

## SPECIALIZED MICROSURGERY SIMULATION TRAINING MODELS FOR THE NEUROSURGERY RESIDENTS

D.A. Devia<sup>1</sup>, Ye. Akelina<sup>2</sup>

<sup>1</sup> Hospital Universitario San Ignacio, Pontificia Universidad Javeriana,  
Bogotá, Colombia

<sup>2</sup> Columbia University,  
New York, USA

### Abstract

**Introduction.** Microvascular training constitutes a foundational element of many highly specialized surgical fields. This manuscript describes my experience (D.A. Devia) as a neurosurgical resident during the advanced microsurgical course guided by the senior author (Ye. Akelina) at the Microsurgery Training and Research laboratory, Dept of Orthopedic Surgery, Columbia University Irving Medical Center.

**Methods.** The technical aspects of advanced vascular exercises performed in the microsurgery laboratory are reviewed and presented, accompanied by figures of each exercise accomplished.

**Conclusions.** Microsurgery vascular training is an important tool in every cerebrovascular surgeon, or any other specialty interested microvascular procedures. The experience and exercises demonstrated in this paper are extremely useful for microvascular practice and should be included in any advanced course around the world for every surgeon interested in this field.

**Keywords:** *microsurgery, training, skills, neurosurgery, training programs on the basics of microsurgery.*

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## СПЕЦИАЛИЗИРОВАННЫЕ МИКРОХИРУРГИЧЕСКИЕ СИМУЛЯЦИОННЫЕ МОДЕЛИ ДЛЯ ОБУЧЕНИЯ ОРДИНАТОРОВ ПО НЕЙРОХИРУРГИИ

Д.А. Девия<sup>1</sup>, Е. Акелина<sup>2</sup>

<sup>1</sup> Университетский госпиталь Сан-Игнасио, Папский университет Хавериана,  
Богота, Колумбия

<sup>2</sup> Колумбийский университет,  
Нью-Йорк, США

### Аннотация

**Введение.** Обучение работе с микрососудами является основополагающим элементом многих узкоспециализированных областей хирургии. В статье описывается опыт обучения резидента из нейрохирургического департамента на продвинутом курсе по микрохирургии в учебно-исследовательской лаборатории микрохирургии Департамента ортопедии Медицинского центра Ирвинга Колумбийского университета (Нью-Йорк, США).

**Методы.** Рассмотрены и представлены технические аспекты каждой манипуляции на сосудах, выполняемой в лаборатории микрохирургии.

**Заключение.** Обучение микрохирургическим навыкам является важным инструментом каждого хирурга, занимающегося лечением cerebrovasкулярных заболеваний. Опыт и упражнения, продемонстрированные в этой статье, чрезвычайно полезны для микрососудистой практики и должны быть включены в любой продвинутый курс по всему миру для каждого хирурга, специализирующегося в нейрохирургии.

- Ключевые слова:** микрохирургия, обучение, навыки, нейрохирургия, обучающие программы по основам микрохирургии.
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## INTRODUCTION

Microvascular training constitutes a foundational element of many highly specialized surgical fields, including neurosurgery, plastic surgery, orthopedic surgery, cardiac surgery, and others. There are many different models to improve microsurgery skills: non-living and living ones [1]. The golden standards living models for practicing are rat models.

Different groups have described practicing models in rat common carotid arteries (CCA), common iliac arteries (CIA), or femoral artery and vein for end-to-end (ETE), side-to-side (STS), or end-to-side (ETS) anastomosis [2–4]. This manuscript describes my experience (D.A. Devia) as a neurosurgical resident during the advanced microsurgical course guided by the senior author (Ye. Akelina) at the Microsurgery Training and Research laboratory, Dept of Orthopedic Surgery, Columbia University Irving Medical Center.

Five rat models were used during the advanced microsurgery course, October 2021. All training protocols were approved by the Institutional Animal Care and Use Committee (IACUC). The rats were anesthetized intraperitoneally using a ketamine (75–95 mg/kg) and xylazine (5–8 mg/kg) cocktail and constantly monitored for the depth of anesthesia. All the procedures were performed with the research and training laboratory microscopes (Model OPMI MD; Carl Zeiss, Inc., Oberkochen, Germany).

## SURGICAL APPROACH-TECHNICAL NOTE

### *End-to-End Common Carotid Artery Anastomosis*

A standard anterior midline cervical approach was used on the subjects. Proper hair removal of the rat in the anterior cervical area was followed by a midline incision. Blunt dissection using cotton tip applicators allowed separation of the neck muscles, which provided a wider surgical exposure and an easier way to find the carotid sheath.

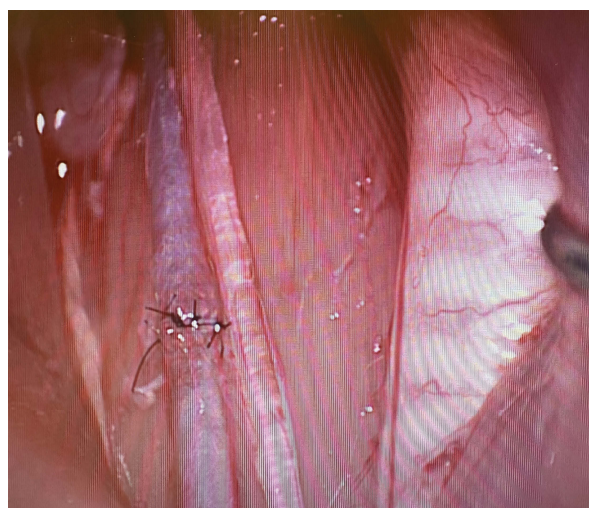


Fig. 1. End-to-end common carotid artery anastomosis

Рис. 1. Анастомоз общей сонной артерии по типу «конец-в-конец»

The carotid sheath was incised, and the internal jugular vein, the vagus nerve, and sympathetic trunk were displaced from the CCA. As a general measure, we applied lidocaine solution directly on the common carotid artery to reduce vasospasm. A little piece of blue rubber background was positioned behind the artery, serving 3 different purposes: generating an adequate contrast, preventing near structures damage, and having a blood-free field (i.e., a clean surgical field). After positioning the background, a double approximator clamp was placed, making sure there was a slack in the vessel between the clamps, so it was not too tightened. Then the carotid artery was transected and flushed with a heparinized saline solution using an ophthalmic cannula. The next step was preparing the edges of the lumen with adventitia trimming, following three basic principles: highest magnification, vessel submerging in saline solution, and keeping scissors parallel. Completion of carotid preparation was done by dilating the vessel edges.

Approximation of the vessel ends was performed by bringing the clamps together and then suturing began. A twelve o'clock stitch with rotation technique was executed first, and the one-way up technique was used for microvascular anastomosis. This technique consists of completing the

posterior wall before completing the anterior wall, precluding the need for approximator clamp flipping, minimizing blood vessels compromise, and simulating a more real-life scenario.

During the course we chose the CCA as the preferred vessel to perform this type of anastomosis for two reasons: deeper location than the femoral artery, creating a more difficult set-up, improving the skills of the student, and a relatively more similar diameter to the middle cerebral artery (MCA), one of the most used intracranial vessels when doing cerebrovascular procedures, which is slightly bigger than the femoral artery.

In the neurosurgical area this type of anastomosis is known with different names: end-to-end anastomosis or bypass, re-anastomosis, or reconstructive bypass [7], and has been utilized during the last four decades to treat complex aneurysms and skull base tumors [8]. Practicing this technique allows neurosurgery residents and junior neurosurgeons to experience a simulation of aneurysmal pathology excision or tumor resection, with the respective re-joining of the transected ends of the artery to restore blood flow, without needing a graft [7]. Generally, ETE anastomosis could be achieved in any cerebral artery, although the ideal location is one with a long arterial loop (e.g., MCA or PICA (postero-inferior cerebellar artery)) and fusiform aneurysm morphology.

#### **Side-to-Side Common Carotid Arteries Anastomosis**

The anterior cervico-thoracic approach was performed on the subjects via a midline incision after proper hair removal, the sternoclavicular joint was dissected, and the first two ribs were exposed on their medial half. An induced costochondral separation of the first two ribs was added bilaterally as part of the surgery to gain more space and dissect both CCAs more proximally to their origin

(Fig. 2), which served as a maneuver for an easier CCAs approximation.

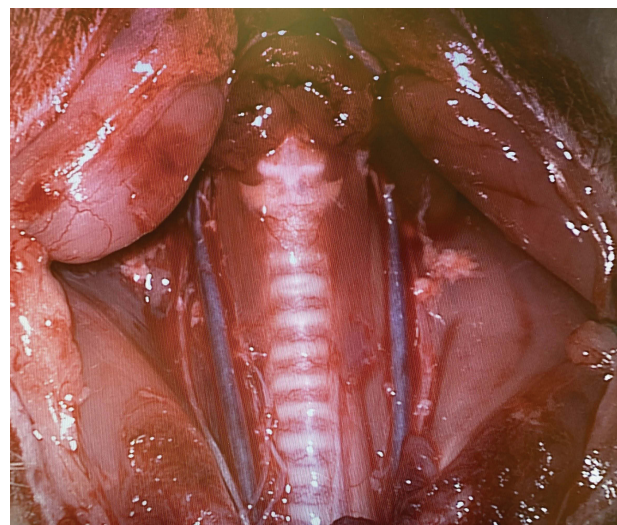
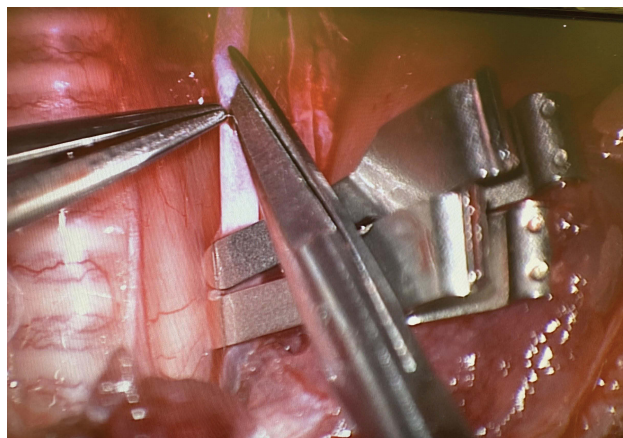


Fig. 2. Common carotid artery exposure after cervico-thoracic approach with costochondral separation of the first two ribs

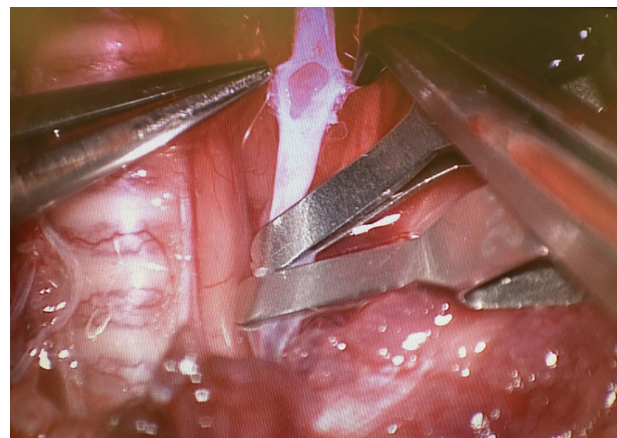
Рис. 2. Выделение общей сонной артерии после шейно-грудного доступа с реберно-хрящевой сепарацией первых двух ребер

The carotid sheath was incised, and the internal jugular vein, the vagus nerve, and sympathetic trunk were displaced from the CCA. The single clamps (4) are positioned as far as possible, 2 proximal and 2 distal on both CCAs.

The CCAs preparation began with adventitia removal, followed by arteriotomies in front of each other (Fig. 3 a, b). We perform these arteriotomies elevating the artery using an adventitia remnant that was left intact on purpose, by elevating the artery a little cut with the microscissors can be done, then the microscissors are inserted in the vessel and a longer cut is accomplished (approximately 2 or 3 times the vessel's diameter, i.e., 2 or 3 mm long).



a



b

Fig. 3. Carotid arteriotomies

Рис. 3. Каротидные артериотомии



Both CCAs were approximated with the apical sutures (Fig. 4), obviating the use of aneurysm clips to bring them together, as they were loose enough by performing the extended cervico-thoracic approach. Both apical sutures keep the appropriate length of the thread (not too long to avoid tangling), as this will be used for the back and front running sutures. In my case (right-handed) I performed the back wall first starting from the right, which was sutured continuously with approximately 8 loops (Fig. 5), then it is secured to the shorter tail of the front wall suture thread. Finally, the anastomosis was completed suturing the front wall starting from the left and using the long tail of the front wall suture thread (Fig. 6), securing it by knotting it with the shorter tail of the back wall suture thread which was left intact.

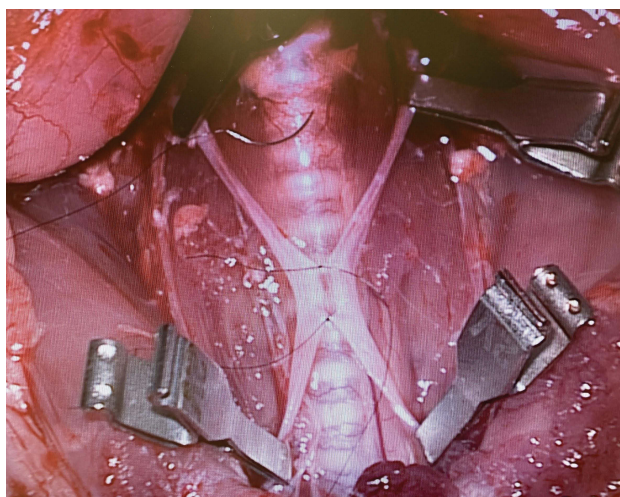


Fig. 4. Common carotid artery approximation with apical sutures

Рис. 4. Сближение общей сонной артерии верхушечными швами

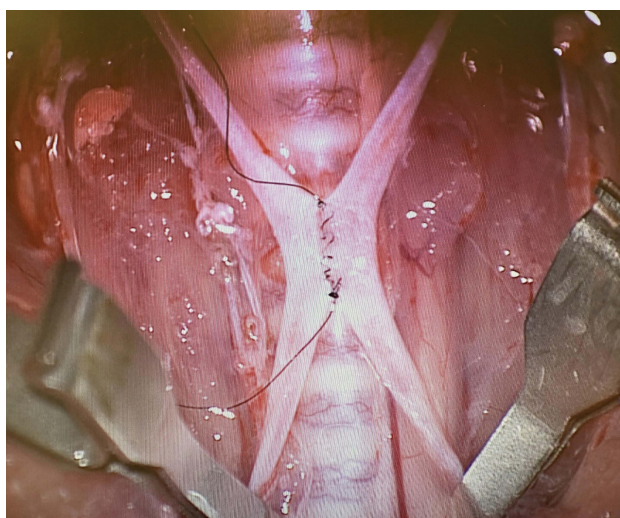


Fig. 5. Back wall was sutured

Рис. 5. Задняя стенка ушита



Fig. 6. Front wall was sutured

Рис. 6. Передняя стенка ушита

The STS anastomosis is a communicating bypass between two arteries that mimics the brain's anterior and posterior communicating arteries [9]. During the microsurgical course, we learn to perform these procedures at the femoral vessels before starting to work at the carotid level. Arteriovenous anastomosis, although providing a good example for STS practice, is not an approximate equivalent for arterial anastomosis as those performed in cerebrovascular practice. This is the reason why we prefer using both carotid arteries for an adequate learning curve during advanced courses. I find the STS anastomosis is very useful in cerebrovascular practice, it used in many types of bypasses, for example, an "R p3 PICA-L p3 PICA *in-situ* bypass" [9] for a fusiform aneurysm on the left lateral medullary segment of PICA, during this procedure you preserve distal postero-inferior cerebellar artery (PICA) flow by joining both PICA's distal segments, in cases in which a proximal aneurysm isn't amenable for surgical clipping.

#### **Ent-to-Side Common Carotid and Femoral Arteries Anastomosis**

During the training, an interpositional arterial bypass between both carotid arteries was performed. CCAs and one femoral artery were dissected and prepared as described before. The femoral artery graft was prepared first, the Murphy branch was ligated and coagulated, then it was cut to free the femoral artery, which was dissected as long as possible and then was excised and left on saline solution. The CCAs preparation began with adventitia removal, followed by arteriotomies in front of each other (1.0–1.5 mm of diameter), and the femoral artery was positioned between both CCAs through bilateral ETS anastomosis (Fig. 7).

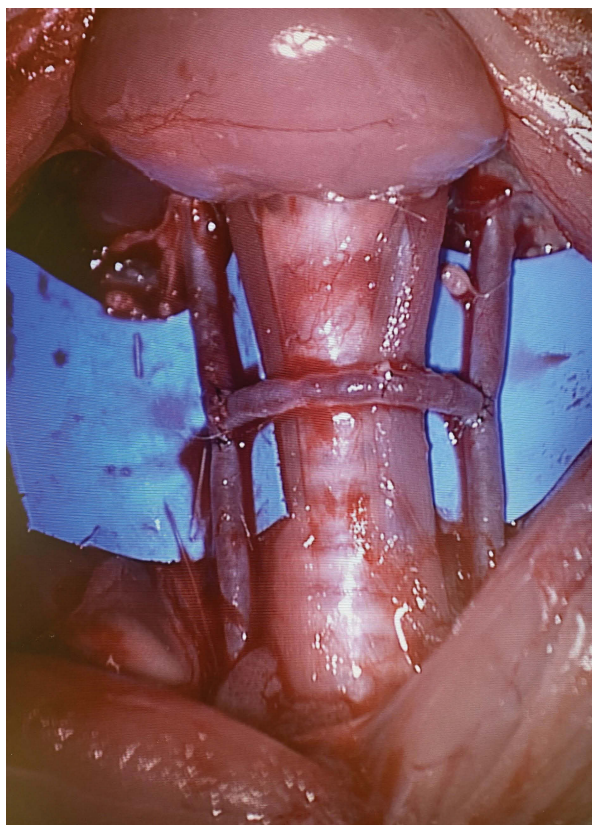


Fig. 7. Bilateral End-to-Side (ETS) – Simulating Interpositional bypass

Рис. 7. Билатеральный шов «конец-в-бок» – имитация межпозиционного обхода

This exercise also simulates real-life vascular surgical procedures, for example, an “OA-RAG-a3 AICA interpositional bypass” for bilateral VA occlusions and vertebrobasilar ischemia [10]. This bypass locates the radial artery (RA) as an interpositional graft between the occipital artery (OA) and the third segment of the anterior-inferior cerebellar artery (AICA), to preserve cerebellar blood flow from the external carotid artery (through the OA) in cases of posterior circulation vascular damage.

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## CONCLUSION

Microsurgery vascular training is an important part of every attending or training surgeon interested in vascular surgery. Animal models are the most accurate when trying to simulate real-life scenarios, but as the learning curve progresses more challenging exercises are demanded. Previously exposed exercises are extremely useful for microvascular practice and should be included in any advanced course around the world for every surgeon interested in microsurgery.

Human performance studies have shown that learning a specific skill – microvascular surgical skills in this case – requires approximately 10.000 hours of practice time [11]. Without a doubt, not only the length of training is important, but the quality of the experience is an important factor in this formula. During my training at the Microsurgery Training and Research laboratory, I was guided by the senior author (Ye. Akelina), on a one-to-one focused teaching, improving my performance not only daily, but on an hourly basis, in which I could see the advances and the progress with every new stitch and anastomosis accomplished. This reflects the importance of starting the training with an expert, giving as (i.e., residents, fellows, or junior attendings) that quality education needed to develop new skills, and is our job to achieve the necessary timing for what we are seeking: evolving our capacities to the maximum for the best of our future patients.

I truly recommend microsurgery vascular training to every single neurosurgical resident, and those residents, fellows, or attendings interested in performing microvascular procedures during their clinical practice. It is important not only because of what was stated before but also because as the skills are obtained and perfected at the beginning, no human patient should be treated surgically by an inexperienced surgeon.



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#### Information about the authors

**Diego A. Devia**, MD, Neurosurgery Department, Hospital Universitario San Ignacio, Pontificia Universidad Javeriana, Bogotá, Colombia.

**Yelena Akelina** ✉, DVM, MS, Research Scientist, Director/Instructor of the Microsurgery Research and Training Laboratory, Department of Orthopedic Surgery, Columbia University, New York, USA.  
e-mail: ya67@cumc.columbia.edu

#### Информация об авторах

**Диего А. Девиа**, MD, отделение нейрохирургии, Университетская больница Сан-Игнасио, Папский университет Хавериана (г. Богота, Колумбия).

**Елена Акелина** ✉, DVM, MS, научный сотрудник, директор/инструктор учебно-научной лаборатории микрохирургии, отделение ортопедической хирургии, Колумбийский университет (г. Нью-Йорк, США).  
e-mail: ya67@cumc.columbia.edu

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