https://doi.org/10.52581/1814-1471/76/11
УДК 617-089:57.086.86]:378.014.5.091.3:001.895(83)

INNOVATIONS IN MICROSURGERY TRAINING FROM CHILE

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Ignacio Cifuentes, MD, is a young plastic surgeon from Chile with high interest in microsurgical simulation and training. This paper summarizes some of the work in which the author has collaborated during his plastic surgery residency under the supervision of Bruno Dagnino, MD, as well as some interesting articles regarding microsurgical education in Chile. Francisca Leon, MD, is a microsurgeon and plastic surgeon from Chile with great interest in lower limb reconstruction who collaborated with the development of this review.

Keywords: *Microsurgery, education, innovation.*

Conflict of interest: the authors declare the absence of obvious and potential conflicts of interest related to the publication of this paper.

Financial disclosure: no author has a financial or property interest in any material or method metioned.

For citation: Cifuentes I.J., Leon F. Innovations in microsurgery training from Chile. *Issues of Reconstructive and Plastic Surgery.* 2021;24(1):92–96. doi: 10.52581/1814-1471/76/11

ИННОВАЦИИ В ОБУЧЕНИИ МИКРОХИРУРГИИ ИЗ ЧИЛИ

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Игнасио Сифуэнтес, MD, молодой пластический хирург из Чили, проявляющий большой интерес к моделированию и обучению микрохирургии. В статье приводятся некоторые работы, написанные им в соавторстве во время резидентуры по пластической хирургии под руководством доктора медицины Бруно Дагнино, а также некоторые интересные статьи о микрохирургическом образовании в Чили. В подготовке этого обзора участвовала также Франческа Леон, MD, микрохирург и пластический хирург из Чили, проявляющая большой интерес к реконструкции нижних конечностей.

Ключевые слова: *микрохирургия, образование, инновации.*

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Для цитирования: Сифуэнтес И., Леон Ф. Инновации в обучении микрохирургии из Чили. *Вопросы реконструктивной и пластической хирургии.* 2021;24(1):92–96. doi: 10.52581/1814-1471/76/11

INTRODUCTION

Microsurgery is an essential technique as part of the armamentarium of the reconstructive surgeon. Common to many surgical subspecialties, this technique requires a magnification device in order to dissect and anastomose vascular and nerve structures.

Due to its steep learning curve, assistance to training courses have had an important growth in the last decade, being nowadays part of the plastic surgery curriculum. Creation and validation of multiple simulation models and the use of objective evaluation methods have allowed the microsurgical skill acquisition in the laboratory. These objective evaluation methods have allowed a transition from a non-structured training in which the expert evaluated the performance of the student according to his experience to a training where the skill acquisition can be quantified with validated learning scales and even some more sophisticated methods like hand movement analysis.

While medical knowledge can be obtained from books, webinars or journals, skills require a lot of training. Every skill has a learning curve and microsurgical proficiency is not the exception. The microsurgical learning curve is steep, which is why simulation by training in different living and non-living models seems to be a great the solution for this problem.

According to Malcolm Gladwell [1] you need 10,000 hours to master any skill. However, this has been challenged by Ericsson [2] exposing that repeating an activity several times doesn't create an expert, while deliberate practice does. It is necessary to acknowledge your mistakes and consciously correct them to improve and master a skill.

Since 2012, there has been a continuous growth of microsurgical training courses in Latin America. In 2016 we performed a simple narrative review of the literature by searching in PubMed the Mesh terms "Microsurgery" and "Training" from 2012 to 2016, completing our search strategy with letter sent to South American presidents of plastic surgery societies. From this review we identified 11 new training courses, which is in concordance with the need for microsurgical training in this region [3].

CHILEAN INNOVATIONS IN MICROSURGICAL TRAINING

The beginnings

We were late in the microsurgical timeline compared to the rest of the World. The first microsurgical case in Chile was done in 1979 by a surgical resident, who later published his first 4 cases [4]. He heavily prepared before in the laboratory, publishing a "New experimental model for microanastomosis between vessels of different diameter" in a rat model and a cervical esophagus reconstruction with small bowel in a dog model [5, 6].

In 2005, Andrades et al. published the first Chilean manuscript regarding how to set up a microsurgical training facility and compared different models going from the simple latex model to some non-living models like the chicken, swine limb, cow heart, human placenta and human epigastric vessels embedded in discarded abdominoplasty tissue [7]. He then concluded that the "microsurgical route" should be a progressive difficulty approach going from the latex model to the living rat.

Using learning theory and non-living models

Until 2016, microsurgical training was done mainly with rat models and without a structured form of evaluation of the microsurgical skill acquisition. The "Halstedian" concept of see one, do one, teach one, combined by a non-structured evaluation of the expert was challenged [8].

Some years earlier, a lot of importance was given on how to objectively assess the microsurgical skill acquisition and many OSATS (Objective Structured Assessment of Technical Skills) were developed and validated [9, 10].

More even, a hand motion analysis system, the imperial college surgical assessment device (ICSAD) had been validated as a method of objectively assess the microsurgical skill [11].

With these assessment tools, the microsurgical learning curve could be mapped [12].

Rodriguez et al. [13] redefined the way microsurgery was been taught in Chile and adapted a progressive difficulty curriculum involving simple knots in latex and vinyl models, moving on to dissection and anastomoses of 2 mm diameter arteries and veins in the chicken tight and finally reaching 1 mm diameter dissection and anastomosis of vessels in the chicken wing. After each training session, effective feedback was given by the experts using validated OSATS scales. This method was designed the same way as a workout sheet in the gym. The students could go whenever they had free time to the laboratory and practice, but in a structured fashion. He also compared how the students performed when doing their first artery anastomosis in a rat living model, and couldn't find any difference with the experts, concluding that the initial steps of the learning curve could be done in non-living models with spaced but constant training, and potentially reducing the number of rats needed.

Creating new assessments, models and going super micro

In the previously mentioned paper, the ICSAD was also used to track the learning curve by analyzing the number of movements and the total length path of both hands while doing the anastomosis. One caveat of this device is that it wasn't designed for small movements and the sensors placed in the fingertips where the size of the distal phalange making more difficult to do a microanastomosis. Cifuentes et al. [14] designed a low cost and more comfortable method of tracking the hand movement while training microsurgery by using colored rubbers in the fingertips and tracking them with a camera. This research concluded that experts made less number of movements and less length distance than non-experts, and correlated well with the level of expertise of the student assessed by the OSATS.

Flap design and dissection is also a key step while learning microsurgery. For this purpose, living rat and pig models had been described. However, there wasn't a non-living model, where one could easily train the pedicle dissection. Cifuentes et al. [15] described the first perforator flap in a chicken model using the chicken leg and studying a big and constant perforator with a long intramuscular path. This same model was later described to train supermicrosurgery, given the different diameters found in the pedicle. Arteries and veins of 0.7, 0.5 and down to 0.3 were anastomosed [16] (Fig. 1).

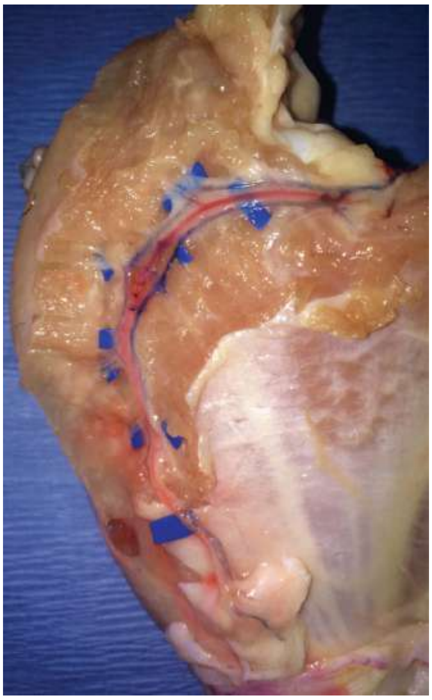

Fig. 1. Intramuscular path of the chicken leg perforator

Рис. 1. Внутримышечный путь перфоратора куриной ножки

Navia et al. [17] carefully dissected the chicken wing, updated the anatomy nomenclature and described smaller vessels. Later Rodríguez et al. [18] described the ulnar artery concomitant veins of the chicken wing for advanced supermicrosurgery training, taking advantage of the resemblance of the veins with the lymphatic vessels.

The swine leg has been described as a lymphatic vein anastomosis training model [19]. By injecting blue dye in the swine foot, the lymphatic vessels can be visualized in the medial aspect of the leg. Interestingly, there is no need for the animal to be alive, which means it can be recycled from other studies. After identifying the lymphatic vessel, a surrounding vein has to be identified in the subcutaneous tissue to perform the lymphatic venous anastomosis, which is not always easy after defrosting the leg. We have proposed an easier way to recycle the limb by taking only the subcutaneous tissue of the leg after the dye injection and harvesting at the same time an inguinal lymph node. The lymph node has veins of multiple diameters, which can be anastomosed to the previously identified lymph vessels in any configuration desired (Fig. 2).

Fig. 2. Subcutaneous tissue of the swine leg with the lymph node and lymphatic vessels

Рис. 2. Подкожная клетчатка ноги свиньи с лимфатическим узлом и лимфатическими сосудами

Moving along with the times

Contemporary microsurgical education supposes the physical presence of an instructor or expert in the laboratory, giving effective feedback after each training exercise. That is to say, correcting the student's errors immediately.

Because of this, the majority of the courses are limited by a maximum number of students per instructor, geographic accessibility due to the lack of experts in the area and the difficulties that suppose their presence in every training.

The distance-based learning or e-learning in the surgical education has been growing in the last decade and potentially allowing students to acquire skills without the physical presence of an instructor.

Cifuentes I.J. et al. [20] described the feasibility of microsurgical skill acquisition using an online platform. The students were exposed to a webpage where progressive difficulty training sessions where explained, starting from basic latex models to the chicken wing. Feedback was done asynchronously by the expert after each session analyzing a video recorded by the student using a camera connected to the microscope and creating a second video in which errors and pitfalls where discussed (Fig. 3 and 4). By the end of training, most students were able to do a 1mm artery anastomosis. Over a one-month period, 6 medical students without any surgical experience, were trained by just one instructor, who employed 6.7 hours in total in doing feedback. In this way, a greater instructor to student ratio could be achieved, optimizing the paucity of teachers in our geographic area and making over the sea instruction possible.

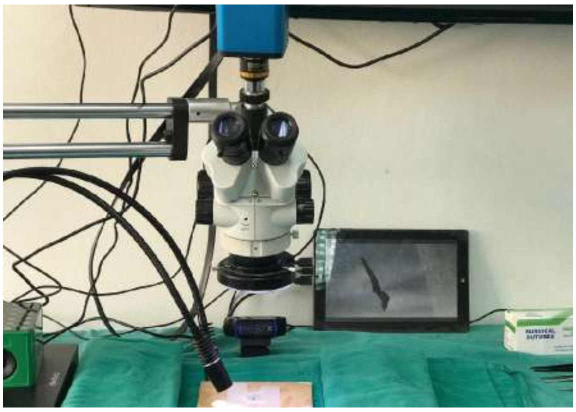

Fig. 3. E-learning Laboratory set up. Microscope with cameras

Рис. 3. Создание лаборатории электронного обучения. Микроскоп с камерами

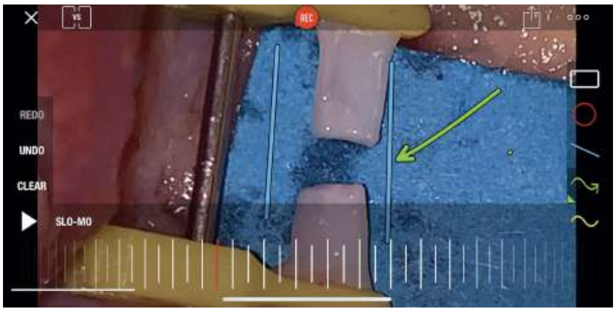

Fig. 4. Snapshot of a video feedback assessing a microvascular anastomosis

Рис. 4. Снимок видео обратной связи, оценивающий микрососудистый анастомоз

Even more, because of the COVID-19 pandemic there has been a shift towards a home-office environment. In the same manner, a modification of the previous model has been suggested in collaboration with Dr. Yelena Akelina, a prestigious international microsurgical instructor from the Columbia University, where a home-based approach using loupes as magnification and the smartphone as the recording device could be employed. Feedback could be done asynchronously with video recordings or synchronously using online platforms as Zoom (Fig. 5).

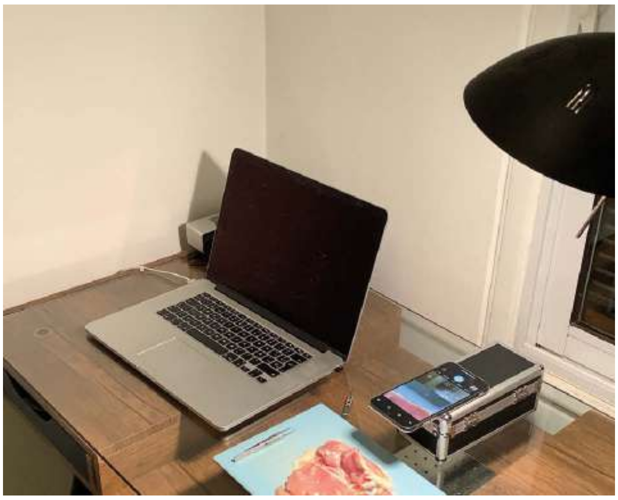

Fig. 5. Home setup for microsurgery training

Рис. 5. Домашняя установка для обучения микрохирургии

In the future, we expect that these technologies could make microsurgical training more accessible to everyone, eliminating geographical barriers and improving patient care all over the globe.

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Поступила в редакцию 14.12.2020, утверждена к печати 18.02.2021
Received 14.12.2020, accepted for publication 18.02.2021

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