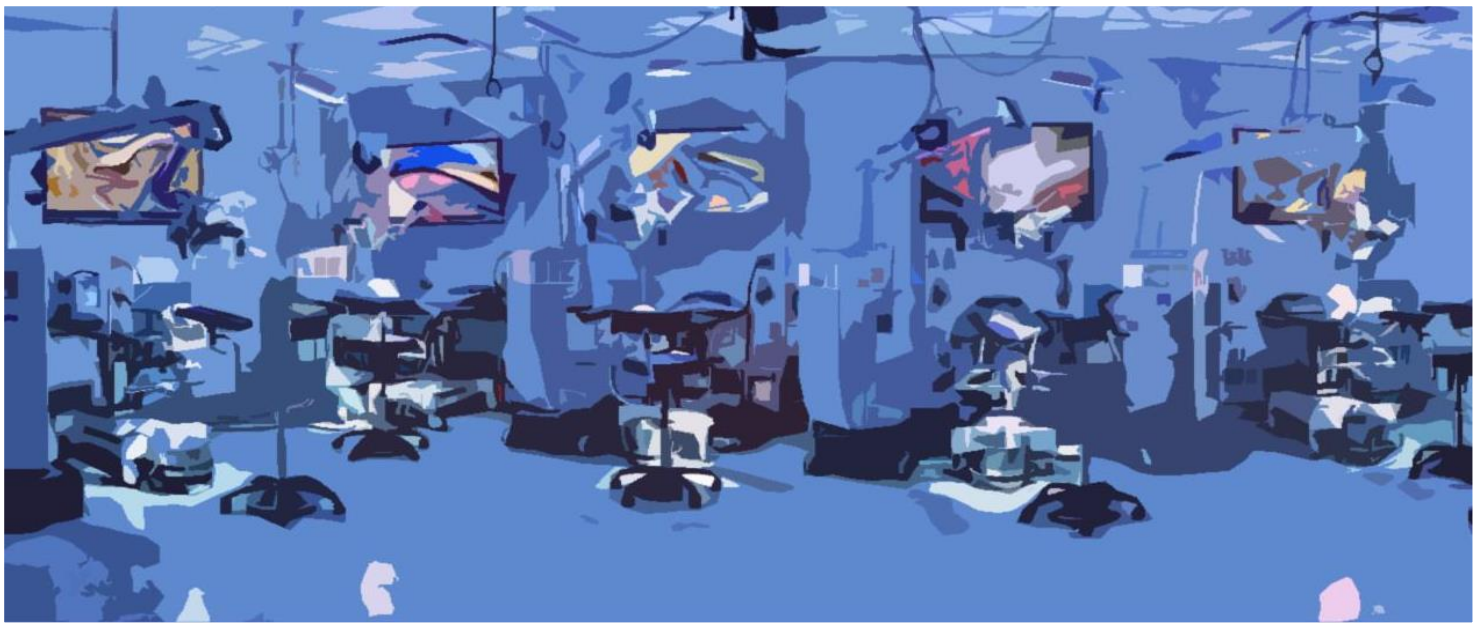
Neurosurgical Innovations and Training Center

A Skull Base and Microneurosurgery Laboratory

A hands-on surgical training and research lab with
3D Visualization



Weill Cornell Medicine
Neurological Surgery

Neurosurgical Innovations and Training Center

Quality of neurosurgical care and patient outcomes are inextricably linked to surgical and technical proficiency and a thorough working knowledge of microscopic surgical anatomy. Today, neurosurgical laboratory-based training is essential for the development and refinement of technical skills prior to their use on a living patient.

Advances in technology now allow neurosurgeons to pursue alternative complex surgical avenues to deep seated targets in the cranium. Minimally invasive endoscopic and more complex approaches to the cranial base are becoming increasingly common and the anatomy associated with these techniques remains both theoretically and technically challenging. These approaches require dexterity with surgical instrumentation through restricted corridors containing vital structures as well as a thorough understanding of the anatomy to be traversed. Developing an understanding of the complex anatomical relationships between anatomical structures is critical to surgical success.

As modern technological advances in neurosurgery—including 3D microscopy and endoscopy, virtual reality, surgical simulation, surgical robotics, and advanced neuroimaging—become more widespread and surgeons begin to rely more on their use, the need for integrated and specified training in their clinical utilization is imperative. These advances have been shown to reduce the learning curve, improve conceptual understanding of complex anatomy, and enhance visuospatial skills, in neurosurgical training. Until recently, few means have allowed surgeons to obtain integrated surgical and technological training in an operating room setting. The neurosurgical laboratory combined with simulation technology is the ideal environment for technologically integrated surgical training.

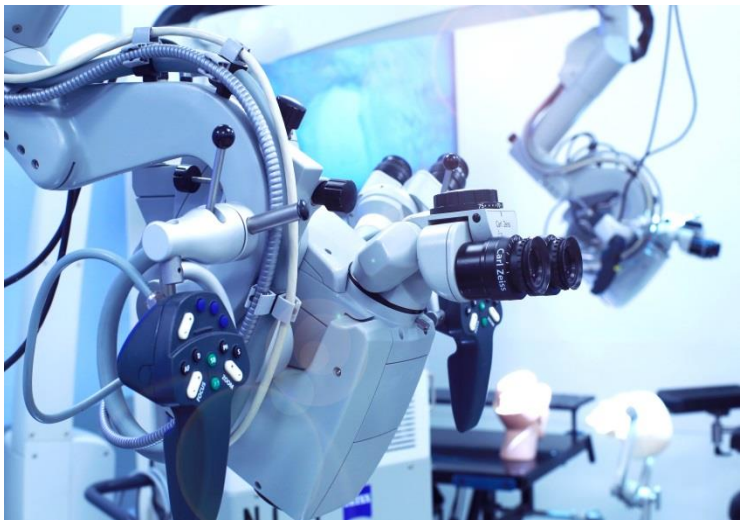
In the Neurosurgical Innovations and Training Center, neurosurgery faculty, fellows, and residents form around the world perform a variety of surgical exercises under conditions that simulate an actual operation as closely as possible in order to provide preoperative training and rehearsal of complex neurosurgical procedures. Our fellows concurrently perform research to expand the current boundaries of neurosurgical practice through the development of novel technologies, techniques, and procedures that improve patient outcomes.

Mission Statement

The Weill Cornell Neurosurgical Innovations and Training Center is committed to the advancement of the art and science of neurological surgery through excellence in research, education, and the maintenance of scientific and clinical scholarship. To this end, we provide skills-based educational opportunities and training for surgeons and medical students from countries throughout the world, and convey emerging medical knowledge to practitioners by offering educational activities that contribute to improved surgical practice and clinical research.

Neurosurgical Innovations and Training Center

Our 1,000 square-foot dedicated facility is a fully immersive 3D environment that closely replicates a neurosurgical operating room. The lab contains five adjacent workstations designed to closely recreate the surgical setting of a working operating room. Each workstation is equipped with an adjustable operating table with a Mayfield head holder, a 3D neurosurgical microscope with a xenon light source, an HD endoscope, a large 3D LCD display, a surgical chair, electric and pneumatic surgical drills, a table-mounted adjustable tablet computer, and a complete set of surgical tools. Additionally, each workstation contains surgical lights and wall-mounted suction, air, and water lines. A refrigerated cold room within the laboratory is used to store upwards of 200 preserved cadaveric heads, and a large row of sinks with filters capable of handling human tissue is available.



The Zeiss NC-4 neurosurgical microscope at each station is connected to a high-definition 3D camera system for screen projection and recording. Recordings are obtained and stored using custom-designed software. Each camera is capable of optical zoom and can be routed to the 3D display at any workstation, or any of the computer workstations, allowing for simultaneous instruction and dissection. The laboratory is also equipped with a 3D projector with retractable screen that can project the input from any of the lab's cameras or computers and facilitate didactic lectures.

The lab houses advanced neurosurgical technologies for technologically integrated training, including a neuronavigation system, a surgical robotic simulator, a surgical robot, a Dextroscope holographic surgical planning system, a mobile fluoroscopy system, and virtual reality and computerized simulation for training of surgical procedures. The simulators utilize technology that provides sensory feedback to the user allowing for the simulation of cutting, pulling, and manipulating of tissue.

We are in the process of building 3D video archives, virtual reality and simulation models, and broadcasting capability for disseminating educational, research, and reference materials to institutions around the world. These initiatives are the first steps of our eventual goal to create a library of stepwise neurosurgical dissection videos and interactive models and simulations which can be accessed and shared in real-time with surgeons throughout the world via the internet.

Educational Programs

Lesions of the skull base present a unique challenge to neurosurgeons. Special training is required to perform intricate surgery in the small recesses of the brain. Most skull base neurosurgical approaches require dexterity with surgical instrumentation, specifically drills, through restricted corridors that contain vital structures. This aspect of surgery demands that surgeons be proficient not only with their tools but also with the complex anatomy to be traversed. The development of a working understanding of the anatomic relationships between neural and vascular structures encased by bone is critical and requires practice. In our skull base laboratory, complex approaches to the cranial base are performed on cadavers under conditions that simulate an actual operation as closely as possible.

We currently offer two educational programs, a Fellowship for neurosurgical residents and a surgical neuroanatomy elective for medical students.

Skull Base and Microneurosurgery Fellowship

We offer a lab-based Fellowship that provides training in the care of patients with pathologies of the skull base region through independent cadaveric dissection to rehearse complex approaches to the skull base. Our Fellowship program involves an initial period of structured anatomosurgical education and dissection, with regular anatomical presentations by the fellow, followed by a period of cadaveric research; wherein Dr. Bernardo works closely with fellows to promote their surgical development. At the conclusion of the Fellowship, fellows should have an exhaustive understanding of the approaches to the cranial base, be able to define cadaveric prosection models to investigate new surgical routes to intracranial targets, navigate through various regions of the skull base, achieve adequate preoperative training for complex operative approaches, and complete at least 1–2 manuscripts suitable for publication depending on the duration of training. The Fellowship varies in length from 4 to 12 months and is available to senior residents in neurosurgery or neurosurgeons who have completed training and are pursuing sub-specialized training. Applicants are admitted based on their background and experience. We receive over 50 applications per year and are fully committed with fellows for the next 2.5 years. There is no tuition cost to complete the Fellowship and the lab is in operation 24 hours/7 days a week. During periods of peak operation, Fellows may be placed onto either day or night schedules. As of January 2020, we will have trained 140 fellows.

Surgical Neuroanatomy Research Elective

We also offer an elective in surgical neuroanatomy and basic concepts of neurosurgery for medical students nearing the completion of their degree who wish to pursue post-graduate specialty training in neurology, neurosurgery, or otolaryngology. This elective provides a comprehensive overview of clinically relevant surgical neuroanatomy and ties in discussions of neurosurgical cases that include concepts of neuropathology, diagnostic techniques, and therapeutic interventions. This research elective is provided with minimal cost for medical students who wish to gain knowledge of neurosurgery and is offered throughout the year. Admission is limited to students currently enrolled in medical degree-granting programs. To we have trained over 200 medical students through this elective.

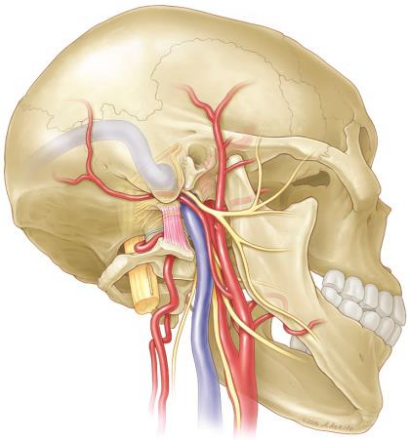
Educational Courses

We currently offer continuing medical education courses entitled *Mastering the Basics: Common Approaches* and *Complex Surgical Approaches to the Skull Base*. These small dissection-centered courses are conducted twice a year and allow participating surgeons to work at 3D interactive cadaver workstations, where they watch cadaveric dissections and review surgical anatomy—all in 3D—before and during their own dissection. We also offer specialized shorter courses on minimally invasive transtubular techniques in neurosurgery. In addition to these, we host annual bootcamp courses for the Society of Neurological Surgeons and the American Association of Neurological Surgeons. In all, over 300 medical students, residents, fellows, and attendings participate in NITC courses annually.

In addition to our onsite courses, we currently present annual 3D dissection courses in Italy, Brazil, China, and Austria, as well as a national resident course in Palm Beach, Florida and pre-meeting dissection courses for the North American Skull Base Society, the Italian Society of Neurosurgery, and other national and international societies.

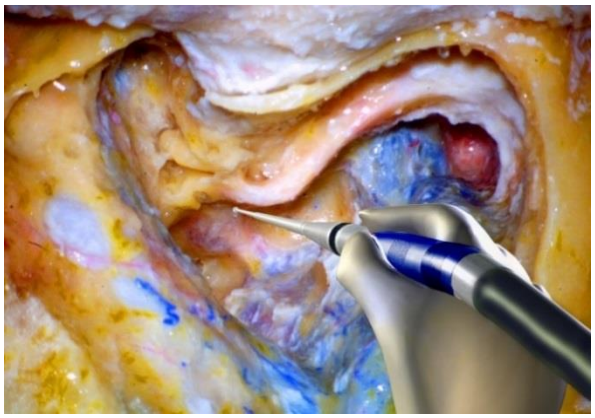
In the future we plan to offer additional courses focusing on specific highly complex regions, topics, or the use of new technologies or techniques. We also plan to expand our medical student offerings to help attract to students to neurosurgery while improving and simplifying learning and comprehension of neuroanatomy.

Research and Innovation



We are committed to the advancement of the art and science of neurological surgery through excellence in research. The Neurosurgical Innovations and Training Center works on the development of new operative techniques in microneurosurgery, skull base surgery, vascular neurosurgery, and neuroendoscopy as well as the integration of neurosurgery with novel technologies. In addition, we aim to expand the current understanding of surgical neuroanatomy by integrating intricate cadaveric dissections with 3D visualization, virtual reality, and computer simulation in order to enhance neurosurgical training and practice.

Our overriding goal is to expand the current boundaries of neurosurgical practice through the development of novel technologies, techniques, and procedures that directly improve patient outcomes.



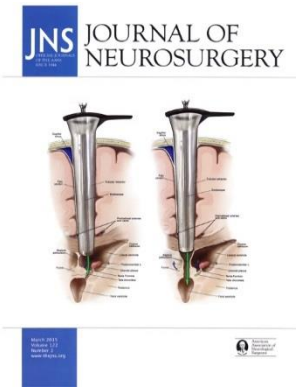
Our current areas of research include minimally invasive and transtubular neurosurgery, surgical simulation and planning, surgical robotics, flexible endoscopy, flexible surgical instrumentation, white matter navigation, 3D printing, virtual and augmented reality, and operative techniques in microneurosurgery.

Neurosurgical Innovations and Training Center research has been extensively published in the neurosurgical literature, the subject of hundreds of conference presentations, featured on the covers of the Journal of Neurosurgery and Operative Neurosurgery, the subject of a supplement to the journal World Neurosurgery entitled the Cornell Annals of Neurosurgery, and has won a number of awards worldwide.

Program Objectives

As of June 2019, we have trained over 120 fellows and 200 medical students. We have published over 50 articles in peer-reviewed journals, published 3 book chapters, presented over 220 times at neurosurgery conferences and meetings, have 3 books in publication, and have hosted over 20 courses. Our alumni network is extremely active in spreading our philosophy of skills-based medicine and has established similar training regimens in the U.K., South America, China, Europe, and Africa. The number of patients who have benefited from this training is incalculable. We hope to continue to improve the lives of people with neurological disorders around the world, one surgeon at a time.

In the future, and pursuant to our mission, we would like to increase our training throughput and reach by providing both in-person and virtual training opportunities to surgeons in developing countries through educational scholarships and courses, as well as increasing our number of monthly in-house fellows by adding several new workstations to our existing facility. Additionally, we are in the process of expanding our range of continuing education programs to include courses in basic, advanced, and highly specialized topics. We are also working to develop a new multiday surgical neuroanatomy boot camp for incoming neurosurgery residents.



NITC research featured on the cover of the Journal of Neurosurgery.

Furthermore, as we begin to expand our reach into multidisciplinary realms, we plan to explore opportunities that would allow us to use our anatomical and surgical expertise to help further the development of functional neurosurgery by defining neuroanatomic targets for the treatment of neurodegenerative disorders, including but not limited to stimulation and conduit implantation targets in Parkinson's Disease; develop neuroanatomic databases for the development and refinement of artificial intelligence in neuroradiology; and build a public outreach portal using educational sites focused on brain information and overall health. To accomplish this would require resources that would enable us to seek out collaboration and development opportunities worldwide.

Program Objectives

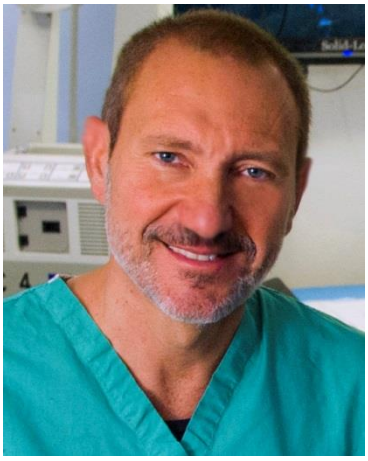
The quadripartite mission of our lab is education, evaluation, innovation, and propagation of the philosophy of skills-based medicine.

As we move forward, we are undertaking initiatives to build 3D video archives, virtual reality and simulation models, and broadcasting capability for disseminating educational, research, and reference materials to institutions around the world. This will help provide a vital resource to surgeons in countries that lack formal neurosurgery training and will help to improve patient care.

We firmly believe that these and other initiatives will help to advance and improve the practice of neurosurgery at home and abroad. To accomplish this mission and function as a worldwide center of academic excellence, we aim to:

1. Develop new and less invasive surgical routes and techniques
2. Provide surgeons and residents with the visuospatial skills required to navigate complex surgical anatomy
3. Allow trainees to achieve adequate preoperative technologically integrated training and rehearsal of complex surgical procedures
4. Produce 3D educational models and animations of complex intracranial regions
5. Train fellows and residents from institutions around the world for advanced neurosurgical practice
6. Establish an accredited and funded skull base surgery fellowship program
7. Perform and publish leading scientific research with the goal of advancing the practice of neurosurgery
8. Curate a comprehensive and high quality digital archive of anatomical and surgical media for use in medical and surgical education
9. Develop a framework for the integration of skill based medicine training into residency training programs
10. Engage in humanitarian work to help provide similar capabilities in developing countries
11. Remain at the forefront of neurosurgical research and training through acquisition of the latest in cutting-edge surgical technologies

With your help, we can achieve these goals and cultivate innovative concepts that will transition research from the laboratory to the operating room, and train surgeons from around the globe on the latest techniques and technologies in neurosurgery. To continue this important work the lab requires regular maintenance and technological upgrades, as well as funding for personnel salaries and supplies. To help support our work, and continue our pursuit of these initiatives, please contact Dr. Antonio Bernardo at (212) 746-1468.



Antonio Bernardo, MD

Professor of Neurological Surgery
Surgical Director, Neurosurgical Innovations and Training Center
Weill Medical College of Cornell University

Dr. Bernardo is a Professor of Neurological Surgery and director of the Neurosurgical Innovations and Training Center for Skull Base Microsurgery in the Department of Neurological Surgery at Weill Cornell Medical College. He is an expert in the understanding of microsurgical anatomy and a pioneer in developing three-dimensional surgical simulators to teach surgeons the visual-spatial skills required to perform skull base surgical approaches. His interactive virtual dissection (IVD) approach integrates cadaveric dissections, 3-D visualization, virtual reality, and computerized simulation for training of surgical procedures.

Dr. Bernardo received his M.D. from University of Naples "Federico II" where he graduated Summa cum Laude. He completed his Neurosurgery residency at Western General Hospital/University of Edinburgh in Edinburgh, Scotland. Dr. Bernardo served as a scholar at the University of California, Irvine from 1997 to 1999. He spent one year as a volunteer neurosurgeon in Peru, where he established skull base surgery programs in hospitals throughout the country, representing the Foundation for International Education in Neurosurgery (F.I.E.N.S.). In 2000, Dr. Bernardo became an Adjunct Professor of Neurosurgery and Director of the Microneurosurgery Skull Base Laboratory at the University of Medicine and Dentistry of New Jersey. Dr. Bernardo then completed a fellowship in Skull Base Surgery at the Barrow Neurological Institute in Phoenix, Arizona under Dr. Robert Spetzler. Dr. Bernardo subsequently joined the Department of Neurological Surgery at Weill Cornell Medical College as an Associate Professor and Director of the Skull Base and Microneurosurgery Laboratory through the support of Dr. Philip E. Stieg. His research interests include skull base surgery, cerebrovascular surgery, and virtual reality in medicine and surgery.

Dr. Bernardo has established himself as a pioneer and expert in the understanding of microsurgical anatomy in skull base surgery. At the Barrow Neurological Institute he developed a three-dimensional surgical simulator to teach surgeons the visual-spatial skills required to perform skull base surgical approaches. The project, called interactive virtual dissection (IVD), integrates cadaveric dissections, 3-D visualization, virtual reality, and computerized simulation for the training of surgical procedures.

Dr. Bernardo has been invited to direct over 150 surgical courses worldwide and is frequently invited as a guest and honored speaker to international neurosurgical meetings. He has trained over 4,000 neurosurgeons through his skull base surgery courses and 100 dedicated fellows since he has joined the Department of Neurological Surgery at Weill Cornell. Dr. Bernardo is currently a neurosurgical consultant in several countries where he continues to operate on complex skull base surgical cases on a routine basis. He is active member of the Italian Association of Neurosurgeons, the Register of Neurosurgeons of the United Kingdom, the American Congress of Neurosurgeons, and an honorary member of the Peruvian Association of Neurological Surgeons of the Peruvian Academy of Surgery, the Colombian Association of Neurological Surgeons, the Caribbean Association of Neurological Surgeons, and the Venezuelan Association of Neurological Surgeons.

Philip E. Steig, PhD, MD

Chairman and Professor of Neurological Surgery
Co-Director, Neurosurgical Innovations and Training Center
Weill Medical College of Cornell University
Neurosurgeon-in-Chief, NewYork-Presbyterian Hospital

Dr. Philip Stieg is a world-renowned neurosurgeon with expertise in cerebrovascular disorders and skull base surgery. He is the Chairman and founder of the Weill Cornell Brain and Spine Center, the leading neuroscience patient care center in New York City. In 2010 Dr. Stieg launched the Weill Cornell Surgical Innovations Lab, the first global multimedia neurosurgical teaching facility in the world.

Castle Connolly Top Doctors 2017 Dr. Stieg is a widely published author and internationally known lecturer, and has been named by Castle Connolly Medical as one of the nation's Top Doctors for 15 years in a row. Dr. Stieg is frequently featured in the media for his expertise and commentary on breaking news in healthcare, and he was the creator and host of the successful NPR radio show "How to Save Your Life." Dr. Stieg is also one of the editors of the definitive textbook on AVMs, Intracranial Arteriovenous Malformations. He is currently the president of the Brain Tumor Foundation, and president of the New York board of the American Heart Association. He is also a past Chairman of the Congress of Neurological Surgeons (AANS/CNS) and former President of the Society of University Neurosurgeons in addition to serving as an advisor to the Defense Department on brain injury. Dr. Stieg is board-certified in Neurological Surgery.

Dr. Stieg received his B.S. degree from the University of Wisconsin at Madison (1974), his Ph.D. in Anatomy and Neuroscience from Union University (1980), and his M.D. from the Medical College of Wisconsin in 1983. He trained at the University of Texas Southwestern Medical School (Parkland Memorial Hospital) with Drs. Duke Samson and Hunt Batjer after completing a fellowship in cell transplantation for restorative neurological function at the Karolinska Institute in Stockholm, Sweden. Dr. Stieg joined the faculty of the Harvard Medical School, Brigham and Women's Hospital, and Children's Hospital of Boston in 1989, after completing his postgraduate training.

Dr. Stieg's research interests include cerebral protection as well as restorative function. He is also interested in neural transplantation and neuronal regeneration after stroke. His initial studies focused on understanding the mechanisms of injury in the central nervous system after trauma. His laboratory was one of the first to develop and characterize primary cultures of astroglial cells. Dr. Stieg's expertise in cerebrovascular disorders combines with his research interests in stem cell biology and cerebral transplantation for restoring neurological function. Dr. Stieg has implemented a multifaceted approach to the management of neurosurgical disorders such as carotid artery disease, vascular malformations, aneurysms, epilepsy, brain tumors, trauma, pediatric disorders, spinal cord problems, and functional diseases, including Parkinson's disease.