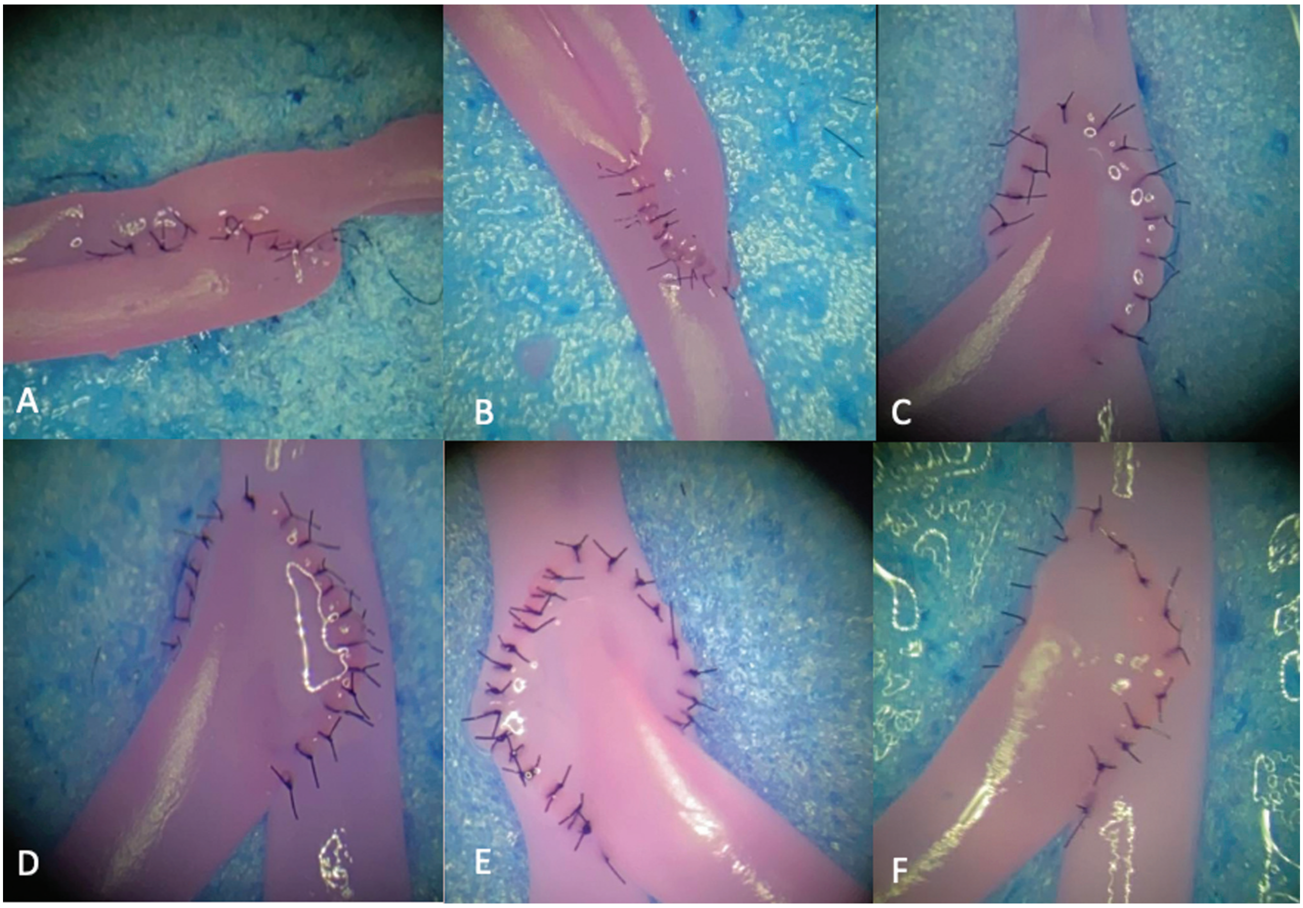

Fig. 3 Comparison of microanastomoses during training (**A**—first week of training; **B**—second week of training; **C**—third week of training; **D**—fourth week of training; **E**—fifth week of training; **F**—seventh week of training).

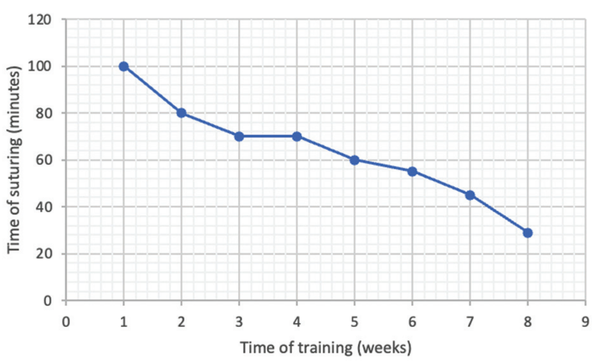

Fig. 4 The learning curve of bypass training performed by a junior resident.

Discussion

Bypass training is based on eye–hand coordination and knowledge of the microsuturing technique.[1] Eye–hand coordination enables fine motor skills and suturing control.[2,3] The surgeon must have excellent knowledge of anatomical relationships and maneuvering with neurovascular structures using surgical equipment in an extremely small surgical field.[4] Every movement must be precise if the bypass area is deep. Previous studies have shown that mastering neurosurgical skills during training improves patient safety and minimizes risk.[5–7]

The earlier publication suggested using a paper box with a small hole to give the impression of the depth of the simulation field.[8] Other authors used a stand made of Lego cubes, a 3D model of blood vessels, and artificial head models.[4,9,10]

The disadvantage of simulation training is that it does not consider the depth of the surgical field, neurovascular structures, and the different positions of the surgeon's hands during operations. After the initial training in the "open field," our residents practiced microanastomoses in a limited field, which were somewhat worse initially. We attribute this to the new environment and the time needed for adaptation. Given that the training was done daily for 60 to 100 minutes, a significant improvement in the quality of microanastomoses performed in the limited field was observed.

Tansley et al reported that simulation-based teaching significantly improves the operative skills of residents, and this improvement remains over 3 months.[11]

Our experience shows that the junior resident made excellent progress during the 2 months of training. Comparing the suturing time of the first and last microanastomosis, an improvement of 71 minutes was achieved. In addition, better visual quality and stoma patency were achieved, which confirm that the junior resident achieved better skills and dexterity in performing over time.

The time invested in learning techniques is the most crucial factor in the learning curve. Inoue et al reported that junior neurosurgeons could perform a stable superficial temporal artery–middle cerebral artery anastomosis after 10,000 stitches.[8,12] Diligent and meticulous training should be a priority in achieving excellence in bypass surgery.

Conclusion

Simulation models, which are part of education, can be beneficial in better understanding surgical techniques and improving the dexterity of residents. Training residents on simulation models should be implemented in the curriculum because this can increase the residents' proficiency, shorten the learning curve, and increase the safety of the residents during the operation and the patient himself. Only continuous training can lead to surgical excellence.

Authors' Contribution

M.J. was involved in data curation and resources. D.J. contributed to conceptualization, formal analysis, writing, review, and editing—original draft. K.S. helped in validation. R.T. was involved in supervision. Y.K. was involved in supervision, writing—review and editing. All authors reviewed the results and approved the final version of the manuscript.

Conflict of Interest

None declared.

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