A Unique Lymphaticovenous Supermicrosurgery Training Curriculum: Reflections on Validation and Competency Thresholds

Georgios Pafitanis, MD*
Mitsunaga Narushima, MD†
Mitsunobu Harima, MD†
Ali Ghanem, MRCS, PhD*
Simon Myers, PhD, FRCS*
Isao Koshima, MD†

Summary: Supermicrosurgery is becoming a commonly used technique in various subspecialties of reconstructive surgery. However, there is a lack of standardization and validation in novel supermicrosurgical training. Current simulation training programs are not adequately focused on the challenges encountered during clinical supermicrosurgery practice. This article describes the authors' experience utilizing a supermicrosurgery competency-based training curriculum, in a simulation-based environment, toward safe clinical practice for lymphatic submillimeter supermicrovascular surgery. This article demonstrates the senior authors' (I.K.) Halstedian competency-based curriculum for lymphaticovenous anastomosis training. Further, a step-by-step training utilizing the chicken thigh and the living rat high fidelity simulation models, which subsequently allows supervised one-to-one clinical training with verified clinical competency outcomes, are demonstrated. *(Plast Reconstr Surg Glob Open 2017;5:e1382; doi: 10.1097/GOX.0000000000001392; Published online 23 June 2017.)*

Halsted first demonstrated the importance of the apprenticeship model training in surgery.[1] In microsurgery, hands-on work-based training opportunities exist and aim to achieve microsurgery competencies. There is a lack of standardization and validation in novel supermicrosurgical (SM) training. With the emergence of SM in the field of lymphatic surgery, hand surgery, perforator-to-perforator flaps, it is necessary to prepare surgeons outside the operative theater by means of simulation training as SM requires finer skill set and specialized equipment not encountered in conventional microsurgery training.[2]

In our experience, microvascular anastomosis in vessels below 0.8 mm of calibers are technically different from those performed on 1 mm or larger vessels. Small caliber vessels microvascular techniques are often performed in challenging circumstances; forceps and conventional dilators are usually not suitable for dilatation and/or intra-lumen cannulation in such small vessels. Therefore, completing an end-to-end anastomosis without inadvertently catching the back wall would require training to reach high level of technical precision.[3] Several microsurgery models for submillimeter training exist and novel simulation models aiming at SM specific skills acquisition on vessels of 0.3–0.8 mm have already been described.[4] These models are often directed to practitioners who are already expert microsurgeons intending to expand their practice in SM-relevant applications. This article describes the authors' experience utilizing an SM competency-based training curriculum, in a hybrid Halstedian/simulation-based environment, toward safe clinical practice for lymphatic submillimeter microsurgery.

Since Koshima et al.[2] first described SM, advancements in instrumentation and microscopes have evolved to enable submillimeter microsurgery.[5] Our experience with a structured SM training demonstrates a clinically applicable platform for future microsurgeons. The relevant SM models described are utilized to enable lymphaticovenous (LVA)–specific SM skill acquisition.[4,6,7] We believe that such a step-by-step approach of SM training should be completed during clinical residency programs to prepare future microsurgeons in SM.

The proposed LVA training curriculum combines high fidelity biological nonliving and living models, each aiming to test and transfer specific skill set along the SM learning curve. A novice microsurgeon starts with deliberate practice sessions and progress in smaller caliber vessels dissection and anastomosis on the chicken thigh model. This takes the trainees from vessels in excess of 2 mm toward 0.5 mm.

*From the *Academic Plastic Surgery Group, Queen Mary University of London, The Royal London Hospital, Barts Health NHS Trust, London, United Kingdom; and †Department of Plastic and Reconstructive Surgery, Tokyo University, School of Medicine, Tokyo, Japan.*

Received for publication March 20, 2017; accepted May 5, 2017.

DOI: 10.1097/GOX.0000000000001392

Disclosure: *The authors have no financial interest to declare in relation to the content of this article. The Article Processing Charge was paid for by the authors.*

After reaching this standard, which depends on trainees' motivation and skill progression, trainees then proceed to perform anastomosis on the femoral artery and vein of living rats (1 mm). This step is necessary to ensure respect of the principles of 3Rs.[8] A competency level of 100% patency of 5 consecutive anastomoses is required to proceed to the following step. Then, anastomosis on reduced vessels' diameter (< 0.5 mm) exercises are commenced using the rat inferior epigastric pedicle-free flap model as described by Yamashita et al.,[6] to achieve 5 successful patent anastomoses. These 3 sets of exercises rely on self-motivation and self-assessment of skill progression; therefore, the time required and overall number of anastomoses necessary to reach competency varies between trainees. All trainees during this curriculum practice SM techniques used in LVA clinical practice such as microdissection, adventitia trimming, end-to-end anastomosis using 11–13/0 suture with 50–80 micrometers needle, intravascular stenting, and learn ways to avoid vessel manipulation during microvascular intervention to minimize damage. In our experience, it is self-motivation and commitment to deliberate practice what decides the duration of simulation training necessary to achieve success in SM. This curriculum, which has been running for more than 10 years, facilitated transition without frustration from the simulation training laboratory to supervised lymphatic SM in the operating room. Self-motivation and commitment to deliberate practice play fundamental role for training in challenging conditions, such as small caliber vessels with thin wall. Weekly exposure to theatre-based LVA procedures offers further valuable trainer-role model learning sessions and the opportunity to assist in clinical SM. The final (fifth) rat inferior epigastric free groin flap is supervised by an expert supermicrosurgeon and acts as an exit competency level confirmation test measured against both anastomosis patency and subsequent 5-day flap survival. The duration of training period varies for junior microsurgeons and it has been validated by exposing trainees to clinical LVA procedures. The limitation of the current protocol lies to the evaluation of outcomes across the learning curve. Objective assessment methodologies for the technique to perform each task, such as global rating scales and hand motion analysis and end-product assessment of the final outcome, could enhance the efficiency of skill acquisition by providing constructive feedback to the trainee-mentor. Surgeons who completed all 3 steps successfully perform clinical LVA anastomosis,[7] initially supervised and further solo establishing successful results via indocyanine green patency testing.

Our experience with LVA training provides evidence that specific skill sets apply to this field of microvascular anastomosis. By addressing certain aspects of clinical challenges and applying competency-thresholds in a low-risk simulated environment, we direct training-based specific curriculum to aiming clinical competency needed for successful LVA SM. Onoda et al. demonstrated that failure of LVA is principally related to endothelial layer alignment, which leads to exposure of subendothelial layers and is directly related to technical errors.[10] The chicken thigh submillimeter vessels and the rat inferior epigastric vein vessel wall demonstrate structural similarities to human lymphatic ducts in wall thickness, elastic texture, and challenging cannulation.[9] Starting from small caliber chicken vessels dissection and anastomosis, applies the principles of 3Rs and enhances precision before the living model training stage.

There is a need for microsurgery specific skill set classification to guide competency-based training. Fellowship programs without hands-on training may incorporate adjunct simulation training components to achieve certain technical competencies. Current SM simulation training lacks validation and standardization; therefore, the existing curriculum combined with objective assessment methodologies could provide the core curriculum for LVA microvascular training.

A standardized competency-based curriculum for LVA SM offers benefits to the next generation of microsurgeons.[10] Our experience demonstrated that self-motivation levels and direct opportunity to be involved in clinical LVA can enhance training. The LVA SM curriculum in conjunction with current objective assessment validated tools could form the platform for a competency-based standardize simulation SM training and produce safe clinical practitioners for the art of submillimeter microsurgery.

Georgios Pafitanis, MD
Academic Plastic Surgery Unit
Queen Mary University of London
The Royal London Hospital
Barts Health NHS Trust
4 Newark Street
Whitechapel, E12AT
London
United Kingdom
E-mail: g.pafitanis@qmul.ac.uk

REFERENCES

1. McClure RD. The Halsted School of Surgery. *Alexander Blain Hosp Bull*. 1947;6:31–39.
2. Masia J, Olivares L, Koshima I, et al. Barcelona consensus on supermicrosurgery. *J Reconstr Microsurg*. 2013.
3. Yamamoto T, Yamashita M, Furuya M, et al. Mono-canalization of adhered lymphatic vessels for lymphatic supermicrosurgery. *J Plast Reconstr Aesthet Surg*. 2014;67:e291–e292.
4. Suami H, Schaverien MV. Swine hind limb model for supermicrosurgical lymphaticovenular anastomosis training. *J Plast Reconstr Aesthet Surg*. 2016;69:723–725.
5. Koshima I. Microsurgery in the future: introduction to supra- microsurgery and perforator flaps. First International Course on Perforator Flap and Arterialized Skin Flaps; 1997; published online June 13.
6. Yamashita S, Sugiyama N, Hasegawa K, et al. A novel model for supermicrosurgery training: the superficial inferior epigastric artery flap in rats. *J Reconstr Microsurg*. 2008;24:537–543.
7. Cifuentes IJ, Rodriguez JR, Yañez RA, et al. A novel ex vivo training model for acquiring supermicrosurgical skills using a chicken leg. *J Reconstr Microsurg*. 2016;32:699–705.
8. Schöffl H, Froschauer SM, Dunst KM, et al. Strategies for the reduction of live animal use in microsurgical training and education. *Altern Lab Anim*. 2008;36:153–160.
9. Kotsis SV, Chung KC. Application of the "see one, do one, teach one" concept in surgical training. *Plast Reconstr Surg*. 2013;131:1194–1201.
10. Onoda S, Kimata Y, Matsumoto K, et al. Histologic evaluation of lymphaticovenular anastomosis outcomes in the rat experimental model: comparison of cases with patency and obstruction. *Plast Reconstr Surg*. 2016;137:83e–91e.