Cavernous Malformations: 7-Tesla MRI Enhances Expertise

Mayo Clinic uses 7-tesla MRI for enhanced visualization of cerebral cavernous malformations (Figure), facilitating optimal management of these vascular abnormalities.

“The 7-tesla magnet gives us significantly greater definition of a cavernous malformation. We are able to better understand the anomalous venous structures often associated with a malformation, which are probably, in many cases, the malformation’s cause,” says Giuseppe Lanzino, M.D., a neurosurgeon at Mayo Clinic in Rochester, Minnesota.

Mayo Clinic was the first center in North America to adopt clinical 7-tesla MRI. The advanced imaging technology augments Mayo Clinic’s expertise with this complex condition, aiding the diagnosis and decision about whether a cavernous malformation should be surgically removed to prevent bleeding.

“Cavernous malformations are challenging because there’s often a substantial risk of bleeding — but also risks associated with surgical removal, especially when malformations are located in highly eloquent areas of the brain,” says Kelly D. Flemming, M.D., a neurologist at Mayo Clinic’s campus in Minnesota. “We have a multidisciplinary team with experience in the natural history of cavernous malformations that works together to evaluate the risks and determine a management strategy.”

A designated Center of Excellence

Mayo Clinic is one of six centers in the United States designated as a Center of Excellence for cavernous malformation treatment and research by the Angioma Alliance, a patient advocacy group. As a fully integrated center, Mayo Clinic coordinates appointments across specialties.

“Usually, a patient can have all the imaging and consultations done and receive a treatment plan within two days,” Dr. Flemming says.

Patients with cavernous malformations are often young adults or sometimes children. A malformation might be asymptomatic and found incidentally, or a patient might present with bleeding, focal neurological deficits, headaches or seizures.

“These seizures can be quite difficult to control with medication. That might be an indication for surgery,” Dr. Lanzino says.

Cavernous malformations have a less than 2 percent annual risk of clinically significant hemorrhage. However, once a patient experiences a hemorrhage, there is a 30 to 50 percent chance of recurrent bleeding or a focal neurological deficit within five years, depending on the location of the cavernous malformation. As yet there are no known risk factors that a patient can modify to prevent future hemorrhage.

Yet the decision whether to resect a cavernous malformation that has bled isn’t necessarily straightforward. “There are a lot of misconceptions about cavernous malformations,” Dr. Lanzino says. “Although the risk of another bleed is fairly substantial, it’s also true that when a cavernous malformation bleeds, the surrounding tissue is often displaced rather than permanently damaged. Patients often improve on their own without any additional treatment.
while remaining at substantial risk of additional hemorrhage.”

At Mayo Clinic, decisions about the management of a cavernous malformation are made on an individual basis. In addition to subspecialized neurologists, the multidisciplinary treatment team includes experts in neuroradiology, stereotactic radiosurgery and open neurological surgery.

“Very particular trajectories and approaches are necessary to reach cavernous malformations, while minimizing as much as possible the risk of damage to surrounding tissue,” Dr. Lanzino says. “Our surgeons are well-experienced with these various approaches. We also have significant experience with cavernous malformations in areas where lesions were once considered inoperable — such as the brainstem and thalamus — with very good results.”

Dr. Lanzino notes that at Mayo Clinic, most patients who present with seizures experience better seizure control after resection of a cavernous malformation. “A significant percentage of these patients can potentially discontinue medication after being seizure-free for one to two years after surgery,” he says.

**Future treatment options**

Mayo Clinic is at the forefront of cavernous malformations research. Mayo researchers have published outcome research on 292 patients and have now enrolled 250 additional patients in the Mayo Clinic Cavernous Malformation Prospective Registry, an effort to learn more about the condition’s natural history.

Mayo Clinic is also part of a multicenter effort to develop the infrastructure for clinical trials of new therapeutics to help patients who aren’t eligible for surgical resection.

“There are now potentially five or six medications coming to clinical trial in the next three to five years. That was unheard of, even five years ago,” Dr. Flemming says. “It’s pretty exciting that there may be candidate medications for people who don’t want or can’t have surgery but also don’t want the risk of bleeding from a cavernous malformation.”

“We have made a lot of progress in the past 20 years with cavernous malformations, in terms not only of imaging and diagnosis but also of understanding the natural history and indications for treatment,” Dr. Lanzino adds. “We bring that experience, and our commitment to the best possible care for our patients.”

---

**Onco-Epilepsy: Simultaneous Management of Tumor and Seizures**

Mayo Clinic uses the term onco-epilepsy to describe the occurrence of seizures in association with brain tumors. Many people with brain tumors experience seizures, and as many as 30 percent of them continue to have seizures after tumor resection. Mayo Clinic takes a multidisciplinary and proactive approach, striving for optimal management of both tumors and seizures in a single surgical intervention.

“As neurosurgeons, we have been trained to remove tumors and leave the rest of the brain untouched, including areas that are epileptogenic. Patients often leave the operating room and immediately go on anti-seizure medication,” says Alfredo Quinones-Hinojosa, M.D., chair of Neurosurgery at Mayo Clinic in Jacksonville, Florida. “Our approach facilitates the safe removal of noneloquent tissue that is potentially epileptogenic, to manage tumor and epilepsy at the same time.”

This approach, described in the September 2018 issue of Mayo Clinic Proceedings, was born of the close collaboration between Mayo’s neurologists and neurosurgeons. “That relationship is so critical for identifying the optimal treatment for a patient with more than a single condition,” says William Tatum, D.O., a neurologist at Mayo’s campus in Florida. “Working together, the neurologist and neurosurgeon can avoid any disconnect and maximize tumor removal while also identifying epileptogenic networks, to improve outcomes.”

**Focus on quality of life**

As a tertiary center, Mayo Clinic has the technology and expertise to meet patients’ complex needs. Neuroradiologists use advanced technology to map the patient’s brain before tumor resection. The neurology and neurosurgery team uses these images to guide the surgical approach and to obtain a sense of which areas of the brain can be dangerous to touch or remove. During surgery, intraoperative stimulation and electrocorticography are used to identify eloquent and potentially epileptogenic tissue.

“Millimeters make a difference between a patient having movement or no movement, or between talking or not talking, after surgery. Extraordinary precision is needed,” Dr. Quinones-Hinojosa says.

After surgery, patients are monitored for
seizure control and for neurological and cognitive deficits. “We are in the very early stages of this approach, but our data seem to indicate that these patients are doing better in terms of seizure control,” Dr. Quinones-Hinojosa says.

“The goal is to avoid the need for anti-seizure medications, so patients can continue to drive and work and have a better quality of life,” he adds. “Mayo Clinic is a unique institution in the sense that neurosurgeons, neurologists, neuropsychologists and neuroradiologists work as a team to answer questions about how we can better provide for our patients who have two very disabling conditions.”

**Unique neurological nosology**

Dr. Tatum notes that brain tumors and seizures share metabolic pathways and molecular markers (Figure). For example, a Mayo Clinic study published in the March 2018 issue of *Neurology* demonstrated that high-frequency oscillations — which can be safely and reliably recorded during awake craniotomy in patients with brain tumor-related epilepsy — are prevalent in that disease. The researchers also found that the rate of high-frequency oscillations was higher in patients with IDH1-mutant than in IDH1-wild-type tumor genotypes.

“Normally, we think of brain tumor and epilepsy as separate entities. However, there’s a great deal of overlap,” Dr. Tatum says. “We might think more usefully about a unique neurological nosology.”

In addition, treatment for brain tumors and seizures is bidirectional. Anti-seizure medications can increase the life span of a person with glioma, and chemotherapy or radiation treatment for glioma can decrease seizures. “This is very exciting because it means that, rather than thinking of two separate conditions, focusing on the management of onco-epilepsy might be more effective,” Dr. Tatum says.

Other neurological conditions, such as traumatic brain injury, can also cause medically refractory seizures. “Eventually, there might be a way to tie together the different approaches that neurologists and neurosurgeons use to treat the huge numbers of patients with seizures who are failing medical therapy,” Dr. Tatum says.

“There’s a lot we still need to learn about individuals with onco-epilepsy and the outcomes of treatment,” he adds. “We need a team approach, with our patients and with other collaborating centers. That’s the only way to change the language we use to talk to one another and to patients, and to make greater strides in treatment.”

**For more information**


---

**Figure.** Illustration depicts the cysteine-glutamate exchange that underlies onco-epilepsy. A diffuse glioma is associated with a breakdown in the cysteine-glutamate exchange, resulting in excitotoxicity and neuronal cell death, leading to epileptiform abnormalities and high-frequency oscillations with seizures. Illustration reprinted with permission from *Mayo Clinic Proceedings.*
Halting the Circle: Comprehensive Neurogenetics Test Panels

Mayo Clinic uses comprehensive next-generation sequencing panels for the diagnosis of neurogenetic disorders, including neuropathy, epilepsy and neuromuscular conditions. The testing covers the expanding genotype-phenotype complexity of these conditions, facilitating timely, accurate diagnosis and optimal treatment.

“Many patients with these disorders keep circling back — getting additional referrals and repeating the same tests without getting an answer. We have developed targeted panels in an effort to provide quicker diagnosis of genetic causes and cost benefits,” says Christopher J. Klein, M.D., a neurologist at Mayo Clinic in Rochester, Minnesota. “We are committed to developing tests that provide accuracy and value.”

The epilepsy and neuromuscular testing allows physicians to order custom gene panels. “Occasionally a physician might have a patient whose phenotype runs so true to the disorder that testing for the whole panel isn’t needed — only a couple of genes,” Dr. Klein says. At Mayo Clinic Laboratories, physicians can select the genes they wish to have tested; the genes listed on the lab’s website link to an online catalog of human genes and genetic disorders, for additional information.

Algorithms to guide diagnosis
Mayo Clinic has developed and published diagnostic algorithms that utilize the targeted next-generation sequencing approach as well as onset age, family history and bedside clinical findings. The algorithms are clickable PDFs with links to the recommended testing.

The hereditary peripheral neuropathy algorithm includes a neuropathy test panel that incorporates 197 genes. Identifying a genetic cause for neuropathy has significant therapeutic implications. For example, last year the Food and Drug Administration approved two medications for the treatment of transthyretin (TTR) amyloidosis, a severe form of inherited neuropathy.

“If TTR amyloidosis is caught early, these drugs can reverse it. If the diagnosis is made later, the drugs can stop the neuropathy from progressing,” Dr. Klein says. “That’s the future of neurogenetics — finding therapies that target particular genes.” He notes that laboratory research is underway to find additional therapies targeting PMP22, another gene associated with the most commonly known inherited neuropathy.

Similar testing algorithms for familial epilepsy (Figure) and inherited neuromuscular myopathy are available from Mayo Clinic Laboratories. They were developed under the leadership of Erik C. Thorland, Ph.D., and Zhiyv (Neal) Niu, Ph.D. As with inherited neuropathy, the goal for familial epilepsy and neuromuscular myopathy is timely diagnosis and treatment.

“Genetic epilepsy often presents in infants with devastating consequences,” Dr. Klein says. “Finding a genetic abnormality can sometimes lead to a change in medical management.” Mayo Clinic’s unexplained refractory and/or familiar epilepsy algorithm also includes metabolic tests and autoimmune evaluations that might be considered.

Identifying a genetic cause for a neuromuscular condition can sometimes help a patient avoid a muscle biopsy. “There remains a role for biopsies, if the test panel results are negative or inconclusive,” Dr. Klein says. “But at Mayo Clinic, we are working to reduce unnecessary and invasive tests.”

New test for NAM
In addition to neurogenetic panels, Mayo Clinic has a range of autoimmune neurology testing — including a new test for necrotizing autoimmune myopathy (NAM), a serious muscle disease. A rare subset of people with NAM have a chronic disease course that can be mistaken for genetic forms of the disease. Early, aggressive immune therapy management can improve outcomes for people with NAM.

Mayo Clinic’s test is a single evaluation that incorporates both antibodies commonly associated with NAM — HMGCR-IgG and SRP-IgG. The detection of SRP-IgG is facilitated by a highly sensitive immunofluorescence-based assay that can discern the distinctive, characteristic pattern in a patient’s serum.

“At Mayo Clinic, we talk about matching the right patient with the right doctor,” Dr. Klein says. “Similarly, we are trying to match the right patient with the right test, for the greatest value and most rapid and accurate diagnosis.”

For more information
Custom gene ordering. Mayo Clinic Laboratories.

Who’s New, What’s New

Leonardo Rangel-Castilla, M.D., recently joined the Department of Neurosurgery at Mayo Clinic in Rochester, Minnesota. Dr. Rangel-Castilla has experience and expertise in the various treatment options for cerebral aneurysms, including microsurgery clip ligation and endovascular embolization. Learn more about Dr. Rangel-Castilla and Mayo Clinic’s approach to treating brain aneurysms. http://medprofvideos.mayoclinic.org/videos/brain-aneurysm-treatment

---

Epilepsy: Unexplained Refractory and/or Familial Testing Algorithm

Unexplained refractory and/or suspect familial epilepsy: All patients should have completed
• Magnetic resonance imaging (MRI)
• Electroencephalogram
Consider: metabolic or autoimmune testing based on clinical presentation (see metabolic and autoimmune testing tables)

Family of epilepsy with known mutation

YES

NO

Epilepsy syndrome present with isolated single gene cause?

YES

Order: single gene(s) via Custom Gene Ordering from ESPAN/Epilepsy/Seizure Genetic Panels by Next-Generation Sequencing (NGS)
See Table below for a list of Individual Gene Suspects*

<table>
<thead>
<tr>
<th>Type</th>
<th>Gene</th>
<th>OMIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceroid lipofuscinosis, neuronal 2</td>
<td>TPP1</td>
<td>204500</td>
</tr>
<tr>
<td>Ceroid lipofuscinosis, neuronal 3</td>
<td>CLN3</td>
<td>204200</td>
</tr>
<tr>
<td>Dravet syndrome, severe myoclonic epilepsy of infancy</td>
<td>SCW1A</td>
<td>607208</td>
</tr>
<tr>
<td>Encephalopathy epileptic, early infantile</td>
<td>PCDH19</td>
<td>300088</td>
</tr>
<tr>
<td>Encephalopathy epileptic, early infantile; seizures, benign neonatal</td>
<td>KCNJ2</td>
<td>613720; 121200</td>
</tr>
<tr>
<td>GLUT1-deficiency syndrome</td>
<td>SLC2A1</td>
<td>606777</td>
</tr>
<tr>
<td>Infantile spasms</td>
<td>ARX</td>
<td>308350</td>
</tr>
<tr>
<td>Myoclonic epilepsy progressive</td>
<td>CSTB</td>
<td>254800</td>
</tr>
<tr>
<td>Myoclonus-nephropathy</td>
<td>SCAR82</td>
<td>254900</td>
</tr>
<tr>
<td>Pyridoxine-dependent epilepsy</td>
<td>ALDH7A1</td>
<td>266100</td>
</tr>
<tr>
<td>Rett syndrome (order as MECPZ/MECP2 Gene, Full Gene Analysis)</td>
<td>MECP2</td>
<td>312750</td>
</tr>
<tr>
<td>Seizures, benign neonatal</td>
<td>KCNJ3</td>
<td>121201</td>
</tr>
<tr>
<td>Temporal epilepsy familial</td>
<td>LGII</td>
<td>600512</td>
</tr>
</tbody>
</table>

*Individual Gene Suspects

Figure. A portion of Mayo Clinic’s algorithm for unexplained refractory and/or familial epilepsy is shown. The full algorithm is at https://www.mayocliniclabs.com/it-mmfiles/Epilepsy_Unexplained_Refractory_and_or_Familial_Testing_Algorithm.pdf.
Headache Disorders: Subspecialized, Compassionate Care

Jonathan H. Smith, M.D., a headache neurologist at Mayo Clinic in Phoenix/Scottsdale, Arizona, answers questions about subspecialized management of headache disorders. Mayo Clinic is committed to providing optimal care for people with headaches, an often-underserved group.

Q: When should a physician think about referring a patient for subspecialized headache care?

Headache disorders need to be taken seriously. They can strike in the prime of life, affecting quality of life, career stability and relationships — truly every aspect of a patient’s life.

Referral to a headache neurologist is appropriate anytime there is uncertainty regarding the diagnosis or management of a patient with headaches. Since the symptoms of many different headache disorders are very similar, a headache specialist will focus on a detailed clinical history and examination to ensure that the diagnosis and treatment approaches are correct.

Unfortunately, headache disorders are often misdiagnosed, mistreated and not given their due respect in the overall scope of medical practice. Patients often feel stigmatized. The members of our group are passionate about the care of patients with headache disorders. We are actively engaged in patient education and advocacy.

Q: What types of headaches can a headache neurologist manage?

Any type of headache falls within the purview of a headache neurologist. At Mayo Clinic, we are able to manage the spectrum of pain treatments, including acute headache, sports-related concussion and chronic pain rehabilitative efforts. Our group also has extensive experience in the care of individuals with common headache disorders, such as migraines and cluster headaches, as well as more unusual headache disorders, such as cerebrospinal fluid pressure disorders, trigeminal neuralgia and giant cell arteritis.

Q: What other medical specialists might be involved in managing headache disorders?

Headache disorders intersect with a wide scope of medical specialties, including internal medicine, sleep medicine, otorhinolaryngology, psychiatry, ophthalmology, allergy, physical medicine, integrative medicine, pain medicine and neuroradiology. As members of a fully integrated practice, Mayo Clinic doctors work as a team to care for all the needs that our patients present, in a coordinated and timely fashion.

Q: What is Mayo Clinic’s approach to the management of headache disorders?

Patients referred to Mayo Clinic can expect a comprehensive and patient-centered approach to their headache concerns. We are able to provide a breadth of treatment options, depending on the patient’s diagnosis and personal preferences, including:

• Nonmedical options, such as acupuncture
• Injection-based treatments, such as nerve blocks and onabotulinumtoxinA
• Device-based approaches, such as non-invasive vagal nerve stimulation
• Traditional medical approaches, such as topiramate or calcitonin gene-related peptide antibodies
• Interventional approaches, such as radiofrequency ablation

We also have opportunities for patients to be involved in clinical trials of emerging treatments. Mayo Clinic is working to advance headache care through research. As clinicians, we regularly interact with our research colleagues and are able to inform one another to advance our shared mission of always improving our level of care for our patients.

With a detailed, patient-oriented and often multidisciplinary approach, we are generally able to help even people with the most challenging conditions.

Q: What new insights and therapies are emerging for the management of headache disorders?

Our understanding of the biology of headache disorders is rapidly advancing. That, in turn, is leading to new therapies.

In the last year alone, the Food and Drug Administration has approved new treatments that are effective and have low side effect profiles, including therapies targeting calcitonin gene-related peptide. Mayo Clinic was actively involved in designing clinical trials for these medications and analyzing the resulting data. In addition, our Neuroimaging of Headache Disorders Laboratory is using functional and structural MRI to identify subtypes of migraine.

It’s an exciting time to be able to care for patients with these conditions. In our practice, we like to empower our patients, validate their concerns and take a compassionate approach to care.
Research Highlights in Neurology and Neurosurgery

Cerebral Microbleeds and Amyloid Burden
Cerebral microbleeds are common in the aging population and may identify asymptomatic individuals at increased risk of intracerebral hemorrhage and cognitive decline. Prior studies using amyloid PET to study cerebral microbleed pathogenesis haven’t been population based; therefore, it hasn’t been clear whether cerebral microbleeds in the general population are related to beta-amyloid burden. Mayo Clinic researchers have found that the prevalence of cerebral microbleeds increases with age and that beta-amyloid load is associated with lobar but not with deep cerebral microbleeds. From the population-based Mayo Clinic Study of Aging, 1,215 participants underwent a medical examination and 1,215 participants underwent MRI from October 2011 to February 2017. Of those, 1,123 participants (92 percent) underwent PiB-PET scans. Among the 1,215 participants, 20.4 percent had at least one cerebral microbleed. The frequency of cerebral microbleeds increased substantially with age by decade (11 percent for people ages 60 to 69 years, 22 percent for 70 to 79 years, and 39 percent for 80 years and older). After adjusting for age, sex, and hypertension, PiB standardized uptake value ratio was associated with increased odds of lobar cerebral microbleed but not deep cerebral microbleed. Amyloid burden correlated with increasing frequency of cerebral microbleeds, supporting cerebral amyloid angiopathy as the pathologic substrate for multiple lobar cerebral microbleeds, even in asymptomatic individuals. The researchers note that identifying individuals at higher risk of intracerebral hemorrhage or complications from anti-amyloid therapy will be important directions for future research. (Graft-Radford J, et al. Cerebral microbleeds: Prevalence and relationship to amyloid burden. Neurology. 2019;92:e253.)

Treatment Outcomes for Spinal Cord Low-Grade Gliomas
Primary spinal cord tumors are rare, and evidence-based management of these patients is a source of controversy. In the largest study of spinal cord low-grade gliomas to date, Mayo Clinic researchers found a significant survival benefit among patients with younger age, gross total resection and the absence of radiotherapy. The Surveillance, Epidemiology, and End Results (SEER) cancer registry was used to identify patients with WHO grade I-II primary spinal cord astrocytomas from 2006 to 2012. A total of 561 patients were identified. Among them, 15.5 percent received a gross total resection, 26.1 percent had a subtotal resection and 46.2 percent had an unidentified extent of resection. More than 59 percent of patients didn’t receive radiation therapy at any point during treatment; 40.6 percent underwent radiation therapy. Only patients with gross total resection had statistically improved survival. Patients with subtotal resection had nearly identical survival compared with patients who had no surgery. Histologic grade didn’t statistically impact survival. Radiotherapy was associated with increased odds of mortality. The researchers note that this finding cannot be safely used to draw conclusions about treatment. Additional research is needed to better define the role of radiotherapy and tumor grading in patients with spinal cord low-grade glioma. (Diaz-Aguilar D, et al. Prognostic factors and survival in low grade gliomas of the spinal cord: A population-based analysis from 2006 to 2012. Journal of Clinical Neuroscience. In press.)

Predictors of Unplanned Returns to the OR After Neurosurgery
Unplanned return to the operating room (ROR) is gaining attention as a metric of surgical quality. However, large-scale data on the appropriateness and usefulness of this measure in neurosurgery are scarce. In a study of nearly 200,000 neurosurgeries performed nationwide, Mayo Clinic researchers found that the most common reasons for unplanned ROR were wound complications or surgical site infections, hematoma evacuations and repeat surgeries. The researchers queried the American College of Surgeons National Surgical Quality Improvement Program multicenter database, and identified 193,459 neurosurgical cases from 2012 to 2016. A total of 7,067 (3.7 percent) of those cases had at least one unplanned ROR within 30 days after the index procedure. The three most common inpatient cranial and spinal operations were craniotomy for intra-axial neoplasm, convexity or falk meningioma, or skull base tumor; anterior cervical discectomy and fusion; and posterior lumbar decompression and posterior lumbar fusion. Operative time was the most important risk factor for unplanned ROR, followed by patient comorbidities and demographics. The researchers note that the findings highlight the factors that may be amenable to modification and quality improvement to optimize neurosurgical outcomes, and also may inform stakeholders on the optimal parameters that need to be considered when crafting, endorsing and implementing quality metrics for neurosurgery. (Kerezoudis P, et al. Predictors of unplanned returns to the operating room within 30 days of neurosurgery: Insights from a national surgical registry. World Neurosurgery. In press.)

To read more about Mayo Clinic neurosciences research and patient care, visit https://www.mayoclinic.org /medical-professionals.
Expedited Patient Referrals to Mayo Clinic
Departments of Neurology and Neurologic Surgery
Continuing Medical Education Programs

2019 courses

April
Mayo Clinic Clinical Autonomic Quantitation Workshop 2019
April 26-27, 2019
Mayo Clinic, Rochester, Minn.

June
8th Quadrennial International Conference on Vestibular Schwannoma and Other CPA Tumors: Advancing Care through Ideas and Innovation 2019
June 18-21, 2019
Mayo Civic Center, Rochester, Minn.

July
Neurology in Clinical Practice 2019
July 18-21, 2019
Hilton Hawaiian Village Waikiki Beach Resort, Honolulu

November
Convergence Neuroscience 2019
Nov. 7-9, 2019
The Ritz-Carlton, St. Thomas, U.S. Virgin Islands

Parkinson’s Disease and Other Movement Disorders 2019
Nov. 15-16, 2019
Mayo Clinic Education Center, Phoenix

Mayo Clinic Multidisciplinary Spine Care Conference 2019
Nov. 22-23, 2019
The Ritz-Carlton Amelia Island, Amelia Island, Fla.

2020 courses

February
8th Annual Acute Care of the Complex Hospitalized Patient for NPs & PAs 2020
Feb. 12-15, 2020

October
12th International Conference on Frontotemporal Dementias 2020
Oct. 7-10, 2020
Hilton Minneapolis, Minneapolis

Information and registration
Mayo Clinic in Rochester, Minnesota
Phone: 800-323-2688 (toll-free) or 507-284-2509
Email: cme@mayo.edu

Mayo Clinic in Jacksonville, Florida
Phone: 800-462-9633 (toll-free) or 904-953-0421
Email: cme-jax@mayo.edu

Mayo Clinic in Phoenix/Scottsdale, Arizona
Phone: 480-301-4580
Email: mca.cme@mayo.edu

Website: https://ce.mayo.edu/neurology-and-neurologic-surgery

Expedit Patient Referrals to Mayo Clinic
Departments of Neurology and Neurologic Surgery

While Mayo Clinic welcomes appointment requests for all neurologic and neurosurgical conditions, patients with the following conditions are offered expedited appointments:

1. Cerebral aneurysms
2. Cerebral or spinal arteriovenous malformations
3. Brain, spinal cord or peripheral nerve tumors
4. Epilepsy with indications for surgery
5. Carotid disease

Mayo Clinic welcomes inquiries and referrals, and a request to a specific physician is not required to refer a patient.