https://doi.org/10.52581/1814-1471/76/12
УДК 617-089:57.086.86]:378.014.5.091.3(460)

MICROSURGERY EDUCATION IN SPAIN

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Prior to microsurgery practice on patients, microsurgical skills should be learned in a simulated and controlled environment to increase success rates and reduce surgical complications. These favorable environments have historically been the microsurgery laboratories. The use of the experimental animals has allowed surgical trainees to interact with anatomical structures and physiological processes that a microsurgeon has to face in daily clinical scenarios. In recent decades, there has been an increase in simulation methods to reduce the number of animals used for training purposes and thus meet animal welfare criteria.

Spain has a long history in the practice and teaching of microsurgery, this manuscript aims to highlight the importance of first educators, as well as to evaluate the current situation and future perspectives.

Keywords: *Microsurgery, training, education, Spain, simulation, anastomosis, assessment.*

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: Ballestín A., Cuadros M. Microsurgery education in Spain. *Issues of Reconstructive and Plastic Surgery*. 2021;24(1)97–102. doi: 10.52581/1814-1471/76/12

ОБРАЗОВАНИЕ В ОБЛАСТИ МИКРОХИРУРГИИ В ИСПАНИИ

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Прежде чем приступить к микрохирургической практике на пациентах, хирургу необходимо получить микрохирургические навыки в смоделированной и контролируемой среде, чтобы повысить вероятность успеха оперативного лечения и снизить риск хирургических осложнений. Благоприятные условия для этого исторически формировались в лабораториях микрохирургии. Использование экспериментальных животных позволило хирургам-стажерам изучать анатомические структуры и физиологические процессы, с которыми микрохирург сталкивается в повседневной клинической практике. В последние десятилетия увеличилось количество методов моделирования, что позволило сократить количество используемых в учебных целях животных.

Испания имеет долгую историю практики и преподавания микрохирургии. Данная статья призвана подчеркнуть роль первых преподавателей микрохирургии, а также оценить текущую ситуацию в этой сфере и ее перспективы.

Ключевые слова: *микрохирургия, обучение, образование, Испания, моделирование, анастомоз, оценка.*

Конфликт интересов: авторы подтверждают отсутствие конфликта интересов, о котором необходимо сообщить.

Прозрачность финансовой деятельности: никто из авторов не имеет финансовой заинтересованности в представленных материалах или методах.

Для цитирования: Баллестин А., Куадрос М. Образование в области микрохирургии в Испании. *Вопросы реконструктивной и пластической хирургии*. 2021;24(1):97–102. doi: 10.52581/1814-1471/76/12

INTRODUCTION

The downing of microsurgery era is preceded by several events historically located in the first half of the 20th century. In 1902 Alexis Carrel was able to perfor end-to-end vascular anastomosis using his triangulation method [1]. This would be a great advance for vascular surgery as well as for organ transplantation. Thanks to this advance, he was awarded the Nobel Prize in 1912. In 1921, the otolaryngologist Nylen introduced the microscope for the first time in the surgical field, using it in a chronic otitis media surgery procedure [2]. These advances, together with the isolation of heparin and its clinical use as an anticoagulant (Jay McLean and Henry Howell) [3], would lay the necessary foundations for Julius H. Jacobson and Ernesto L. Suárez to perform the first vascular anastomoses with the use of a surgical microscope in vessels with a diameter of 1 mm [4].

The beginning of vascular microsurgery opened up new horizons in reconstructive surgery by enabling the practice of free microvascularized transfer of different tissues. A significant number of surgeons began to develop techniques that would allow the first successes in reimplantation of amputated limbs [5]. During this period, Harry J. Buncke, one of the fathers of microsurgery, conducted innovative studies on replantation and tissue transplantation in animals and developed many of the principles of this discipline [6].

Since then until today, a multitude of techniques have been described and are used in countless procedures (replantation, neurosurgery, limb reconstruction, head and neck surgery, breast reconstruction, peripheral nerve surgery, lymphedema, transplantation, etc.). Microsurgery has ostensibly improved the treatment of patients affected by a wide range of defects and pathologies.

HISTORY OF MICROSURGERY IN SPAIN

In Spain, microsurgical techniques began to be performed in the 1950s by the ophthalmologist Dr. Ignacio Barraquer in Barcelona and by Dr. Antolí Candela in Madrid in the field of ear, nose, and throat surgery.

Following in the footsteps of great names such as Julius H. Jacobson or Harry Buncke, reconstructive microsurgery began in Spain in the 1970s. The peripheral nerve unit of Dr. Santos Palazzi was created in Barcelona, where in 1972 was performed the first surgery of an adult brachial plexus in Spain, and later in 1979 the first brachial plexus in a child. In 1978 Dr. Carmen Pena, in Oviedo, performed the first digital replantation in a girl, and in 1979 the first hand replantation in an adult man. In the same year, the first free flaps were performed by Dr. Nava Pechero, as well as by Dr. Serra and Dr. Ramón Vila. In 1981, the first toe-to-hand transfers were operated by Dr. Vila Rovira. And in 1982 the first vascularized fibular flap by Dr. González del Pino.

The first microsurgery course was carried out at the University of Navarra by doctors J.M. Cañadell, H. Ayala, and H. Millesi.

In the 70s and 80s in Barcelona, thanks to Santos Palazzi, microsurgery was taught with the essential collaboration of big professors such as Gilbert, Narakas, Merle, Morelli and Raimondi among others. In those same decades, in Madrid, Professors Scheker, Chen Zon Wuein and Kleinert were some of the foreign professors who collaborate with national surgeons such as Dr. Monereo Alonso and Dr. Diaz Pardo.

Dr. Eduardo Nava Pechero was possibly the most important figure in the field of experimental microsurgery teaching in Spain. Nava Pechero trained an important group of surgeons who would lead these techniques in different regions of the country in the following years.

Dr. Eduardo Nava Pechero, pioneer in the teaching of experimental Microsurgery in Spain

Доктор Эдуардо Нава Печеро, пионер преподавания экспериментальной микрохирургии в Испании

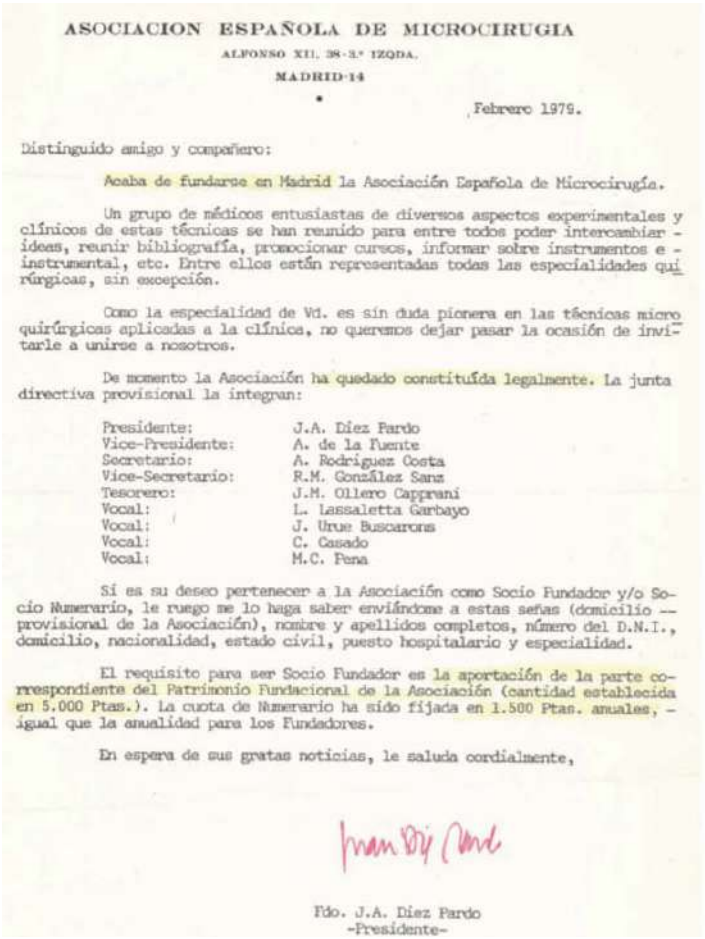
The training was given at the Virgen de la Luz Hospital in Cuenca, but also at a nearby rural location called "El Terminillo". There, with few technical resources, Dr. Nava Pechero taught vascular microsurgery and limb replantation techniques in rats, rabbits and dogs. Today the quality standards for teaching are higher and the legislation to be followed in terms of animal welfare is much more restrictive and necessary, but at that time it was a primary push for the teaching of the main surgical techniques with the use of microscopy.

It is important to highlight the efforts of some illustrious surgeons and reference centers that were essential in the early days of microsurgery teaching in Spain: Dr. Joan Pi Folguera, Sabadell; Dr. Gracía Julve and Dr. Pedro Marquina, MAZ Hospital, Zaragoza; Mrs. Marisa Sanz, Experimental Surgery, Gregorio Marañón Hospital; Dr. César Casado, Burgos; Dr. Carlos Vaquero, Valladolid; the group of Dr. Jesús Usón, Veterinary Medicine, Extremadura University, Cáceres; Dr. Gutiérrez de la Cámara, A Coruña; Dr. Carlos Irisarri and Dr. José Luis Haro, Madrid; etc.

SPANISH ASSOCIATION FOR MICROSURGERY (AEM)

In February 1979, the "Asociación Española de Microcirugía" (AEM, Spanish Association for Microsurgery) was founded. The association was constituted by the following surgeons: Juan Antonio Díaz Pardo (President), Antonio De la Fuente (Vice President), Antonio Rodríguez Costa (Secretary), R.M. González Sanz (Vice Secretary), J.M. Ollero Caproni (Treasurer) and as board members doctors Lasaleta Garbayo, Urueta Buscaons, César Casado and Carmen Pena.

The presidents of the AEM society to date have been the following: Juan Díaz Pardo, Antonio de la Fuente González, Santos Palazzi Coll, Enrique Jáureguizar Monereo, Higinio Ayala, J. A. Gutiérrez Díez, Gustavo García Julve, Juan Gonzalez del Pino, José María Serra Renom, María Luisa Sanz, Joan Pi Folguera, Miguel Cuadros Romero, Pedro Marquina Solá, Salvador Fernandez, Javier López de Alaya, Gabino de Diego Aranda, Carlos Puente, J. M. Rodríguez Vegas, Daniel Camporro, Miguel Ángel Toledo and currently José María Lasso Vázquez.



ASOCIACION ESPAÑOLA DE MICROCIRUGIA

ALFONSO XII, 38-3.º IZQDA.

MADRID-14

Febrero 1979.

Distinguido amigo y compañero:

Acaba de fundarse en Madrid la Asociación Española de Microcirugía.

Un grupo de médicos entusiastas de diversos aspectos experimentales y clínicos de estas técnicas se han reunido para entre todos poder intercambiar - ideas, reunir bibliografía, promocionar cursos, informar sobre instrumentos e - instrumental, etc. Entre ellos están representadas todas las especialidades quirúrgicas, sin excepción.

Como la especialidad de Vd. es sin duda pionera en las técnicas micro quirúrgicas aplicadas a la clínica, no queremos dejar pasar la ocasión de invitarle a unirse a nosotros.

De momento la Asociación ha quedado constituída legalmente. La junta directiva provisional la integran:

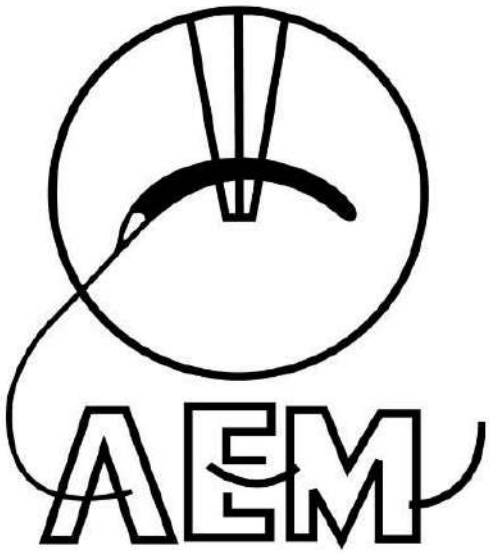
Presidente:	J.A. Díez Pardo
Vice-Presidente:	A. de la Fuente
Secretario:	A. Rodríguez Costa
Vice-Secretario:	R.M. González Sanz
Tesorero:	J.M. Ollero Capprani
Vocal:	L. Lassaletta Garbayo
Vocal:	J. Urue Buscarons
Vocal:	C. Casado
Vocal:	M.C. Pena

Si es su deseo pertenecer a la Asociación como Socio Fundador y/o Socio Numerario, le ruego me lo haga saber enviándome a estas señas (domicilio -- provisional de la Asociación), nombre y apellidos completos, número del D.N.I., domicilio, nacionalidad, estado civil, puesto hospitalario y especialidad.

El requisito para ser Socio Fundador es la aportación de la parte correspondiente del Patrimonio Fundacional de la Asociación (cantidad establecida en 5.000 Ptas.). La cuota de Numerario ha sido fijada en 1.500 Ptas. anuales, - igual que la anualidad para los Fundadores.

En espera de sus gratas noticias, le saluda cordialmente,

Fdo. J.A. Díez Pardo
-Presidente-



Historical foundation record of the Spanish Association for Microsurgery (Asociación Española de Microcirugía) (left). Logo of the Spanish Association for Microsurgery (right).

Документ об организации (слева) и логотип (справа) Испанской ассоциации микрохирургии (Asociación Española de Microcirugía)

TRAINING PROGRAMS AND METHODS

During last decades, the demand for microsurgical training has increased, as well as the centers that carry out this training in Spain: Jesús Usón Minimally Invasive Surgery Center (Cáceres), Francisco de Vitoria University (Madrid), La Paz University Hospital (Madrid), Clinical University Hospital (Zaragoza), University of León (León), Technological Training Center (A Coruña), Burgos University Hospital (Burgos), IAVANTE (Granada), Parc Taulí Hospital (Sabadell), Experimentation and Simulation Center (Orense), University Hospital of Asturias (Oviedo), Antequera Hospital Center - IACE (Málaga), Germans Trias i Pujol University Hospital (Badalona), etc.

Some of the educational programs led from Spain are today international references in microsurgical training. The "Reconstructive Microsurgery European School", an initiative from Sant Pau Hospital (Barcelona), has a global impact since hundreds of microsurgeons worldwide have been trained in these courses, which several of them have been organized at the Jesús Usón Minimally Invasive Surgery Center in Cáceres, a state-of-the-art training facility.

Educational programs differ among institutions. Most of them use the rat as the experimental animal for training. However, there are many courses that start with exercises in synthetic tissues like cardboard sheets [7] or synthetic tubes [8], or with the use of inert organic materials such as chicken tight or chicken wing [9].

Courses differ on teaching methods but also in microscopy and instruments, as well as the ratio between teachers and students. There was a need to standardize this courses and to set the minimum requirements for training. In this sense, the International Microsurgery Simulation Society (IMSS) was created and has connected together the main international specialists and educators worldwide in microsurgery education. The IMSS has recently published a consensus article where it sets main recommendations for organizing microsurgery courses [10] which may help to refine the methodologies of these teaching courses.

MICROSURGICAL TECHNIQUES ASSESSMENT

The objective evaluation of microsurgical techniques is gaining increasing interest in recent years. Objective assessment of procedures and surgical skills are obtaining relevance in accreditation processes and in training curriculums. Practicing in a controlled and validated environment can improve and advance the microsurgical learning curve [11]. Different methods have been described to evaluate procedures and skills such as specific Global Rating Scales for microsurgery [12, 13]. But also the use of technologies is important. Transit-time ultrasound allow nowadays to quantify and predict the results of microsurgical procedures, if a set of recommended minimum thresholds related to blood flowmetry are followed [14].

SUPERMICROSURGERY AND ROBOTIC MICROSURGERY

The exponential increase of microsurgery practice has led to the improvement of microscopes, the refinement of instruments, the development of smaller suture materials, as well as the creation of needles of 30 microns, to facilitate precise supermicrosurgical procedures [15]. Supermicrosurgery is the surgical technique that allows the performance of microneurovascular anastomoses of submillimetric vessels and nerves, between 0.3 and 0.8 mm diameter [16]. These techniques have revolutionized the treatment of lymphedema, but also have allowed the performance of more distal digital replantations, and have facilitated the design of perforator-to-perforator flaps expanding the possibilities of the microsurgical armamentarium [17].

Therefore, the industry has focused its efforts on reducing surgeon tremor and improving surgical precision. Europe is currently leading the research and development of the main surgical robots in the field of reconstructive microsurgery with two different systems: MUSA (MicroSure, Eindhoven, The Netherlands) and Symani Surgical System (MMI, Italy). Part of the preclinical studies performed for MMI's Symani development have been carried out at the Jesús Usón Minimally Invasive Surgery Center (Cáceres, Spain). This robotic system offers the surgeon wrist microinstruments and provides movement scaling and tremor reduction to perform precise supermicro-movements.

In relation to robotic microsurgery teaching, new simulators and specific models are being developed for training. But some of the models already described for reconstructive microsurgery training and research [18–22] are also useful, especially those based on the rat epigastric skin free flap (groin flap) in rats. This flap is perfused by the caudal epigastric artery (0.35 mm diameter) and the caudal epigastric vein (0.70 mm diameter), thus, it is a good model in which to perform suprermicrosurgical anastomoses with 11/0 and 12/0 sutures.

FUTURE IN MICROSURGERY EDUCATION

Microsurgery as well as surgery training is undergoing a rapid transformation due to several

factors. The main change is related to the training models used. The increasing requirements for the use of animals are reducing *in vivo* training methods in many countries, while in some it is not even possible anymore. Furthermore, the emergence of new simulators and improving virtual technologies may represent an easy, cost-effective and portable way of learning microsurgery. And in addition, the current COVID-19 pandemic has accentuated the needs for distance training.

This already changing landscape of microsurgical training will bring new opportunities to young surgeons who will benefit from optimized educational curriculums through accurate objective assessment of skills and new simulator set-ups for rapid and effective learning of microsurgical and supermicrosurgical techniques.

ACKNOWLEDGMENTS

The authors acknowledge support and data sharing from Dr. Daniel Camporro, Dr. Jesús Usón Casaús, Dr. Pedro Marquina, Dr. José María Lasso, Ms. Marisa Sanz and Dr. Santos Palazzi. Authors also appreciate the comments and friendly discussion of this manuscript with the current Board of Directors of the Spanish Association for Microsurgery.

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Поступила в редакцию 22.12.2020, утверждена к печати 18.02.2021
Received 22.12.2020, accepted for publication 18.02.2021

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