A New Synthetic Model for Microvascular Anastomosis Training? A Randomized Comparative Study Between Silicone and Polyvinyl Alcohol Gelatin Tubes

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INTRODUCTION: Assessment of a resident's microsurgical competency with the rodent model remains the current gold standard. However, cost and ethical issues related to animal welfare may limit training opportunities. Therefore, synthetic alternatives such as silicone tubes have been developed to provide easy access to training, shorten the learning curve, and have been incorporated into microsurgical courses as a low-fidelity model for basic skills acquisition. This study compares the use of polyvinyl alcohol (PVA) gelatin tubes with silicone for resident microsurgical training.

MATERIAL AND METHODS: Residents were randomized into silicone (S) or PVA (P) groups and underwent the same training. Following basic instruction, microsurgical anastomoses were performed with the rat's aorta or carotid artery or both. Performance was assessed using the Objective Structured Assessment of Technical Skills (OSATS) score and 5 different items to assess the quality of the anastomosis. Posttest questionnaires were also conducted for qualitative assessment of both students' and trainers' experience with silicone and PVA in comparison with rat vessels.

RESULTS: OSATS score in Group P was higher than Group S (18.2 ± 2.6 vs 16.6 ± 2.5, p = 0.015). Results of anastomoses were similarly better in Group P based on OSATS score (19.3 ± 1.2 vs 17.7 ± 0.7, p = 0.027). Subjectively, both students and trainers found that PVA tubes resembled the rat aorta more closely than silicone. The number of rats used was also significantly lower in Group P than Group S (65 vs 75 total, p = 0.023).

CONCLUSION: PVA gelatin tubes may be a viable alternative to silicone for microsurgical training because this synthetic model mirrors better rat vessels and can improve training performance based on objective assessment while using less animals overall. (J Surg Ed ▮:▮▮▮-▮▮▮. © 2017 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: microsurgery, simulation, silicon, PVA tube, low fidelity model

COMPETENCIES: Practice Based Learning and Improvement, Professionalism, Interpersonal Skills, Simulation

INTRODUCTION

Surgical simulation[1] has an increasing role to play in modern surgical training including microsurgery.[2] Although success rates for free tissue transfers are approximately 95%, if not higher,[3] technical mastery of microsurgery is a prerequisite. Typically, this is achieved through training with increasing complexity, starting from low-fidelity

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models[4] before progressing to the current gold standard in rats.[5] However, due to cost and ethical concerns over animal use, synthetic models have been proposed to help bridge the learning curve in microsurgery. These include low-fidelity models such as silicone tubes[6] or organic models[7] before moving on to the rat model. Currently, silicone tubes (Silastic, Dow Corning, Laboratory tubing Midland, MI) are typically used for initial microsurgical training. Based on recent studies on small vessel replacement,[8,9] we evaluate the use of polyvinyl alcohol gelatin tubes (PVA) as an alternative in basic microsurgical training.

MATERIALS AND METHODS

PVA Gelatin 1% Preparation Tube

Hydrogels were prepared using a chemical crosslinking process described in previous publications.[9,10] Each tube was kept in PBS for 48 hour to 15 days, before testing or implantation at 4°C. The rod measures 1.2 mm, and the outer diameter of the mold 4 mm, the inner diameter 2 mm. The final product is flexible and has a semiopaque aspect and keeps an open lumen (Fig. 1). PVA used for training was 4 to 5 cm in length with a mean outer and inner diameters of 1.81 ± 0.35 and 1.4 ± 0.23 mm, respectively.

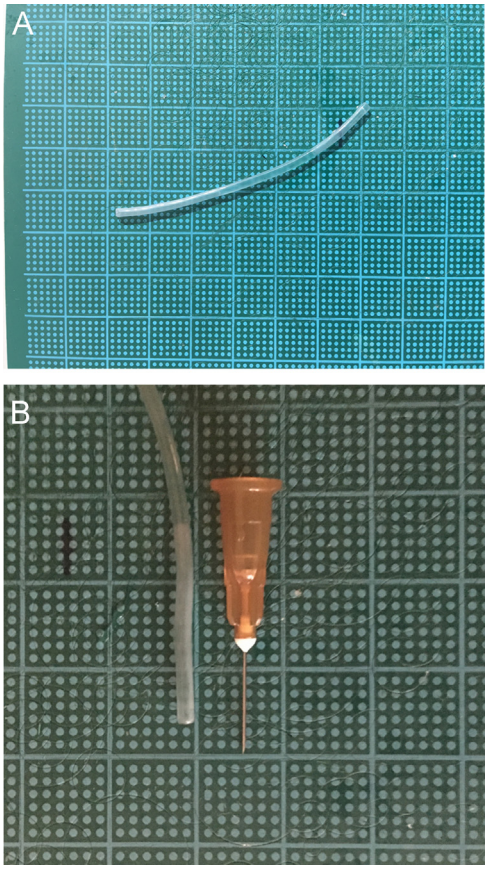

FIGURE. (A) PVA gelatin tube: 1 square is 1 cm^2. (B) The needle is a 26G × ½ (0.45 × 13 mm^2).

TABLE 1. Number of Trainees in Different Specialty

Specialty/Surgeons	Number of Trainees
Orthopedic	18
Plastic surgery	14
Veterinary	11
Ear, nose, and throat	5
Maxillofacial	9
Others	14
Total	71

The cost of production (Sigma Aldrich products) is 0.312 euros per cm of tube. These tubes are not currently commercially available and were developed (not with an industrial process) only for research purpose for small vessels replacement.

Similarly, the corresponding outer and inner diameters of silicone tubes (Silastic, Dow Corning, Laboratory tubing Midland, MI) were 1.97 and 1.47 mm with a wall thickness of 0.23 mm for a cost of 0.0516 euros.

Training

Study subjects were residents enrolled in the basic, 3-day (20 hours) microsurgery course conducted at the School of Surgery of Paris (University Pierre et Marie Curie). The curriculum was as follows:

(1) *Day 1*: Theoretical lessons and introduction to synthetic tube models (PVA or silicone). Anastomoses were performed using 9/0 or 10/0 nylon sutures.
(2) *Day 2*: Synthetic model (morning) and living model (afternoon).
(3) *Day 3*: Living model (rat).

Microvascular anastomoses were performed on the rat's carotid artery (CA) and abdominal aorta (AA) with a maximum of 2 tries per vessel. Sex, smoking status, age, clinical experience, and surgical specialties of each enrolled resident was also recorded (Table 1).

Animals

All animal experiments were performed at the School of Surgery of Paris (University Pierre et Marie Curie), with institutional approval. All male adult wistar rats (225-360 g) used were housed in a climate-controlled facility with water and pellet food provided ad libitum. Before surgery, anesthesia was administered intraperitoneally with ketamine (75-95 mg/kg) and xylazine (5-8 mg/kg).

Evaluation

Subjects were blinded and randomized into 2 study groups: PVA (P) or silicone (S). Subjects were randomly selected from each group in each course and recorded through a