To Our Colleagues:

Attacking the essence of a person, neurological diseases often cause life-altering transformations in the lives of patients and their families. However, given the epic upsurge in our knowledge of the nervous system — coupled with the development of revolutionary technology, progressive techniques and ground-breaking treatments — we are responding to the challenge of caring for these patients with increasingly impressive results.

In this issue of Progressive Neuroscience, we focus on some notable patient outcomes directly related to the use of sophisticated technologies and treatments, including:

- Minimally invasive total stereotactic resection of a giant intraventricular meningioma
- Image-guided spine surgery
- Resection of a lumbar giant cell tumor and reconstruction that obviated the need for adjuvant therapy
- State-of-the-science monitoring of cardiac output and fluid management in the NeuroICU

In addition, we highlight important research currently underway at Winthrop-University Hospital’s Institute for Neurosciences. Neurology and environmental medicine experts are collaborating in an exciting study to expand our understanding of the effects of dust from the World Trade Center disaster on peripheral nerves.

Our objective continues to be to provide the most advanced, collaborative and world-class care for your patients.

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Table of Contents

Research
Effects of Dust from World Trade Center Disaster on Peripheral Nerves | 2

Minimally invasive Total Stereotactic Resection of a Giant Intraventricular Meningioma | 4

Case Report
Resection of Lumbar Giant Cell Tumor | 6

Image-Guided Spine Surgery Revolutionizes Visualization | 8

State-of-the-Science Cardiac Output Monitoring and Fluid Management in the NeuroICU | 10

Contributing Clinicians | 12
The World Trade Center (WTC) disaster of 9/11/2001 was associated with a number of health problems for those exposed.1-3 Although research is being conducted to understand the full extent of these problems, the National Institute of Occupational Safety and Health (NIOSH) includes asthma, chronic laryngitis, chronic respiratory disorder, interstitial lung diseases, reactive airway disease, sleep apnea, upper airway hyper-reactivity, and WTC-exacerbated chronic obstructive pulmonary disease among the conditions linked to the catastrophe. Major depression, post-traumatic stress disorder (PTSD) and generalized anxiety disorder are also included.

The chemical compounds present in the dust produced by the WTC disaster are contributors to these medical disorders. Paul Lioy, PhD, an eminent environmental scientist and Vice Chair of the Department of Environmental Medicine UMDNJ - Robert Wood Johnson Medical School, demonstrated that the dust contained many very complex hydrocarbons and hexacarbons that may be neurotoxic, as well as lead and arsenic, which certainly are.4

By
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Effects of Dust from the World Trade Center on Peripheral Nerves
We are still learning about the full effects of the WTC disaster on those exposed. Since some WTC responders and survivors have experienced neuropathic symptoms, we have undertaken a study of the effect of WTC site dust on peripheral nerves, using the invitro sciatic nerve preparation. The dust was obtained from Dr. Lioy.4

Method

In the invitro sciatic nerve model,5 (Fig.1) sciatic nerves from a rat are harvested and then placed in a perfusion apparatus, where the solution bathing the nerve can be well controlled. In these experiments, the temperature of the perfusate is maintained at body temperature (37°C) and consists of a salt solution similar to that of the cerebrospinal fluid.

Each experiment lasts 16 hours, during which the nerve action potential (NAP) is recorded every four seconds. From each nerve action, we determine its amplitude, velocity, duration and response to paired pulses (conditioned stimulus response-CSR). Normally, during the course of the experiment, the amplitude of the NAP drops slightly, as does the velocity.

We have been able to compare the effects of WTC dust on peripheral nerves under two conditions: First, 1gm of dust was extracted with saline and injected into the fluid bathing the nerve. Second, 10gms of dust were extracted with methanol and injected into the bathing fluid. Infusion of 1gm of dust extract had no effect. However, the nerve exposed to 10gms of dust extracted with methanol demonstrated reduced conduction velocity in comparison to nerves exposed to the same amount of methanol without dust. (Fig.2)

It has been shown that WTC dust contains toxic substances that have caused disease in those exposed. The dust may have a direct toxic effect on myelin. However, it is difficult to apply these data directly to determine whether WTC dust may produce neuropathy in humans.

First, this is an acute model, and in humans it is more likely that damage due to lower levels accumulates over time. Second, although the conduction studies performed in the invitro sciatic nerve system are similar to those produced in humans for the assessment of neuropathy, these studies are not associated with any assessment of physiologic changes. Thus, although more physiologic measurements are indicated, and may be helpful in identifying the nature of the toxic substance, it is important to assess humans who were exposed.

For more information, call the Institute for Neurosciences at 1-866-WINTHROP or visit www.winthrop.org

REFERENCES


![Fig. 1](image1.png)

**Fig. 1**

on peripheral nerves, using the invitro sciatic nerve preparation. The dust was obtained from Dr. Lioy.4

**Fig. 2**

**Effect of WTC Dust on Nerve Conduction Velocity**

![Diagram](image2.png)
A woman in her 60s presented with gait instability and a history of memory disturbance. She was neurologically nonfocal, and after ruling out the possibility of a middle ear problem, a diagnostic MRI/MRA of the brain was performed. It revealed the existence of multiple meningiomas, including one very large intraventricular mass filling the lateral ventricle, with downward displacement of the deep and internal cerebral veins. In addition to obstructive hydrocephalus, which was causing her symptoms, there was evidence of increased vascularity fed mostly by the posterior choroidal artery (PCA) branches and consistent with a diagnosis of meningioma.

To keep intracranial pressure from increasing and to treat the hydrocephalus, surgery was recommended. The goal was to prevent further neurologic deterioration and help the patient recover neurologic function.

Incidence, Symptoms, Diagnosis

Intraventricular meningiomas are slow growing, benign tumors that generally develop into large masses prior to detection. Considered rare, they account for 0.5%-5% of all intracranial meningiomas, generally presenting in the fourth-to-sixth decades of life, and occurring twice as often in women than men.1,2 Since the brain’s ventricles provide space for expansion, patients are usually asymptomatic until the mass grows large enough to cause compression of the adjacent neural structures or hydrocephalus increases intracranial pressure. Symptoms may include headache, imbalance, visual disturbances, memory difficulties, language function impairment, seizures and mood or personality changes.

“
Intraventricular surgery is high risk and involves meticulous navigation around the critical thalamostriate vein and the fornices.”

Michael Brisman, MD
Chief, Neurosurgery
Depending on the patient’s age, specific tumor site and radiological characteristics, deep-seated masses in the ventricles can have significant differential diagnoses, including low-grade gliomas, astrocytomas, metastases and lymphoma, as well as sarcoidosis, arteriovenous malformations and cavernous hemangiomas.

“Accurate diagnosis is crucial so the surgeon is aware of the type of tumor and its possible complications,” explained Jonathan Brisman, MD, Winthrop’s Director of Cerebrovascular and Endovascular Neurosurgery. With dual training in microneurosurgery and endovascular techniques, he performed the digital subtraction diagnostic angiography to evaluate the vascularity of the tumor.

Treatment

Excising a large intraventricular meningioma burrowed into the middle of the brain requires a complex and challenging surgical procedure. It involves passing through essential and eloquent cortical areas with minimal manipulation of the neural structures encircling the ventricles. Retraction must be minimized, functional cortical areas avoided and feeder vessels controlled early.

Dr. Jonathan Brisman collaborated with Winthrop’s Chief of Neurosurgery, Michael Brisman, MD, in this carefully planned effort. Several surgical approaches to meningiomas of the lateral ventricle have been developed in order to reduce the risk to vital neurological structures and the potential for creating speech and cognitive deficits. They elected to use a transcortical approach, considered least invasive and most direct.

“Intraventricular surgery is high risk and involves meticulous navigation around the critical thalamostriate vein and the fornices,” explained Dr. Michael Brisman. “Tumors located in the lateral ventricle are more easily accessed through a cortical incision. The technique also provides superior working space and flexibility.”

In this case, MRI images helped guide the proposed corticectomy tract for tumor excision. To obviate the need for multiple retractors, obtain safe access to the deeply embedded tumor and reduce the risk of retraction-related complications, they used a recently developed transparent plastic tubular retractor. The completely clear cylindrical device provided excellent visualization — as it was carefully guided toward the lesion — and facilitated the evacuation of the meningioma, which was completely removed through the retractor’s lumen without placing extra pressure on the brain tissue.

“After the rim of the tumor was coagulated, we debulked the mass, rolling it onto itself and ultimately achieving gross total resection,” Dr. Michael Brisman reported. “The patient returned home after several days of hospitalization and remains symptom-free without neurological deficits.”

For more information, call the Institute for Neurosciences at 1-866-WINTHROP or visit www.winthrop.org

REFERENCES


A man in his 40s presented with intractable, worsening pain that traveled from his right hip and buttock down the posterolateral aspect of his right leg to the foot. The left lower and upper extremities were normal. He complained of difficulty walking and episodes of right lower extremity paralysis, as well as being unable to function independently because of the pain and neurological problems.

An MRI of the lumbar spine showed a lytic lesion consuming the body of L4 with extradural extension and compression of the thecal sac. The remaining L4 vertebral body had deteriorated to nothing more than an “egg shell.”

A needle biopsy confirmed that the lesion was a benign giant cell tumor (GCT) that needed to be excised in order to address the patient’s neurological deficits and spinal instability.

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Angiogram & Embolization

Given the vascular nature of most GCTs, a preoperative angiogram was conducted, revealing a hypervascular mass at L4. Embolization was performed to reduce the tumor’s vascularity and the potential for extensive blood loss during surgery. Using the right transfemoral approach, a catheter
was placed in the L4 lumbar artery, where a small amount of polyvinyl alcohol (PVA) glue was instilled to achieve devascularization of the tumor.

**Resection & Stabilization**

The surgery consisted of an intricate two-stage procedure conducted over two days. Stage one involved a complete posterior laminectomy from the bottom of L3 to the top of L5, with stabilization and fusion. The procedure resulted in the removal of a good portion of the L4 vertebral body, a wide surgical resection of the tumor and decompression of the nerves.

Stage two involved an anterior corpectomy at L4 for resection of the remaining tumor with reconstruction using an expandable cage. Near-complete resection of the tumor was completed. Since the lesion was contained in one area and near total resection was achieved, adjuvant therapy was not recommended.

Two weeks postoperatively, the patient reported significant improvement of his symptoms, with the preoperative right lower extremity pain, weakness and dysfunction completely resolved.

To help determine this patient’s future care and ensure timely treatment should the GCT recur, postoperative monitoring will involve regular examinations with interval X-rays, CT scans and MRI studies.

**REFERENCES**

Viewing the intricate, multifaceted anatomy of the spine during surgery has always been challenging. However, with the development of microsurgery, advanced imaging technology and — most recently — image-guided spine surgery, visualization of the complex structure has reached new heights.

Now, instead being restricted to traditional invasive spine surgery — where only the part of the anatomy that is exposed can be seen — spine surgeons have more treatment options to offer select patients. Because they can obtain a full view of the spine with the new visualization technology, they can perform less invasive, safer surgery percutaneously, through small incisions.

A 70-year-old man with a history of laminectomy using instrumentation and fusion, was experiencing uncontrollable back and leg pain that was worsening steadily and preventing him from walking or standing for more than 30 seconds.

Artem Vaynman, MD, a Board-Certified neurosurgeon, recently employed image-guided surgery to treat this patient, who was diagnosed with postlaminectomy syndrome at L3-L4 and L4-L5. He also had residual stenosis at that site and developmental stenosis at
L2-L3, as well as bilateral radiculopathy and instability.

“After his first surgery at another institution seven years earlier, the patient never improved,” reported Dr. Vaynman, who specializes in complex and minimally invasive spine surgery. “When he presented recently, he was in severe pain, had great difficulty walking, and his symptoms were growing progressively worse, reducing his independence substantially.”

Revision spinal surgery carries additional risks, including poor healing, increased incidence of wound infections and cerebrospinal fluid leaks. Since this patient needed decompression of his nerve roots, fusion would be necessary to re-establish spinal alignment and stability. This made him an ideal candidate for a combination of minimally invasive and open surgery.

Dr. Vaynman recommended a complex two-stage surgical procedure: Stage one consisted of a minimally invasive anterolateral diskectomy with interbody fusion from L2-L3 and L3-L4. The second stage comprised revision of the L3-L4 and L4-L5 laminectomy, and an L2-L3 laminectomy with bilateral facetectomy and foraminotomy, as well as L4-L5 diskectomy with interbody fusion.

Image-guided technology includes an infrared navigation camera that tracks the movement and position of Smart instruments with LEDs in the surgical field. However, at its core is specialized computer software that correlates pre-operative CT scans with intraoperative anatomy, providing the surgeon with real-time guidance during the operation when visibility with the human eye is problematic.

First, the patient’s CT scan was downloaded into the surgical navigation computer, which converted the 2-D images into a virtual 3-D model of his unique spinal anatomy. Then, on the day of the surgery, he was fitted with a special probe carrying the LEDs. A camera, hooked to the computer, tracked the LEDs as Dr. Vaynman moved.

During the operation, image registration matched pre-defined points on the computer model to the patient’s real-time anatomy, creating a digital road map of the spine, and enabling Dr. Vaynman to avoid potential damage to surrounding tissue and structures. The surgery was successful and the recovery uneventful. Two days postoperatively, the patient had only incisional pain, which was controlled with small doses of pain medication. He no longer felt the pre-operative pain and was walking without difficulty.

“In the past, such complicated procedures were extraordinarily long and would necessitate taking multiple X-ray images to guide us and verify the location of instruments, placement of implants and alignment,” Dr. Vaynman explained. “Today, we can work with unprecedented precision, safety and accuracy without exposure to radiation or the need for open surgery. Additionally, in spinal fusion, image-guided surgery helps us plan the position, length and diameter of the pedicle screws, and then plant instruments exactly as planned.”

Image-guided surgery not only enhances visibility, reduces use of radiation in the OR and shortens the length of the procedure, it also allows for a speedier recovery, and provides immediate quality control, as well as the ability to check progress before concluding the operation.

For more information, call the Institute for Neurosciences at 1-866-WINTHROP or visit www.winthrop.org
Besides treating the underlying disease, critical care specialists focus on optimizing brain perfusion and fluid management. It has been demonstrated that sufficient brain perfusion, which secures oxygen delivery to the cells of the body, decreases morbidity and mortality.¹

“Oxygen delivery is a blood-flow issue vital to the well-being of NeuroICU patients, and effective fluid management is crucial,” said Elzbieta Wirkowski, MD, Medical Director of Winthrop’s NeuroICU and Director of the Cerebrovascular Disorders and Stroke Program.

In fact, the literature suggests that accurate measurement of fluid status and subsequent appropriate treatment remain unmet needs in neurological intensive care units, since only 50% of all hemodynamically unstable patients are considered fluid responsive.²

“Our goal is to optimize cardiac output by increasing the amount of fluid or by increasing blood pressure or heart rate. Proper assessment of fluid responsiveness can improve prognosis and prevent complications of fluid overload,” Dr. Wirkowski explained.

Winthrop’s NeuroICU utilizes NICOM, a completely noninvasive novel technique to establish objective parameters that determine fluid responsiveness.

Traditionally, hemodynamic assessments have relied heavily on blood pressure and ECG measurements. For decades, the use of...
invasive intravascular catheters (Swann-Ganz) has been the monitoring method of choice for accurate evaluation of hemodynamic status. However, while it provides essential real-time data, the practice carries significant risk, and benefits in patient outcomes have not been reported.

Winthrop’s NeuroICU utilizes NICOM — a completely noninvasive novel technique — to establish objective parameters that determine fluid responsiveness. (Fig. 1) The technology, which provides an immediate and continuous flow of information, is based upon the fact that the electrical impedance of the chest varies with the amount of blood present. Thus, when an alternating current is applied to the chest, the resulting voltage changes with the pulsatile blood flow in the large thoracic arteries.

The data are delivered to a computer for analysis, storage and future recall. “We’ve long known that the cardiovascular system forms a new dynamic for every heartbeat,” said Dr. Wirkowski. “Therefore, hemodynamically significant blood flow is not cardiac output flow per minute, but rather an indexed blood flow per beat.”

Monitoring cardiac output with NICOM begins with the placement of four dual sensors on the outside of the patient’s chest or back, with two sensors positioned above and two below the heart. (Fig. 2) An electric current of known frequency is applied across the thorax between the outer pair of electrodes. Then, a signal is recorded between the inner pairs of the sensors. The change in phase of the voltage and current waveforms is analyzed with the help of a highly sensitive phase detector that can sense tiny phase shifts produced by changes in impedance, which are closely correlated with aortic blood volume. The signal is translated into flow. Ventricular outflow drives changes in the phase shift of radiofrequency waves as they cross the chest, and measuring the difference in phase between the current and voltage waveforms enables the calculation of blood flow. “With the ECG leads built into the medical censors, we can detect heart rate and measure cardiac output,” Dr. Wirkowski said.

NICOM permits users to obtain a hemodynamic profile for differential diagnosis and baseline assessment. If oxygen perfusion needs to be improved, the technology first assesses fluid status. If fluid is optimized, but oxygen perfusion remains inadequate, the available data guide the practitioner to the next step in treatment, which could be drug intervention to increase contractility of the heart or reduce afterload. Continued monitoring with NICOM also quickly assesses the intervention’s effectiveness. In addition to fluid management and optimization of oxygen delivery, NICOM can also help reduce over or under resuscitation, prevent unnecessary intubations or delayed extubations, and avoid unwarranted fluid removal or fluid overload.

“Our data show that NICOM is safe and useful in cases of intubated patients with sepsis, hypotension, hypertensive therapy in subarachnoid hemorrhage or during hypothermia therapy,” reported Dr. Wirkowski. “It is also useful in non-intubated and alert patients where fluid status must be monitored closely.”

For more information, call the Institute for Neurosciences at 1-866-WINTHROP or visit www.winthrop.org

REFERENCES
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Dr. Mark Stecker is Board Certified by the American Board of Psychiatry and Neurology in Neurology and Clinical Neurophysiology, as well as by the American Board of Clinical Neurophysiology in EEG and by the American Board of Neurophysiologic Monitoring in IntraOperative Neurophysiology. His special clinical interests are EEG/epilepsy and intraoperative neurophysiologic monitoring. His research interests center on the response of peripheral nerve to ischemia, the properties of electrodes and information theory. Prior to his appointment as Chairman of Neuroscience at Winthrop, he was Associate Chair for Neurology in the Department of Neuroscience at Marshall University in Huntington, West Virginia, where he was also a Professor of Neuroscience. His postgraduate training includes a Dana Fellowship in Neuroscience/Epilepsy/EEG at the University of Pennsylvania and Graduate Hospital in Philadelphia. He completed a residency in neurology at the Hospital of the University of Pennsylvania and an internship in medicine at Lankenau Hospital in Philadelphia. Dr. Stecker earned his medical degree from Columbia University’s College of Physicians and Surgeons. He is a Fellow of the American Clinical Neurophysiology Society. Dr. Stecker is a senior member of the IEEE (Institute of Electrical and Electronics Engineers) and has authored over 100 papers and articles.

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Dr. Michael Brisman specializes in stereotactic surgery and radiosurgery for brain tumors and trigeminal neuralgia. He is Board Certified by the American Board of Neurological Surgeons and is a Fellow of the American College of Surgeons. His postgraduate training includes a neurosurgical residency and surgical internship at The Mount Sinai Medical Center in New York, where he was Chief Resident. He received his medical degree from Columbia University’s College of Physicians and Surgeons. Dr. Brisman has published numerous articles in professional journals. He is past President of the Nassau County Medical Society and President of the New York State Neurosurgical Society.

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Dr. Jonathan Brisman specializes in cerebrovascular and endovascular surgery for diseases of the central nervous system. As one of fewer than 100 neurosurgeons nationwide with dual training in microneurosurgery and endovascular techniques (and the first on Long Island), he is skilled in aneurysm clipping and endovascular coiling for brain aneurysms, as well as in advanced procedures to treat brain arteriovenous malformations (AVM), carotid stenosis and acute stroke. His postgraduate training includes an Interventional Neuroradiology Fellowship at Roosevelt Hospital in New York and a Microvascular Neurosurgical Fellowship at Swedish Hospital in Seattle. He completed a neurosurgical residency and surgical internship at Massachusetts General Hospital, where he was Chief Neurosurgery Resident. Dr. Brisman received his medical degree from Columbia University’s College of Physicians and Surgeons. He has published over 40 articles in peer-reviewed neurosurgery journals, including “Medical Progress: Cerebral Aneurysms” in the New England Journal of Medicine and one on stroke management in Lancet Neurology.

Benjamin R. Cohen, MD  
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Dr. Benjamin Cohen is a Board Certified Neurosurgeon specializing in spinal surgery. His practice includes revision spine surgery, adult scoliosis and the treatment of spinal infection and metastasis. Fully versed in standard laminectomy and fusion techniques, Dr. Cohen has a special interest in minimally invasive procedures, including kyphoplasty and microdiscectomy, as well as surgery for spinal tumors. His postgraduate training includes a Fellowship in Complex Spinal Surgery at the University of Alabama, as well as a neurosurgical residency and general surgery internship at the Albany Medical Center, where he also received the House Staff Scholarly Research Award. Dr. Cohen earned his medical degree from The Chicago Medical School, where he was elected to Alpha Omega Alpha, the medical honor society. He has authored and co-authored numerous manuscripts and articles in the fields of neurosurgery and the spine, and has given many presentations on these topics.
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Dr. Artem Vaynman specializes in complex spinal surgery, minimally invasive spinal surgery and 3D spinal navigation. He treats a variety of spine problems, including degenerative scoliosis, spinal stenosis, compression fractures, back pain, herniated disc and sciatica. His postgraduate training includes a Fellowship in Complex Spine Surgery at the Cleveland Clinic Foundation and residencies in general surgery and neurosurgery at the New Jersey Medical School, University Hospital in Newark, where he served as Chief Resident in Neurosurgery. He obtained his medical degree at SUNY Downstate College of Medicine in Brooklyn. Dr. Vaynman has authored “Spinal Cord Injury and Paralysis” a chapter in Essentials of Orthopedic Surgery: Spine.

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Dr. Marc Wilkenfeld — a recognized expert in environmental medicine and the impact of 9/11 on victims, first responders and individuals near the site at the time of the disaster — has more than 20 years of clinical and teaching experience in the specialty. Board Certified in Occupational Medicine, Dr. Wilkenfeld served on an expert review panel of the Environmental Protection Agency’s Technical Advisory Task Force following the 9/11 terrorist attacks. He also consulted with corporations, community groups and government agencies on the disaster’s impact on health, assisting in the development of screening protocols for individuals exposed to the site. Dr. Wilkenfeld has evaluated hundreds of patients with illnesses related to the disaster, continuing to treat many of them. His postgraduate training includes a residency in occupational medicine at The Mount Sinai Medical Center in New York. He earned his medical degree from the University of Vermont College of Medicine. Dr. Wilkenfeld has authored several articles and book chapters on environmental medicine and has lectured extensively on the topic throughout the U.S., Europe, Canada and the Middle East.

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Dr. Elzbieta Wirkowski specializes in cerebrovascular neurology and neurocritical care. She is Board Certified in Neurology, Vascular Neurology and Neurocritical Care. Her postgraduate training includes a Cerebrovascular Fellowship at Long Island Jewish Medical Center (LIJ), where she participated in multiple research trials dealing with neurocritical and cerebrovascular problems. She also completed a residency and internship in neurology at LIJ. Dr. Wirkowski earned her medical degree with honors from Warsaw University in Poland, where she also studied molecular biology. She is the author of many publications dealing with neurocritical care and stroke, and presents regularly at national and international meetings.
Winthrop-University Hospital is a 591-bed teaching hospital located on Long Island in Mineola, NY. A major regional healthcare resource, the Hospital has been a leading healthcare provider for more than a century, dedicated to the integrity, dignity and well-being of every individual. Winthrop offers a full complement of advanced inpatient and outpatient services with a deep commitment to medical education and research.

Physicians and surgeons in Winthrop’s Institute for Neurosciences are pioneering the use of technologically advanced approaches for the diagnosis and treatment of diseases of the brain and spine, including computerized imaging systems, state-of-the-art surgical interventions and the latest generation of medication therapies.

The Institute’s interdisciplinary team includes neurologists; neurosurgeons; neurointensivists; pediatric neurologists and neurosurgeons; neuroradiologists; vascular surgeons; orthopaedic spine surgeons; neuro-oncologists; neuropathologists; neurophysiologists; and specially trained nurse practitioners, physician assistants and nurses. Specialized physical and occupational therapy, social work and other supportive services are also key components of the Institute. The Institute’s experts are up to date on the latest developments in neuroscience and help pave the way for new discoveries through participation in clinical research trials, which enable them to provide patients with access to tomorrow’s most promising therapies.

Winthrop-University Hospital’s Institute for Neurosciences

Programs & Services Offered by the Institute for Neurosciences

Neuroscience Intensive Care Unit
The 14-bed acute care NeuroICU is reserved for patients with serious, complex neurological issues. The focus is on providing continuous monitoring and instantaneous results of critical values, allowing the expert staff, experienced in using advanced technology and providing neurocritical care, to employ aggressive interventions that treat neurological deterioration.

Neurology
- Comprehensive Level 4 Epilepsy Center
- Movement Disorders Program
- Multiple Sclerosis Care Center
- Neurodiagnostic Laboratory
- Neuroradiology
- Neurosurgery
- Aneurysm Coiling & Clipping
- Disc Replacement
- Brain Aneurysm Program
- Brain Tumor Program
- Brain & Skull Base Surgery
- Carotid Stenting & Endarterectomy
- Cerebrovascular & Endovascular Surgery
- Chiari Decompression Surgery
- Complex & Minimally Invasive Spinal Surgeries
- Complex Cranial Surgery
- Computer-Assisted Resection of Brain Tumors
- CyberKnife® Radiosurgery
- Endoscopic Pituitary Surgery
- Epilepsy Surgery Program
- Facial Pain/Trigeminal Neuralgia Program
- Image-Guided Spine Surgery
- Kyphoplasty

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- Image-Guided Spine Surgery
- Kyphoplasty

Neuroradiology
- Aneurysm Treatment
- CT Perfusion Scanning
- Interventional Neuroradiology
- Neuroangiography

Pediatric Neurology & Neurosurgery
- Attention Disorders & Learning Disabilities Treatment
- Craniosynostosis Surgery
- Brain Tumor Treatment
- Evaluation & Treatment of Children with Headaches
- Evaluation & Treatment of Neurological Disorders

Pediatric Neurology & Neurosurgery
- Aneurysm Treatment
- CT Perfusion Scanning
- Interventional Neuroradiology
- Neuroangiography

For more information, call the Institute for Neurosciences at 1-866-NEURO-RX.