



Original Article

Building a microneurosurgical laboratory in Latin America: challenges and possibilities

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ABSTRACT

Background: Training in microsurgical neuroanatomy is a priority for neurosurgical education. During the 20th century, microsurgical laboratories arose and provided a way to develop surgical skills. Few reports addressed the assembly, construction, and details of a training laboratory.

Methods: We have conducted a literature review and searched legislation on the need to plan the structure of the laboratory.

Results: We projected and built a laboratory through a public-private partnership. High-tech workstations and instruments were planned to meet the needs of residents, fellows, and student. All steps and materials were in accordance with the Brazilian legislation and articles previously selected.

Conclusion: We described our experience and demonstrated the implementation of a micro neurosurgical skills laboratory.

Keywords: Laboratory training, Microsurgical techniques, Neuroanatomy, Neurosurgical education

INTRODUCTION

The study of anatomy has always been in the foundation classes of modern medical schools,^[15] and the teaching of neurosurgery cannot be outside this context. The introduction of anatomy as a key subject in medical education is important so that students can perform a safe surgery and achieve good outcomes. This process also occurs in the neurosurgical field. The introduction of the microscope by Theodore Kurze in 1957 was the first step in the development of the concept of microsurgical neuroanatomy.^[8] Establishing an appropriate place for neurosurgeons and residents training in neurosurgery is a priority for neurosurgical education. With the development of surgical microscopes, neurosurgery has evolved, leading to the need for appropriate training.

During the second half of the 20th century, micro neurosurgical laboratories arose, and the laboratory of the University of Florida, headed by the iconic Professor Albert Rhoton, was the most highlighted in terms of medical publications.^[10] In Brazil, the laboratory of Professor Evandro de Oliveira, located at the Hospital Beneficência Portuguesa de São Paulo, is another laboratory which provides a successful way to develop microsurgical skills. It is of great importance in Latin

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America and is involved in training many neurosurgeons and producing a great number of important scientific papers.

Funding, planning, and expertise are the main challenges in the construction of a laboratory, however, few studies have addressed the assembly, construction, and details of a training laboratory. Thus, we will describe our experience building a micro neurosurgical skills laboratory in Latin America.

MATERIALS AND METHODS

We have conducted a literature review of the MEDLINE and SCIELO databases with the keywords “surgical training,” “surgical simulator,” “microneurosurgical anatomy,” “neurosurgical training,” “surgical technique laboratory,” and “neurosurgical laboratory.” The articles of these categories were chosen based on the need to plan the structure of the laboratory.

The legislation to obtain the specimens was searched on Brazil government websites with the keywords “use of cadaver for training,” “cadaver for learning,” “technical standards for laboratories of training,” and “legislation about surgical training.”

After the literature review, we described our experience and lessons learned building a microsurgical skills laboratory at our institution.

RESULTS

Laboratory training

The microsurgical technique became the cornerstone of modern neurosurgery. Kshetry *et al.* studied the prevalence of these training laboratories and found that more than 90% of the residence programs teach anatomical dissections.^[9] Zammar *et al.* evaluated residents during a course of vascular anastomosis performed in a microsurgical laboratory and obtained an improvement of 46–56% ($P = 0.001$) in the Northwestern Objective Microanastomosis Assessment Tool score.^[17] Hagen *et al.* studied the perception and actions of residents of general surgery and demonstrated that those residents who had been trained in a laboratory had a high confidence in their daily professional activities.^[6]

In the economic findings, there are important features that are not recognized and studied for a cost-benefit analysis. Scott *et al.* compared the training costs for residents of general surgery and found that surgical simulators decreased costs and improved surgical skills, which brought the need to use these educational tools while teaching.^[14]

Every construction in public spaces, such as the Federal University of São Paulo, has specific standards for inspection and execution and is standardized by public regulation

organs in the following steps: (1) a preliminary phase before bidding; (2) an internal phase of bidding; (3) an external phase of bidding; (4) a contractual phase; and (5) a posterior phase after contract.^[16]

Recently, with the new Federal Brazilian law of 2017, public-private partnerships have become flexible and favor public universities.^[3] According to Salma *et al.*, the use of refurbished and no longer usable instruments in the operating room made possible the destination of these materials to a laboratory.^[13]

Workstations and instruments

Based on the requirements previously cited, such as those of structure and law, the laboratory was projected and the layout of the building was constructed. The space was designed with two main entrances, independently, and one access was constructed between the two parts of the laboratory. The instructor’s workstation was in the central part of the laboratory and students could follow the transmission screens. The project had 20 workstations [Figure 1] according to the large space available. Salma *et al.* state the laboratory should have a minimum of 36×39 ft and two workstations.^[13]

In terms of permanent laboratory items, we projected the workstations with materials authorized by the National Health Surveillance Regulatory Agency to allow adequate cleaning.^[7] The stands were made of medium-density fiberboard. Ergonomics was also a key concern when choosing the items. Each station measures $4.69 \times 3.77 \times 2.9$ ft (length \times height \times width). The chairs have adjustable height to suit each student.

Each workstation has a bifocal microscope with fixed or adjustable distance, articulated and fixed on the stand with its lighting system. The most advanced models included light-emitting diode (LED) lighting systems. The LED lamp has good sharpness and color reproduction, focusing



Figure 1: The floor plan of the new laboratory.

on white.^[12] The project also has portable electric surgical aspirators and electric drills for maintenance and ease of use. For the surgical approach simulation program, the laboratory was conceived with four head-fix systems to improve the simulation experience [Figure 2]. Together with a private company (Macom Instrumentais), an adaptation of the stand version of its skull fixator was planned, which presented all the angles of movement necessary for the positioning of the specimen. There are other devices to hold the cadaveric head that may be useful in other scenarios where a head holder offered by a specialized company is not available, as described in the literature.^[5]

The instruments in the project were intended to provide the basic instruments necessary for the use of cranial approaches and micro-instruments for the use of microsurgical tasks. The instruments planned to meet our needs were adapted from the work of Salma *et al.*^[13] and are presented in [Table 1].

Documentation

Careful documentation of dissections performed in the laboratory is crucial. One way to do this is by taking a three-dimensional photograph. For this purpose, a digital single-lens reflex (DSLR) camera (Nikon D5600), a tripod, a two-way rail slider (FOTOMATE® LP-01), and a regular ring flash were used. The sample is placed on a black background and light contamination is avoided. This can avoid turning the laboratory lights off or the isolation of the specimen in a box with a black background.

The camera (with the ring flash and the rail slider) over the tripod, is placed in front of the specimen, at a proper distance, depending on the purpose of photography. Two photographs are taken, one from the left and one from the right, always focusing on the same spot. The side-to-



Figure 2: Lateral view of the head fix system (Macom Instrumental).

side distance is calculated after measuring the distance in centimeters from the camera to the specimen and then dividing it by 30. The pair of photographs are uploaded to a website (www.3dthis.com/buildstereo.htm), where adjustments can be made. The two main options of three-dimensional photographs are anaglyph or side-to-side pictures.

Specimens

According to the Brazilian law, for a corpse to be forwarded to an educational institution, it should be established that: it has not been claimed within 30 days or it is not identified. Even after identification, it has to be secured that is not possible to obtain information related to the addresses of relatives or legal guardians after publication in the main newspapers of the city, as a public benefit, at least 10 days after the news of the death.^[4] The law also mentioned the prohibition on the use of bodies that have died with some indication of death resulting from criminal activity. In cases of death from unnatural causes, an autopsy by competent agencies is necessary. All of these aspects cited above are difficult to study with fresh specimens.

As in the Brazilian federal law, no articles have addressed the separation of corpses into parts for specific training, such as in neurosurgery. It is used as a legal prerogative of the State of São Paulo that establishes in one of the articles the prohibition on the forwarding of cadaver parts to other educational or research institutions, so that, in case they are identified, they

Table 1: Instruments of the laboratory.

General instruments	
Scalpel with blades 11, 15, and 23	1
Mayo and Metzenbaum scissors	1
Retractor	1
Craniotome	1
High-speed drill	1
Curette	1
Rongeur	1
Bone rongeur Kerrison (1–5 mm)	1 kit
Self-retaining retractor	2
Posterior fossa retractor	2
Penfield dissector	1 kit
Surgical aspirator tip	1 kit
Kelly forceps	1 kit
Head fix	1 system
Backhaus forceps	4
Suture thread	1 kit
Needle holder	1
Micro Instruments	
Micro dissector	1
Microhook	1
Microbayonet forceps	2
Microscissors	2

do not cause inconvenience to the corpse's family.^[11] This does not preclude the importation, for example, of specimens already separated from the rest of the corpse, as the guidance makes it clear that the referral is about unclaimed corpses in Brazil.

Preparation of the specimens is another key point in providing a great anatomical dissection. Many substances can be used, with formaldehyde, alcohol, and glycerin being common, with their advantages and limitations.^[2] Due to its practicality and cost, formaldehyde has been widely used in Brazilian anatomical teaching programs.^[1] The best dissection experience for training is from freshly used specimens, that is, those with <1 week of death, with difficulty because they must be stored at a temperature of 4°C.^[13]

The technique for silicone injection is cannulation of the vessels in the neck, previously washed with saline to remove clots. Subsequently, the vessels are injected with colored silicone with adequate pressure to mark the vasculature, making multimedia records interesting and dissection a good learning experience. Some mixtures have been explored by the authors to inject into the vessel. We used an adaptation of the study of Rhoton, using a thinner-to-silicon ratio of 2:1 for arteries and 1:1 for veins.

DISCUSSION

The laboratory was built through a public-private partnership to provide materials.^[13] It became financially independent by promoting events and courses without using public resources from the university. The laboratory is located within the university campus, which can be easily accessed by neurosurgeons and residents with all the necessary infrastructure.

The Laboratory for the Development of Microneurosurgical Techniques was inaugurated on December 3, 2018, under the name of the Laboratory of Microneurosurgical Anatomy. This laboratory was installed applying all the factors described in this study. Currently, the laboratory has 20 stations, each one consisting of a stand [Figures 3 and 4] and an instruction microscope [Figure 5] with a basic instrumental box with micro and macro instruments. There is also: A station with a standard surgical instruction microscope, with a box with the same instruments cited previously; six high-definition screens for image transmission; loudspeaker systems; a visual registration system with DSLR digital camera with macro lens and ring flash with a mini studio for recording specimens; four head fix systems with adaptation for use in the stand; five electric high-speed drills; a freezer and a refrigerator to store the specimens; an air-conditioned environment, with a 24-h surveillance system and an entrance with a biometric system.



Figure 3: Training microscopes with electrical surgical vacuum pump and head fix systems (room 1).



Figure 4: Training microscopes and workstations (room 2).



Figure 5: Instructor's workstation with microscope and transmission screen.

CONCLUSION

The process of building and implementing the laboratory of micro neurosurgical techniques is essential for any neurosurgery training service to help other services globally with this difficult task for the development of microsurgical techniques.

Other neurosurgical services can study this model as an example and adapt it to their requirements, especially in countries with many bureaucratic barriers and find a way to complete this fundamental tool to improve neurosurgical techniques. Public-private partnerships are another way to obtain inputs for carrying out this project. Despite the limitations related to planning, fundraising, and implementation of this type of a project, we demonstrate the feasibility of building a world-class laboratory with all the standards and high-tech equipment.

Declaration of patient consent

Patient's consent not required as there are no patients in this study.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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