The Neurosciences Center at University of Colorado Hospital has experienced tremendous growth during the past five years.

In addition to recruiting acclaimed faculty and acquiring important equipment and technology, we have more than doubled the size of our neurocritical care unit and created several new clinical and research programs, including cognitive disorders and a headache medicine center.

Even in the midst of building, the Neurosciences Center has been recognized often for our consistent and impressive performance— and we owe these achievements to the countless individuals at University of Colorado Hospital (UCH) who, for many years, have been steadily improving patient care while advancing the field of neurosciences. In fact, our history includes many innovative “firsts” that have helped pave the way for the success we enjoy today.
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Dear Colleagues,

Chances are, your reasons for pursuing a career in neurosciences are similar to ours. Like you, we are awestruck by the power and mystery of the brain. We are excited about its untapped potential and the discoveries yet to be made. And we are humbled by our ability to help people with life-changing neurological conditions, many of whom are living longer and fuller lives thanks to research that has paved the way for new medical and surgical treatment options.

At University of Colorado Hospital (UCH), we share your passion – and our accomplishments prove it. As the following pages illustrate, in 2014 and 2015 our team continued to produce outcomes in quality, safety, clinical care and research that are often unrivaled. Our achievements have been validated time and again by independent organizations that rate health care institutions or allocate funding based on objective data. While many hospitals can claim a national ranking of some kind, fewer have received multiple prestigious designations within one particular field. Some of the awards and certifications we are most proud of include:

- UCH is one of only three institutions named by the American Stroke Association and Bugher Foundation as a Center of Excellence in Stroke Collaborative Research (which came with a four-year grant to study how children recover from stroke).
- The Society of Neurological Surgeons (SNS) has designated fellowship training in Neurocritical Care, Stereotactic and Functional Neurosurgery, and Spine Neurosurgery to the University of Colorado Department of Neurosurgery.
- We have received five-year funding from the National Multiple Sclerosis Society thanks to our designation as a Collaborative MS Research Center.
- UCH has been certified by the Muscular Dystrophy Association (MDA) as the only MDA/ALS program in Colorado, and one of only 42 in the country. We also have an active research grant from the MDA.
- We have been named a Network for Excellence in Neuroscience Clinical Trials (NeuroNEXT) site by the National Institutes of Health and the National Institute of Neurological Disorders and Stroke.
- UCH is the home to neurocritical specialists certified by both the SNS CAST and the United Council for Neurologic Subspecialties. Our Neuro ICU received the prestigious Beacon Award for Excellence – Gold Level, one of seven in the nation.
- Our epilepsy center, including our inpatient monitoring unit, is a National Association of Epilepsy Centers Level 4 program.
- Our neurology and neurosurgery programs were again ranked in the top 30 nationally by U.S. News and World Report.

While it is evident that research is a cornerstone of our program, we are just as passionate about patient care and teaching. Throughout this report, you will find many examples that demonstrate our commitment to clinical effectiveness, safety, efficiency and the overall patient experience. Less tangible, but just as important, is the spirit of innovation that is present in everything we do. Lastly, throughout these pages you will get a sense of just how critical our people are. Our accomplishments simply would not be possible without the hundreds of individuals who are equally devoted to healing, science and education. This report is a salute to our caregivers, physicians, scientists, professors and administrative partners.

We are proud to share our annual summary of neurosciences outcomes, and hope you find the content as energizing and interesting as we do.

Kevin O. Lillehei, M.D.  
Chair, Neurosurgery

Kenneth L. Tyler, M.D.  
Chair, Neurology
UCH is an academic medical center within UCHealth, and a partner to the University of Colorado School of Medicine. Together we have created a Neurosciences Center that is committed to the pursuit of superior patient care, excellent medical education and pioneering research.

### Outpatient Satisfaction by Practice

<table>
<thead>
<tr>
<th>Practice</th>
<th>Satisfaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spine</td>
<td>97%</td>
</tr>
<tr>
<td>Neurosurgery</td>
<td>99%</td>
</tr>
<tr>
<td>Neurology</td>
<td>96%</td>
</tr>
</tbody>
</table>

Source: Patient Pulse surveys; percentage of positive responses in 2014
Our physicians offer subspecialty expertise in cerebrovascular and stroke care, cognitive disorders, epilepsy, headache, movement disorders, multiple sclerosis, neurocritical care, neuromuscular care, neuro-oncology, neuro-ophthalmology, neuroradiology and spine care.

BY THE NUMBERS

UCH is the largest provider of neurological and neurosurgical care in the region, and leads the state in the amount and quality of care provided to patients. We also enjoy a growing and well-funded research program.

» In 2014 we saw more than 45,000 outpatient visits, and our neurosciences units accounted for 3,015 admissions, with 18,110 patient days and nearly 3,400 neurosurgical and spine procedures.
» Our ambulatory patient satisfaction scores confirm that 96 percent of patients “highly recommend” our neurology and spine services, and 99 percent highly recommend our neurosurgery program.
» With more than $18 million in research grants and awards in 2014, our neurosciences program is among the top 30 programs funded by the National Institutes of Health.
» Together the departments of neurology and neurosurgery are participating in more than 100 active clinical trials, including more than 45 clinical and laboratory trials for multiple sclerosis alone.

TRADITION OF EXCELLENCE

Patients with neurological conditions ranging from the familiar to the rare are often referred to UCH for access to the latest medical and surgical treatment options — including therapies developed or tested by our own physicians and scientists. For example:

» UCH was the first center in Colorado to perform cerebral intra arterial lysis for stroke.
» We have the oldest neuro intensive care unit and hired the first neuro-intensivist in the region.
» We offer the only neurocritical care and neurovascular fellowship programs in the state.
» Our neuro-ophthalmologists have pioneered the use of 3-D simulation vision testing.
» We are the only academic medical center in Colorado to offer an EEG biofeedback program for patients with epilepsy.
» As one of the most experienced deep brain stimulation (DBS) centers in the nation, we were the first in the region to perform stereotactic guided sedated implantation (also known as MRI-based DBS).
» Our stroke team is reshaping how we deliver acute stroke care with the implementation of the nation’s third mobile stroke treatment unit in early 2016.

THE JOURNEY CONTINUES

While we have much to be proud of, UCH has purposely created an environment of continuous improvement that forces us to challenge ourselves. Whether we are recreating processes that have led to an unsatisfactory patient experience or inefficient care, or launching new programs and services that require vast amounts of time and energy, our team understands that maintaining a laser focus on outcomes is one of the most important things we can do for our patients.
REDEFINING HEALTH CARE QUALITY

At University of Colorado Hospital, we take pride in our work. Sure, we are proud of our reputation and rankings, but it goes well beyond awards and achievements. Mostly we are proud to be that special kind of place where collaboration is key and the patient experience informs all of our decisions. We find joy and gratification in knowing we have provided the best care possible.

As the primary teaching hospital for University of Colorado School of Medicine, UCH offers a unique blend of academic-based and community-focused care. This partnership also allows us to conduct research that gives our patients access to novel clinical trials, and ultimately helps us attract top clinical staff, including faculty who are world renowned for their efforts to bring science to the bedside.

Indeed, the success of our Neurosciences Center is not an anomaly – in 2015, UCH was nationally ranked by U.S. News & World Report in 11 adult specialties, including the distinction of being named second in the country for pulmonology.

Our ability to provide exceptional patient care across so many service lines is due largely to our hospital-wide focus on quality. The task of continually self-monitoring our performance is baked into our culture, and allows us to be nimble in response to variances in patient satisfaction scores, clinical outcomes or medical quality measures. Evidence of our commitment includes:

» In 2014, UCH received its fourth consecutive Magnet designation by the American Nursing Credentialing Center. Notably, fewer than 30 hospitals in the world have achieved this.

» For five consecutive years, we have been named one of the highest-performing academic hospitals in the U.S. by the University Health System Consortium, which ranks hospitals based on outcomes in patient safety, clinical effectiveness, clinical efficiency, patient experience, mortality, and equity of care for patients, regardless of their ethnic or socioeconomic backgrounds.

» Compared to national data, our overall patient experience scores from June 2014 to June 2015 place UCH in the top 25 percent of hospitals.

While health care quality can be defined and measured in many different ways, at UCH one thing is consistent: the care we provide must be safe, effective and evidence-based. We are proud – and fortunate – to work in an environment that never loses sight of that.
KEY 2014 METRICS

» Compared to the previous year, the percentage of our hospital patients who rated UCH a nine or 10 (out of a possible score of 10) increased from 77 percent to 78 percent, compared to a national average of 71 percent. This places UCH in the 89th percentile.

» 83 percent of our hospital patients said they would “definitely recommend” UCH, compared to a national average of 71 percent.

» Compared to other U.S. teaching hospitals, our neurosciences unit scored in the 80th percentile in terms of overall rating, and our Neuro ICU scored in the 90th percentile.

» UCH is nationally ranked by U.S. News & World Report in 11 adult specialties, including Neurology & Neurosurgery (26th).
Embracing Innovation to Create New Standards of Care

At University of Colorado Hospital, we have uncovered a simple truth: The best patient care is found at the intersection of clinical practice, medical education and research. When these three elements are performed well – and performed together – the results speak for themselves. We achieve outstanding quality, strong outcomes and happy, healthy patients.

As an academic medical center, we are fortunate to be able to weave a fourth element, innovation, into everything we do. In our environment of continuous improvement, innovation serves us well because it allows us the freedom to make changes, try new things and adopt new practices that ultimately enhance patient care.

In 2014 and 2015, our Neurosciences Center found several new ways to bring innovation to our patients. In some cases we are offering innovation at the bedside, for example, with advanced intraoperative imaging equipment or new surgical treatments for patients with epilepsy. In other cases, we are bringing innovation out into the community, thanks to the launch of programs such as our mobile stroke treatment unit (MSTU). Below are a few examples of how we’ve helped transform clinical care during the last year.

INTRAOPERATIVE MRI

Earlier this year, we were thrilled to go live with intraoperative magnetic resonance imaging (iMRI) guidance in our operating suite. This technology will offer tremendous value, in the form of safety and efficacy, to our neurosurgeons and patients during delicate brain or pituitary tumor resections.

The addition of the 3.0T unit, which weighs nine tons and spans two operating rooms, represents a major step forward in neuroimaging, because it allows our neurosurgeons to view the brain in real time before, during and after surgery. Specifically, iMRI increases surgical vision by helping to localize and target the tumor, precisely identifying tumor margins and accounting for shifts in the brain that can occur during surgery.

Recently published results of the first randomized controlled trial of iMRI found significantly lower residual tumor volume than conventional microsurgery. Using iMRI, 95.8 percent of patients were found to have had complete tumor resection, compared to 68 percent in the conventional surgery group.

Not only can iMRI guidance help our surgeons confirm that the entire tumor was removed, it helps ensure there is minimal damage to surrounding healthy structures that are key to the patient’s postoperative functional ability. This also helps reduce the need for a patient to have a second surgery.
MOBILE STROKE TREATMENT UNIT

It goes without saying that stroke can have devastating consequences if not treated quickly, but those of us in the medical community are all too familiar with the myriad reasons a patient may not receive tissue plasminogen activator (tPA) or neurointerventional surgery in time to prevent disability or death.

While we cannot control how long it takes for a stroke victim or their loved one to call 911, we have a greater influence on the treatment process including “door to needle” times once a patient arrives in our emergency room – and UCH has met or exceeded all of the American Heart Association’s “Target: Stroke” guidelines for getting a stroke patient evaluated, diagnosed and treated.

Despite better-than-average outcomes, our cerebrovascular team felt strongly that there was still room to dramatically alter and improve care for stroke patients in Denver and beyond. With that in mind, we embarked on a complicated but much needed effort to create the country’s third mobile stroke treatment unit. This “emergency room on wheels” which launched early 2016, will allow eligible patients to receive tPA at the scene, saving precious time and brain function.

From creating agreements with local emergency response services and 911, to building the unit and getting it inspected and staffed, to ensuring the on-board data communication systems are functional and HIPAA compliant, establishing a MSTU is no small feat – but we believe the payoff will be invaluable in terms of improving public health.

To put our theory to the test, we will participate in a national, multicenter study assessing the feasibility of implementing mobile stroke units and their effects on treatment time and outcomes, compared to traditional emergency services such as ambulance transport. Together, we hope to change the standard of care for stroke across the nation.
EPILEPSY SURGICAL ADVANCES

Epilepsy diagnosis and treatment has come a long way in the last 50 years, thanks to the convergence of several factors, including: new classes of medication that are safer and more tolerable; the development of surgical treatments including vagus nerve stimulation; new neuroimaging techniques such as functional MRI and magnetoencephalography; and the acceptance of evidence-based, integrative approaches like neurofeedback.

The Comprehensive Epilepsy Center at UCH has long been a leader in seizure disorder management, and we are continuing that legacy by offering our patients novel surgical treatments that are not widely available. In addition to performing traditional and neocortical resections, and implanting vagal nerve stimulators, we are now offering the next generation of implantable devices – specifically, the RNS Neurostimulator made by NeuroPace.

The programmable NeuroPace device provides responsive neurostimulation, meaning it detects abnormal electrical activity in the brain with the help of intracranial leads that are constantly recording brain activity, and then responds by delivering mild electrical stimulation. This response helps interrupt the abnormal activity associated with an impending seizure, and prevents the seizure from occurring. To date, clinical trials have shown patients who received the NeuroPace cranial implant are experiencing significant improvement in seizure frequency.

UCH also offers intracranial electrode placement prior to epilepsy surgery, a technique that allows our physicians to precisely map where in the brain seizures are occurring. In cases where a routine EEG cannot detect the origin of seizure activity, our surgeons can place electrodes directly on the brain. These depth electrodes not only provide detailed EEG monitoring, they help our physicians identify the healthy parts of the brain – including critical areas responsible for speech and motor control – that need to be preserved during surgery.
NEW PAIN RELIEF OPTIONS FOR HEADACHE PATIENTS

To some, treating headache disorders may not seem as glamorous as treating other neurological conditions that require lifesaving surgery or other dramatic measures. But in terms of making a difference, something as “simple” as a headache can cause frequent debilitating pain for millions of people in the U.S. Compare that to the relatively rare incidence of brain cancer, for example, and it’s easier to understand the importance of high-quality headache medicine.

In 2012, UCH created its multidisciplinary headache center, offering patients a combination of top-notch neurological care and access to new clinical trials. As anticipated, our program is growing quickly due to patient demand. People who have been unable to manage their pain through traditional methods, including medication, are turning to UCH for innovative new options that are safe and effective.

For example, our physicians are performing sphenopalatine ganglion (SPG) blocks much more easily—with far less discomfort to the patient—thanks to a relatively new device called the SphenoCath. Historically, SPG blocks were performed with a long needle through the side of the head or with a stiff cotton swab pushed up through the nose. Results were often inconsistent and patients sometimes had to be sedated. Today, with the aid of the SphenoCath, our physicians can quickly apply anesthetic to the sphenopalatine ganglion in both children and adults, often providing immediate relief to patients suffering from migraine, cluster headache, or facial pain.

UCH also is part of a pilot study to evaluate prophylactic treatment of chronic migraine using the Cefaly device, which was approved by the Food and Drug Administration in March 2014 for episodic migraine prevention. Formally called a cranial analgesic electrotherapeutic device, this “wearable headband” generates micro-impulses that stimulate the trigeminal nerve, often associated with migraine pain. Because the Belgian device is so new to the United States, there is little data to support its claims, and patient and physician reviews to date are mixed. To that end, UCH researchers are helping evaluate whether use of the device leads to fewer migraines and a reduction in use of migraine medication.

3-D NAVIGATION DURING SPINE SURGERY

Thanks in part to our status as a tertiary referral hospital, patients turn to the UCH Spine Center when they need complex surgery such as spinal fusion or spinal tumor resection. While there are risks associated with any surgical procedure, today spine surgery is safer and more effective than ever as a result of the development of minimally invasive techniques and advancements in surgical imaging.

At UCH we’ve witnessed strong patient outcomes associated with the use of our three-dimensional surgical navigation system, which offers our neurosurgeons and orthopedic surgeons enhanced surgical vision before, during and after spine surgery. In addition to pre-operative planning, our 3-D system provides intraoperative imaging that helps the surgeon view the patient’s anatomy in real time, allowing for better instrument and hardware placement, as well as navigation around critical structures in the spine that need to be preserved.

REMAINING THOUGHTFUL ABOUT INNOVATION

While innovation helps guide us, at UCH we’re also careful about when, where and how to innovate. As technology rapidly changes the way we deliver care, we must balance our need for better devices and the latest equipment with the knowledge that sometimes, what our patients most need is simple human connection—feeling like their physician answered all their questions, or receiving reassurance prior to a procedure.

At UCH we use innovation to help improve patient care, while preserving the old-fashioned elements that can make the patient and caregiver relationship so meaningful.
SETTING NEW STANDARDS FOR CANCER CARE

Within the cancer treatment community, University of Colorado Hospital is known for our depth and breadth of research, as demonstrated by the University of Colorado Cancer Center’s elite designation as one of only 45 National Cancer Institute Comprehensive Cancer Centers in the country.

While we are proud to provide access to the latest clinical trials addressing brain and other nervous system cancers, equally important to patient care is our use of emerging therapies and leading edge technology along with our vast support services. Our survival rates are often higher than average and supported by the close collaboration of physicians from multiple disciplines, including neurologists and neurosurgeons with subspecialty expertise in brain cancers and skull base surgery.

Several qualities differentiate our cancer program from other institutions. For example:

» We offer one of the busiest neuroendocrinology programs in the country, providing surgery for as many as 100 patients with pituitary tumors each year.

» During brain tumor surgery, our neurosurgeons often use stereotactic guidance to map the cortex in three dimensions, a highly sophisticated option not available at many hospitals.

» Our team offers expertise in minimally invasive skull base surgeries for craniopharyngiomas and other complex tumors.
Our state-of-the-art radiosurgery services include Gamma Knife surgery for benign and malignant tumors, and the Novalis system for brain tumors and arteriovenous malformations that require multiple doses of radiation.

Thanks to the addition of intraoperative magnetic resonance imaging (iMRI), our neurosurgeons now have the ability to view images of a patient’s brain during surgery. Not only does this help our surgeons confirm that the entire tumor was removed, but the use of iMRI helps ensure there is minimal damage to surrounding healthy structures that are key to the patient’s post-operative functional ability. This technology is especially helpful for tumor resection, especially low grade gliomas, and pituitary tumor resection.

On the research side, UCH is involved in a multicenter, national study assessing a tumor vaccine for newly diagnosed high-grade gliomas. Among other efforts, our team also is studying the role of the immune system in intracranial tumor recognition and eradication.

KEY 2014 METRICS

» Our five-year survival rate for brain and other nervous system cancers is 45 percent (national average 33 percent).
» 94 percent of our pituitary tumor patients have a survival rate of at least five years following treatment (national average 88 percent).
» Our 30-day, cause-related readmission rate was 6 percent (national average 7 percent).

OUTPATIENT VISITS

LENGTH OF STAY (DAYS)

6
5.5

Observed
Expected


Source: UCH Finance
MORTALITY INDEX

- University of Colorado Hospital
- Comparably-sized academic medical centers (average value for group)
- Leading neuroscience hospitals (average value for group)

Mortality index is the ratio of observed to expected mortality based on a risk adjustment algorithm. An index score of 1 indicates observed and expected mortality are equal. Values below 1 are desirable.


COMPLICATION RATES

- University of Colorado Hospital
- Comparably-sized academic medical centers (average value for group)
- Leading neuroscience hospitals (average value for group)

BRAIN (GBM ONLY) 5-YEAR SURVIVAL

- UCH (n=124)
- Colorado (n=801)

Source: UCH Hospital Tumor Registry, COLORADO: Colorado Central Cancer Registry, NATIONAL: National Cancer Registry

Leading neuroscience hospitals is an aggregate of top ranked hospitals from sources such as US News & World Report, Becker’s 100 Great Hospitals, and NeuStrategy Centers of Excellence.
30-DAY READMISSION RATES: ALL CAUSE

- 2012: 14% (12.6%)
- 2013: 13.8% (12.3%)
- 2014: 13.5% (12.6%)

30-DAY READMISSION RATES: RELATED CAUSE

- 2012: 7.6% (6.8%)
- 2013: 7.3% (7.0%)
- 2014: 7.4% (6.7%)


GAMMA KNIFE PROCEDURES
(Performed by UCH Neurosurgeons)

- 2010: 98
- 2011: 106
- 2012: 103
- 2013: 165
- 2014: 166

Source: CU Department of Neurosurgery
**BRAIN TUMOR PROCEDURES**

*Excludes stereotactic radiosurgery and gamma knife procedures.

Source: UCH Hospital Tumor Registry

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**BRAIN TUMOR DIAGNOSIS DISTRIBUTION**

Meningiomas, pituitary tumors, gliomas and nerve sheath tumors comprise about 90% of neuro- oncology diagnosis seen at UCH in the past three years.

Source: UCH Hospital tumor registry

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**BRAIN (INCLUDING BENIGN (5-YEAR SURVIVAL))**

*Source: UCH Hospital Tumor Registry, COLORADO: Colorado Central Cancer Registry,*
THE GOLD STANDARD IN STROKE CARE

The Stroke Center at University of Colorado Hospital has enjoyed another fruitful year — and shows no signs of slowing down.

Right on the heels of becoming one of the first 30 hospitals in the nation to receive the Joint Commission’s esteemed Comprehensive Stroke Center certification, we launched our telestroke program and created the country’s third mobile stroke treatment unit (MSTU). Having gone live in early 2016, this “emergency room on wheels” allows eligible patients to receive tissue plasminogen activator (tPA) at the scene, saving precious time and brain function.

Given the significant investments of time, money, training and other resources necessary to create a MSTU and put it into service, we intend to test our theory that its use will significantly improve treatment time for many stroke patients — and ultimately reduce the incidence of stroke-related death or disability in the community. To that end, UCH will participate in a national, multicenter study assessing the feasibility of implementing mobile stroke units and their effect on treatment time and outcomes, compared to traditional emergency services such as ambulance transport.

April 2014 marked the activation of our four-year grant from the American Stroke Association and the Bugher Foundation, called the Centers of Excellence in Stroke Collaborative Research for Regeneration, Resilience and Secondary Prevention. This prestigious award was given to only three health care institutions in the country.

UCH also has partnered with pediatric neurologists from Children’s Hospital Colorado to create a young adult stroke clinic. Through this effort we’re learning more about what causes stroke in young people, with the goal of clarifying treatment guidelines and returning young stroke victims to long, productive lives. By uncovering the mechanisms of brain injury, recovery and repair, scientists can attempt to restore some of the remarkable brain plasticity that is lost with age.

Our researchers also are participating in the multicenter POINT trial, studying the effectiveness of anti-platelet treatments such as aspirin alone versus an aspirin-plus-clopidigrel combination, among patients with transient ischemic attack or minor stroke.
**CEREBROVASCULAR AND STROKE**

**COMPLICATION RATES**

**Hemorrhagic Stroke**

- 2012: 35.3%
- 2013: 26.6%
- 2014: 31.1%

**Ischemic Stroke**

- 2012: 9.4%
- 2013: 8.0%
- 2014: 7.1%


**THROMBOLYTIC COMPLICATIONS**

- 2012: 5.0%
- 2013: 4.5%
- 2014: 3.4%
- 2015: 1.9%


**NIHSS SCORE IMPROVEMENT (N=149)**

- 28%
- 21%
- 51%

Source: data provided by UCH Stroke Council, 5/8/2015, for patients discharged in 2014.

Leading neuroscience hospitals is an aggregate of top ranked hospitals from sources such as US News & World Report, Becker’s 100 Great Hospitals, and NeuStrategy Centers of Excellence.
Outpatient Visits

Source: UCH Finance

NIHSS Score Improvement (N=149)

Source: Data provided by UCH Stroke Council, 5/6/2015, for patients discharged in 2014.

Length of Stay (Days)

Hemorrhagic Stroke

24

Observed

Expected

Length of Stay (Days)

Ischemic Stroke

8.1

Observed

Expected

KEY 2014 METRICS

» 93.5 percent of ischemic stroke patients who arrived at UCH within two hours of stroke onset received intravenous (IV) tPA within three hours of onset.

» Mortality index for ischemic and hemorrhagic stroke patients were [.68] and [.91], respectively.

» 51 percent of patients showed significant improvement in their National Institutes of Health Stroke Scale score.

» IV tPA door-to-needle time was 46 minutes in 2014, well ahead of the National Stroke Association’s goal of 60 minutes.
IV RT-PA ARRIVE BY 2 HOURS, TREAT BY 3 HOURS

Higher is better


30-DAY READMISSION RATES: RELATED CAUSE
Hemorrhagic Stroke

2012
2.6%

2013
1.9%

2014
2.6%

University of Colorado Hospital
Comparably-sized academic medical centers (average value for group)
Leading neuroscience hospitals (average value for group)


30-DAY READMISSION RATES: RELATED CAUSE
Ischemic Stroke

2012
3.2%

2013
3.0%

2014
2.6%

University of Colorado Hospital
Comparably-sized academic medical centers (average value for group)
Leading neuroscience hospitals (average value for group)


Leading neuroscience hospitals is an aggregate of top ranked hospitals from sources such as US News & World Report, Becker's 100 Great Hospitals, and NeuStrategy Centers of Excellence.
30-DAY READMISSION RATES: ALL CAUSE

**Hemorrhagic Stroke**

<table>
<thead>
<tr>
<th>Year</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>6%</td>
<td>7.5%</td>
<td>8.3%</td>
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</table>

University of Colorado Hospital, Comparably-sized academic medical centers (average value for group), Leading neuroscience hospitals (average value for group)


**Ischemic Stroke**

<table>
<thead>
<tr>
<th>Year</th>
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<tbody>
<tr>
<td>%</td>
<td>7.7%</td>
<td>5.2%</td>
<td>8.2%</td>
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University of Colorado Hospital, Comparably-sized academic medical centers (average value for group), Leading neuroscience hospitals (average value for group)


ACUTE ISCHEMIC STROKE
IV tPA Door to Needle Time (minutes)

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<tr>
<th>Year</th>
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<tbody>
<tr>
<td>Time</td>
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University of Colorado Hospital’s median door to needle time in 2014 was 46 minutes and continues to be well below the American Stroke Association’s Target: Stroke door to needle time goal of 60 minutes.

Leading neuroscience hospitals is an aggregate of top-ranked hospitals from sources such as US News & World Report, Becker’s 100 Great Hospitals, and NeuStrategy Centers of Excellence.
 THE JOINT COMMISSION STROKE CORE MEASURE SET
Antithrombotic Therapy by End of Hospital Day 2

<table>
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<tbody>
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THE JOINT COMMISSION STROKE CORE MEASURE SET
Assessed for Rehabilitation

<table>
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<td>100%</td>
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THE JOINT COMMISSION STROKE CORE MEASURE SET
Discharged on Antithrombotic Therapy

<table>
<thead>
<tr>
<th>Year</th>
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<th>2013</th>
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THE JOINT COMMISSION STROKE CORE MEASURE SET
Discharged on Statin Medication

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<tbody>
<tr>
<td>UCH</td>
<td>98.3%</td>
<td>100%</td>
<td>100%</td>
<td>98.4%</td>
</tr>
<tr>
<td>N</td>
<td></td>
<td></td>
<td></td>
<td>95.6%</td>
</tr>
</tbody>
</table>

VTE Prophylaxis (2012-2013) was formerly measured as DVT Prophylaxis (2011-2012). Source: Get With The Guidelines® report run on 6/25/2015. University of Colorado Hospital scores better than the national average on all Joint Commission Core Measures for Stroke in 2014 and continues to focus on this critical service for the future.
VTE Prophylaxis (2012-2013) was formerly measured as DVT Prophylaxis (2011-2012). Source: Get With The Guidelines® report run on 6/25/2015. University of Colorado Hospital scores better than the national average on all Joint Commission Core Measures for Stroke in 2014 and continues to focus on this critical service for the future.
COMPLICATION RATES FOR ISCHEMIC STROKE TREATED WITH CAROTID ENDARTERECTOMY AND STENTING PROCEDURES

4.3% 5.3% 5.1%

- University of Colorado Hospital
- Comparably-sized academic medical centers (average value for group)
- Leading neuroscience hospitals (average value for group)

COMPLICATION RATES FOR UNRUPTURED ANEURYSMS TREATED WITH CLIPPING AND COILING PROCEDURES

8.3% 7.6% 1.8%

- University of Colorado Hospital
- Comparably-sized academic medical centers (average value for group)
- Leading neuroscience hospitals (average value for group)

2012 2013 2014

82% 91% 95%

- University of Colorado Hospital
- Comparably-sized academic medical centers (average value for group)
- Leading neuroscience hospitals (average value for group)


NEW ALZHEIMER’S PROGRAM HITS THE GROUND RUNNING

While the Alzheimer’s Clinical and Research Program at University of Colorado Hospital doesn’t yet have the longevity of some of our more established neurosciences programs, we’ve proven that sometimes age doesn’t matter. Despite having just been established in 2012, our cognitive disorders program has already experienced explosive growth and is poised to join the ranks of institutions nationally known for neurodegenerative disease research and patient care.

In less than three years, we have met several milestones that are key to our program’s success. For example, thanks to the addition of new faculty and physicians, outpatient visits by people with Alzheimer’s disease, dementia or other cognitive disorders has increased 20 percent – and our capacity for new patients has increased seven-fold. This growth in volume is an important step in having patient cohorts large enough in which to initiate clinical trials.

In 2014, together with the University of Colorado School of Medicine, we filed our nearly 600-page application to become a National Institute of Aging (NIA)-funded Alzheimer’s Disease Center. Today there are only 29 of these centers in the U.S., each working to translate scientific advances into better patient care and to ultimately find a cure. Our proposal includes a special focus on Alzheimer’s disease within the American Indian and Latino populations.

Along these same lines, in fall 2015 we will submit our proposal to become an NIA-funded Alzheimer’s Disease Core Center. These centers are designed to support and conduct research on Alzheimer’s disease, provide a platform for training, develop novel techniques and methodologies, and translate these research findings into better diagnostic, prevention and treatment strategies.

In the meantime, we have kicked off several clinical trials, including recruitment for a pioneering study that will examine the chromosomal link between Alzheimer’s disease and Down syndrome. Other active research efforts include:

» A study of the effects of granulocyte macrophage colony-stimulating factor, better known as Leukine, on patients with Alzheimer’s disease. Our team will assess whether Leukine is effective in combating the microscopic clumps of protein that become tangled and ultimately destroy cognitive processes in Alzheimer’s patients. Early findings in mice pre-programmed to develop Alzheimer’s have shown promise.

» An assessment of postsynaptic calcineurin signaling with regard to amyloid beta toxicity in animal models of Alzheimer’s disease and in human brain samples. Our hypothesis is that a particular scaffold protein (AKAP79/150) helps amyloid beta deposits interfere with calcineurin signaling, leading to dendritic spine loss and diminished cognitive function. Should this prove true, this specific synaptic interaction could become a therapeutic target.

As we look toward 2016 and beyond, we will continue our journey of program expansion, including recruitment of new faculty and management of our behavioral neurology and neuropsychiatry fellows.
EXPLORING NEW FRONTIERS IN SEIZURE DISORDERS

The Comprehensive Epilepsy Center has long been a pinnacle of the neurosciences program at University of Colorado Hospital. As a National Association of Epilepsy Centers Level 4 program, we offer a combination of diagnostic, therapeutic and support services not widely available. More importantly, our outcomes confirm that many people who come to UCH seeking care for debilitating seizures are finding relief.

In 2014 we enjoyed further program growth with the addition of new clinics for epilepsy patients who have highly specialized needs. Our clinic for women with epilepsy focuses on reproductive issues, while a second program is geared toward epilepsy patients who have neurocutaneous syndromes, including tuberous sclerosis. We also launched a program for people who suffer from psychogenic non-epileptic seizures, in collaboration with the department of psychiatry.

These new initiatives are augmented by our active and growing programs in epilepsy monitoring, surgery and neurofeedback. Highlights include:

» More than 300 patients each year are admitted to our eight-bed, inpatient epilepsy monitoring unit. Through 24/7 video EEG surveillance, our physicians can pinpoint when and where in the brain seizures are occurring – a critical step in determining the best medical or surgical treatment options for each patient.

» Our neurosurgeons perform the full spectrum of surgical treatments for epilepsy, including traditional and neocortical resections, and implantation of devices such as vagus nerve stimulators and NeuroPace neurostimulators. More recently we’ve begun placing stereotactic electrodes in the brain prior to invasive epilepsy surgery.

» We are also one of the few academic medical centers in the country to offer EEG biofeedback. Also known as neurofeedback, this treatment method has been shown in studies to both reduce seizure frequency and improve cognitive function.

As always, we round out our program with clinical trials to evaluate promising new therapies. Some of our active studies are assessing medications for daily seizure prophylaxis or to stop seizures as they occur, while others are testing neuromodulation devices intended to better control seizures. Our physicians also are working in collaboration with neuroradiology, investigating the use of diffusion tensor tractography to predict language and memory localization in people with epilepsy.
KEY 2014 METRICS

» Our surgical patients achieved a 78 percent reduction in seizures (and no patients reported an increase in seizures).

» Patients who did not experience full freedom from their seizures still experienced a 63 percent reduction in seizure activity.

» Patients with refractive epilepsy surgery reported a reduction in median monthly seizure frequency from 11 to less than 1.

EMU ADMISSIONS

343 303 386

2012 2013 2014

MORTALITY INDEX

1.75 1.75 1.75

1.75 1.75 1.75

Mortality index is the ratio of observed to expected mortality based on a risk adjustment algorithm. An index score of 1 indicates observed and expected mortality are equal. Values below 1 are desirable.

30-DAY READMISSION RATES: ALL CAUSE

- 2012: 5.3%
- 2013: 7.6%
- 2014: 4.0%

30-DAY READMISSION RATES: RELATED CAUSE

- 2012: 4.5%
- 2013: 3.4%
- 2014: 1.3%

OUTPATIENT VISITS

- 2011: 3,923
- 2012: 4,505
- 2013: 4,521
- 2014: 4,579

RESECTIVE SURGERY

- 2012: 12
- 2013: 16
- 2014: 22

Source: UCH Finance

Leading neuroscience hospitals is an aggregate of top ranked hospitals from sources such as US News & World Report, Becker's 100 Great Hospitals, and NeuStrategy Centers of Excellence.
### Complication Rates

<table>
<thead>
<tr>
<th>Year</th>
<th>University of Colorado Hospital</th>
<th>Comparably-scaled academic medical centers (average value for group)</th>
<th>Leading neuroscience hospitals (average value for group)</th>
<th>Similar epilepsy centers</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>3.2%</td>
<td>1.6% 1.6%</td>
<td>1.3%</td>
<td>1.5%</td>
</tr>
<tr>
<td>2013</td>
<td>2.5%</td>
<td>1.6% 1.6%</td>
<td>1.4%</td>
<td>1.3%</td>
</tr>
<tr>
<td>2014</td>
<td>3.0%</td>
<td>1.5%</td>
<td>1.4%</td>
<td>1.3%</td>
</tr>
</tbody>
</table>


### Length of Stay (Days)

- **Observed**: 5.6
- **Expected**: 4.4


### Vagal Nerve Stimulation (VNS) Surgery

- 2012: 35
- 2013: 39
- 2014: 34

Source: CU Department of Neurology

### Epilepsy Surgery

- 2012: 47
- 2013: 55
- 2014: 56

Source: CU Department of Neurology
HELPING PEOPLE STAY AHEAD OF THEIR PAIN

In an effort to better meet community need, University of Colorado Hospital launched a multidisciplinary headache center in 2012 – and we experienced strong demand right out of the gate from children and adults seeking care for disabling headaches or facial pain.

Simultaneous with program expansion - including faculty recruitment and recent approval to start an accredited fellowship program in headache medicine - great strides have already been made in clinical care, as well as research and quality-related initiatives. Highlights include:

- Our physicians are performing sphenopalatine ganglion blocks much more easily and quickly – with far less discomfort to the patient – thanks to a relatively new device called the SphenoCath.

- On the research side, UCH is part of a pilot study to evaluate prophylactic treatment of chronic migraine using the Cefaly device. This cranial analgesic electrotherapeutic device generates micro-impulses that stimulate the trigeminal nerve.

- A quality improvement project that ran through 2014 found that people with migraine could successfully be treated with intravenous medication on an outpatient basis, thanks to a collaboration with UCH’s infusion clinic. This allowed our patients to avoid an emergency room visit and receive the care they needed more quickly.
CHANGING THE LANDSCAPE OF CARE

Like so many complex neurological conditions, Parkinson’s disease and other movement disorders, including essential tremor, dystonia and ataxia, have proven difficult to treat and impossible to cure – but that hasn’t stopped the team at University of Colorado Hospital’s Movement Disorders Center from trying.

We are devoted to using (and improving) the latest treatment options that give today’s patients a satisfying quality of life, while simultaneously exploring emerging medical and interventional approaches that could pave the way for tomorrow’s prevention or cure.

In 2014 we continued strengthening our program with the addition of new clinical and supportive care clinics, as well as new research efforts bolstered by several grants. Our novel program, the supportive and palliative care clinic, includes two-hour visits with their caregivers to address the multifaceted complexities of their particular disorder, including medical and psychological issues, emotional difficulties, spiritual questions and medical financial concerns.
LENGTH OF STAY

3.6 Observed 5 Expected


MORTALITY INDEX


Mortality Index is the ratio of observed to expected mortality based on a risk adjustment algorithm. An index score of 1 indicates observed and expected mortality are equal. Values below 1 are desirable.

COMPLICATION RATES

3.4% 6.1% 2.5%

2012 2013 2014


OUTPATIENT VISITS

2,727 3,139 3,029 2,944

2011 2012 2013 2014

Source: UCH finance

Leading neuroscience hospitals is an aggregate of top-ranked hospitals from sources such as US News & World Report, Becker’s 100 Great Hospitals, and NeuStrategy Centers of Excellence.
### DBS Procedures

Excluding battery implants/explants

<table>
<thead>
<tr>
<th>Year</th>
<th>Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>47</td>
</tr>
<tr>
<td>2011</td>
<td>53</td>
</tr>
<tr>
<td>2012</td>
<td>61</td>
</tr>
<tr>
<td>2013</td>
<td>91</td>
</tr>
<tr>
<td>2014</td>
<td>57*</td>
</tr>
</tbody>
</table>

*Neurosurgeon six-month sabbatical

Source: DBS database

### 30-Day Readmission Rates: All Cause

<table>
<thead>
<tr>
<th>Year</th>
<th>University of Colorado Hospital</th>
<th>Comparably-sized academic medical centers (average value for group)</th>
<th>Leading neuroscience hospitals (average value for group)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>20.7%</td>
<td>11.5%</td>
<td>10.3%</td>
</tr>
<tr>
<td>2013</td>
<td>24.5%</td>
<td>9.8%</td>
<td>9.6%</td>
</tr>
<tr>
<td>2014</td>
<td>15.4%</td>
<td>10.4%</td>
<td>9.7%</td>
</tr>
</tbody>
</table>

### 30-Day Readmission Rates: Related Cause

<table>
<thead>
<tr>
<th>Year</th>
<th>University of Colorado Hospital</th>
<th>Comparably-sized academic medical centers (average value for group)</th>
<th>Leading neuroscience hospitals (average value for group)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>10.3%</td>
<td>4.6%</td>
<td>3.6%</td>
</tr>
<tr>
<td>2013</td>
<td>14.3%</td>
<td>4.9%</td>
<td>4.2%</td>
</tr>
<tr>
<td>2014</td>
<td>12.8%</td>
<td>4.9%</td>
<td>4.5%</td>
</tr>
</tbody>
</table>


Leading neuroscience hospitals is an aggregate of top ranked hospitals from sources such as US News & World Report, Becker’s 100 Great Hospitals, and NeuStrategy Centers of Excellence.
Overall, 84% (34) had normal Epworth Sleepiness Scale (ESS) scores both before and after DBS. As shown in this standard box plot chart, the average score decreased by 1 point and the median score moved from 10 to 8 after a mean post-op interval of 13 months. However, this difference was not statistically significant (p=0.149). A total of 33 patients, or 62%, had lower or the same ESS scores after DBS while 38% (20) had higher ESS scores. Lower scores indicate less daytime sleepiness.

The average PDQ-39 Summary Index score decreased significantly by 8 points after DBS implant (n=47, p<0.004) with mean duration of follow-up at 1 year. 73% of patients showed improvement while 21% remained stable or had increasing symptoms after DBS. Lower scores reflect better health and fewer symptoms.

Balance confidence is an important indicator of functional mobility and independence in people with Parkinson’s disease. The Activities-Specific Balance Confidence (ABC) Scale measures balance confidence in progressively more challenging and complex situations ranging from walking around inside the home to shopping at the mall or navigating an icy sidewalk. Prior to DBS implant, 75% (21 of 28) patients rated themselves as highly or moderately confident on the ABC scale. After DBS that number rose to 80% (24 of 28), indicating that 3 patients increased from very little confidence to either moderate or high confidence.
OFFERING PATIENTS BOTH SCIENCE AND SUPPORT

Given the complexities of treating multiple sclerosis (MS), with its wide range of symptoms, its potential to cause disability and the frequency with which patients are prone to comorbidities, it is no wonder MS research efforts are numerous and diverse.
As one of the many organizations devoted to finding a cure, University of Colorado Hospital understands that research will be key to eventually stopping this terrible disease. To that end, our robust investigational efforts within the Rocky Mountain Multiple Sclerosis Center have allowed us to be designated one of only 12 Collaborative MS Research Centers in the country by the National Multiple Sclerosis Society (NMSS). In 2014 we also were accepted as one of only 12 NMSS-supported pediatric MS centers.

As usual, 2014 was a busy year for us in terms of both clinical care and research, with more than 9,000 outpatient visits and 40 active clinical and laboratory trials – including the first controlled medication trial among pediatric MS patients. Some of our most recent endeavors are summarized below:

» Having long recognized the importance of quality-of-life scales when assessing a patient’s response to therapies, our team initiated several patient-reported outcomes (PRO) studies, including an analysis of changes that occur over time between two common MS medications, Gilenya and Tysabri. Another new PRO study uses tablet devices to collect survey data within physical, mental and social domains, using NeuroQOL as a core scale. Long term, the data will allow our physicians to retrospectively study quality-of-life changes and improve clinical care.

» We opened a NeuroNEXT study examining the safety and tolerability of Ibudilast (MN-166) in patients with progressive MS. Other new effectiveness studies include a comparative evaluation of long-term fingolimod versus glatiramer acetate on brain atrophy rates, cognition, and patient-reported outcomes, in people with MS.

» Our neurologists have partnered with the neuroradiology team to determine the utility of making quantitative, volumetric MRI part of the standard clinical workflow for patients with MS.

» Our team also has begun investigating whether there are biomarkers that predict how a person would respond to different medications for MS.

While we are passionate about our MS research efforts, we’d be remiss if we didn’t highlight our philosophy about the importance of continuous, high-quality clinical care and support. Our physicians believe strongly that with early and aggressive intervention, including appropriate use of the most effective medications, the majority of MS patients can substantially reduce their risk of new inflammatory disease activity, allowing them to live productive and happy lives. Our team has helped lead the movement to promote life-long brain health among the MS population, in part by promoting health and wellness through weight reduction, smoking cessation, exercise and treatment of comorbidities.
### Complication Rates

<table>
<thead>
<tr>
<th>Year</th>
<th>University of Colorado Hospital</th>
<th>Comparably-sized academic medical centers</th>
<th>Leading neuroscience hospitals</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>1.7%</td>
<td>.9%</td>
<td>.7%</td>
</tr>
<tr>
<td>2013</td>
<td>.9%</td>
<td>.8%</td>
<td>.8%</td>
</tr>
<tr>
<td>2014</td>
<td>0%</td>
<td>.8%</td>
<td>.8%</td>
</tr>
</tbody>
</table>


### Outpatient Visits

<table>
<thead>
<tr>
<th>Year</th>
<th>Visits</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>8,101</td>
</tr>
<tr>
<td>2012</td>
<td>9,209</td>
</tr>
<tr>
<td>2013</td>
<td>9,332</td>
</tr>
<tr>
<td>2014</td>
<td>9,508</td>
</tr>
</tbody>
</table>

Source: UHC finance.

### Mortality Index

<table>
<thead>
<tr>
<th>Year</th>
<th>University of Colorado Hospital</th>
<th>Comparably-sized academic medical centers</th>
<th>Leading neuroscience hospitals</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>.51</td>
<td>.58</td>
<td>.57</td>
</tr>
<tr>
<td>2013</td>
<td>.41</td>
<td>.57</td>
<td>.57</td>
</tr>
<tr>
<td>2014</td>
<td>.81</td>
<td>.81</td>
<td>.81</td>
</tr>
</tbody>
</table>


Mortality Index is the ratio of observed to expected mortality based on a risk adjustment algorithm. An index score of 1 indicates observed and expected mortality are equal. Values below 1 are desirable.

Leading neuroscience hospitals is an aggregate of top ranked hospitals from sources such as US News & World Report, Becker’s 100 Great Hospitals, and NeuStrategy Centers of Excellence.
30-DAY READMISSION RATES: ALL CAUSE

- 2012: 6.7%
- 2013: 6.4%
- 2014: 6.4%

30-DAY READMISSION RATES: RELATED CAUSE

- 2012: 4.6%
- 2013: 4.0%
- 2014: 3.8%


LENGTH OF STAY

- Observed: 7.4
- Expected: 4.3


NeuroQoL
UPPER EXTREMITY DISABILITY


Leading neuroscience hospitals is an aggregate of top ranked hospitals from sources such as U.S. News & World Report,
Backer's 100 Great Hospitals, and NeuStrategy Centers of Excellence.

uehealth.org | 47
NeuroQoL
LOWER EXTREMITY DISABILITY

BAD
GOOD

Dept. score: 47.76, # responses: 1293. NeuroQoL mean score: 50

NeuroQoL
SOCIAL

BAD
GOOD

Dept. score: 47.81, # responses: 1235. NeuroQoL mean score: 50

NeuroQoL
POSITIVE AFFECT

BAD
GOOD

Dept. score: 53.09, # responses: 1291. NeuroQoL mean score: 50

NeuroQoL
GENERAL CONCERNS

BAD
GOOD

Dept. score: 41.32, # responses: 1248. NeuroQoL mean score: 50

NeuroQoL
EXECUTIVE FUNCTION

BAD
GOOD

Dept. score: 45.24, # responses: 1234. NeuroQoL mean score: 50
RENOWNED CRITICAL CARE WITH REMARKABLE RESULTS

The 24-bed neuro intensive care unit at University of Colorado Hospital is an uncommon program. It is one of only a handful of Neuro ICUs in the country, led by one of the nation’s first board-certified neurointensivists, and offers one of the leading programs in the U.S. for critical care residents and neurointensivist fellows.

Rarer still, our Neuro ICU not only provides a level of care unmatched by most other hospitals, but at any given time our neurocritical care team is involved in 10 or more active research studies.

As evidence of our quality, our Neuro ICU was one of only seven in the country to earn a three-year Gold-level Beacon Award for Excellence from the American Association of Critical Care Nurses. This designation means we achieved the highest scores possible in five areas including outcomes and use of evidence-based practices.

Our research efforts are varied and include participation in multicenter trials as well as collaboration with other specialists across the UCH Health system. Recent studies include:

» An examination of platelet-oriented inhibition in new transient ischemic attack and minor ischemic stroke, and intravascular cooling as part of stroke treatment.

» A National Institutes of Health-funded assessment of neuromuscular dysfunction in critically ill patients.

» A study of the physiological effects of intrathoracic pressure regulation in patients with decreased cerebral perfusion due to brain injury or intracranial pathology.

NEUROCRITICAL CARE UNIT PATIENT DAYS

<table>
<thead>
<tr>
<th>Year</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days</td>
<td>3,375</td>
<td>3,538</td>
<td>5,630</td>
<td>6,420</td>
</tr>
</tbody>
</table>

Source: UCH finance

NEUROCRITICAL CARE UNIT ADMISSIONS

<table>
<thead>
<tr>
<th>Year</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admissions</td>
<td>287</td>
<td>161</td>
<td>616</td>
<td>1,081</td>
</tr>
</tbody>
</table>

Source: UCH finance
**KEY 2014 METRICS**

» Our catheter-associated urinary tract infections rate of 0.95/1000 days was significantly lower than the national benchmark of 5.3/1000 days.

» Compared to other U.S. teaching hospitals, our Neuro ICU scored in the 90th percentile for patient satisfaction.

» 1,081 patients were admitted, with 6,420 bed days.

---

**CATHETER-ASSOCIATED URINARY TRACT INFECTIONS PER 1000 URINARY CATHETER DAYS**

<table>
<thead>
<tr>
<th>Year</th>
<th>UCH Neurocritical Rate</th>
<th>NHSN (CDC) Benchmark Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>1.35</td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>.95</td>
<td></td>
</tr>
</tbody>
</table>

Source: UCH Infection Prevention

Complications caused by catheter-associated urinary tract infection (CAUTI) cause discomfort to the patient, prolonged hospital stay, and increased cost and mortality. CAUTI rates are expressed as the number of infections per 1000 urinary catheter days. In 2013 and 2014, the Neurocritical Intensive Care Unit at UCH was well below the benchmark provided by the National Healthcare Safety Network (NHSN).

---

**CENTRAL LINE-ASSOCIATED BLOODSTREAM INFECTIONS PER 1000 LINE DAYS**

<table>
<thead>
<tr>
<th>Year</th>
<th>UCH Neurocritical ICU Rate</th>
<th>NHSN (CDC) Benchmark Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>1.41</td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>1.10</td>
<td></td>
</tr>
</tbody>
</table>

Source: UCH Infection Prevention

Central line-associated bloodstream infections (CLABSIs) typically cause prolonged hospital stay, increased cost and risk of mortality. CLABSIs rates are expressed as the number of infections per 1000 central-line days.
COMBATING NEUROMUSCULAR DISEASE WITH COMPASSION AND RESEARCH

As one of the oldest programs of its kind in the U.S., University of Colorado Hospital’s Neuromuscular Clinic is changing lives. Whether it’s by diagnosing and managing depression common among patients with peripheral nervous system disorders, or by studying the efficacy of a diaphragm pacing system in patients with amyotrophic lateral sclerosis (ALS), we are demonstrating that it is possible to make a difference — even among people afflicted with some of the most severe neuromuscular disorders.

More than 1,000 new patients each year seek neuromuscular care at UCH from six surrounding states, thanks in part to our certification by the Muscular Dystrophy Association (MDA) as the only MDA/ALS program in Colorado (and one of only 42 in the country). As an active neuromuscular research center, we also are able to offer our patients access to novel therapies not widely available.

In 2014 we continued to strengthen our program through a variety of research and quality-related initiatives, including:

» We opened a NeuroNEXT study to determine if Rituxan (rituximab) is safe and beneficial for patients with myasthenia gravis.

» We completed enrollment in a diaphragm stimulation study among patients with ALS who have chronic hypoventilation. This post-market study is evaluating the long-term efficacy of the NeuRx Diaphragm Pacing System, which allows patients with mild to severe respiratory insufficiency to breathe normally through a self-controlled device that is implanted via minimally invasive surgery.

» We began screening patients for the Patisiran Phase 3 study for treatment of transthyretin-mediated amyloidosis in patients with familial amyloidotic polyneuropathy.

» We are enrolling patients in a comparative effectiveness study to determine the best treatment for painful peripheral neuropathies.

» With an eye toward process improvement, our team engaged in a project to standardize our approach to peripheral neuropathy evaluation.
KEY 2014 METRICS

» Based on PHQ-9 scores, 66 percent of our patients reported an improvement in their depression symptoms.
» Our inpatient mortality index was 0.
» UCH has the only MDA/ALS program certified by the Muscular Dystrophy Association in Colorado.
30-DAY READMISSION RATES: ALL CAUSE

- University of Colorado Hospital
- Comparably-sized academic medical centers (average value for group)
- Leading neuroscience hospitals (average value for group)


30-DAY READMISSION RATES: RELATED CAUSE

- University of Colorado Hospital
- Comparably-sized academic medical centers (average value for group)
- Leading neuroscience hospitals (average value for group)


MORTALITY INDEX

- University of Colorado Hospital
- Comparably-sized academic medical centers (average value for group)
- Leading neuroscience hospitals (average value for group)


Mortality index is the ratio of observed to expected mortality based on a risk adjustment algorithm. An index score of 1 indicates observed and expected mortality are equal. Values below 1 are desirable.

Leading neuroscience hospitals is an aggregate of top-ranked hospitals from sources such as US News & World Report, Becker’s 100 Great Hospitals, and NeuroStrategy Centers of Excellence.
COMPLICATION RATES


IMPROVEMENT IN PHQ-9 SCORES (N=31)

Patients whose PHQ-9 scores initially suggested possible depressive disorder showed significant improvement. Eighty-one percent of patients (n=25) moved out of the “Depression Suggested” category with an average decrease of 5 points at 281 days follow up interval. Six patients continued to have scores suggestive of depression.

Source: Epic.
A UNIQUE WAY OF SEEING NEUROLOGICAL CONDITIONS

While it may sound like something out of a science fiction novel, neuro-ophthalmologists at University of Colorado Hospital are helping diagnose and treat a variety of neurological disorders by examining the eye and its optic nerve.

In reality, many diseases that affect the brain and central nervous system are often coupled with vision problems; for example, brain tumors can cause double vision, and optic neuritis is common in people with multiple sclerosis (MS). But it requires a highly trained and experienced physician to make the connection between “ordinary” vision problems and complex neurological disorders.

Taking things one step further, our neuro-ophthalmologists are conducting pioneering research into visual testing that may one day allow for earlier detection of many neurological conditions.

In 2014 UCH wrapped up a four-year study, sponsored by the National Institutes of Health and the Alzheimer’s Association, assessing whether impaired visual processing may be an early sign of Alzheimer’s disease. The study, “Virtual Reality Assessment of Visuospatial Disorientation in Alzheimer’s Disease,” enrolled 110 people including both healthy controls and people with either mild memory impairment or a formal Alzheimer’s diagnosis.

Other research initiatives focus on inflammation of the brain and optic nerves, which is often present in people with MS and related disorders such as neuromyelitis optica. By better understanding what causes the immune response associated with demyelinating diseases, researchers have a better shot at early detection and creating new targeted therapies.

OUTPATIENT VISITS

1,376
1,591
1,694
1,897

2011 2012 2013 2014

Source: UCH finance
RAISING THE BAR IN NEUROIMAGING CARE

The highly specialized diagnostic services performed by our neuroradiology team at University of Colorado Hospital are essential to our goal of remaining a nationally ranked neuroscience center.

In addition to conducting more than 27,000 exams each year, including advanced functional imaging studies, our neuroradiologists have subspecialty interests that drive their clinical and translational research efforts in four key areas: multiple sclerosis (MS); acute ischemic stroke; movement disorders; and epilepsy. Recent endeavors are highlighted below.

MULTIPLE SCLEROSIS

The neuroradiology team is performing investigative work to determine the utility of making quantitative, volumetric MRI part of the standard clinical workflow for patients with MS.

Additionally, we have received two grants to investigate patient-reported outcomes among people treated with fingolimod and glatiramer acetate.

ACUTE ISHEMIC STROKE

Working in close cooperation with stroke neurologists, neurosurgeons, neuro-interventionalists and neurontensivists, our ongoing studies of interventional stroke treatments and outcomes have resulted in refined imaging and treatment methods for patients with acute ischemic stroke. These efforts have played no small part in helping UCH attain and maintain its designation as a Comprehensive Stroke Center.

MOVEMENT DISORDERS

While deep brain stimulation (DBS) has become a viable treatment option for people who are unable to manage their condition through medical therapy, some patients cannot have conventional DBS because their symptoms are so severe they are unable to undergo the required pre-operative MRI brain mapping. Our neuroradiologists and physicists have played a critical role in giving UCH patients another option: real-time, frameless MRI-guided mapping that can take place while the patient is sedated.

Additionally, our research to better understand the mechanisms of movement disorders recently showed differences in the shape of ventral striatum in different subtypes of Parkinson’s disease. We are also investigating the use of diffusion tensor tractography in Parkinson’s motor subtypes.

EPILEPSY

Our functional neuroimaging service is vital to helping diagnose and treat patients with epilepsy. To that end, our physicians are currently investigating the use of diffusion tensor tractography to predict language and memory localization in people with epilepsy.
ADVANCED TECHNIQUES PRESERVE MOTION AND MORE

At University of Colorado Hospital, spine surgery is rarely the first line of defense for people suffering from back pain or spine problems. But for those patients who have exhausted all other options, our Spine Center offers the right blend of neurosurgery, orthopedic surgery, and physical medicine and rehabilitation services for even the most complex cases. Even better, our clinical care is integrated with research that’s driving improvement in long-term clinical functional outcomes.
Thanks in part to our status as a tertiary referral center, our surgeons perform more than 900 surgeries annually, ranging from spine micro-discectomies to sophisticated procedures that require computer-assisted, three-dimensional surgical navigation. In fact, our Spine Center is home to one of the few neurosurgeons in the country qualified to perform percutaneous lumbar endoscopic discectomy or decompression. The procedure utilizes new endoscopic hardware that allows surgeons to access the spine through transforminal, interlaminar or posterolateral approaches.

Our physicians also are involved in a variety of research projects designed to propel new advancements in spine surgery, and to refine current techniques with an eye toward patient outcomes. Some of our current studies include:

- Evaluating new devices and materials used in artificial disc replacement
- Testing minimally invasive techniques for fusion of the sacroiliac joint
- Evaluating epidural effectiveness for spinal stenosis

As an added measure of excellence, UCH is helping train the next generation of orthopedic and neurosurgical spine surgeons. Here we offer one of only 18 accredited orthopedic spine surgeries and one of 31 accredited neurosurgical spine fellowships in the country, in addition to a fellowship in pain medicine.

The UCH Spine Center team continues to advance spine care with the implementation of 3D full body spinal imaging, a rapid and low dose method to more fully assess the patient’s condition. This imaging allows for viewing of the interplay of the spine, the hips and the lower limbs in a functional weight bearing position. Used in conjunction with 3D modeling and calculation of clinical parameters, and stereotactic surgical planning, more accurate and advanced surgical planning is fostered.

Our collective efforts have paid off – UCH continues to be the only comprehensive spine program in Colorado named a “Blue Distinction Center for Spine Surgery+” by the BlueCross BlueShield Association. This accolade confirms we meet important quality measures for patient safety and outcomes, as well as cost measures.
### 30-Day Readmission Rates: All Cause

<table>
<thead>
<tr>
<th>Year</th>
<th>University of Colorado Hospital</th>
<th>Comparably-sized academic medical centers (average value for group)</th>
<th>Leading neuroscience hospitals (average value for group)</th>
<th>Comparable spine hospitals (average value for group)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>6.2%</td>
<td>5.9%</td>
<td>5.0%</td>
<td>5.0%</td>
</tr>
<tr>
<td>2013</td>
<td>5.7%</td>
<td>5.7%</td>
<td>5.5%</td>
<td>5.2%</td>
</tr>
<tr>
<td>2014</td>
<td>5.5%</td>
<td>5.6%</td>
<td>5.3%</td>
<td>5.2%</td>
</tr>
</tbody>
</table>


### 30-Day Readmission Rates: Related Cause

<table>
<thead>
<tr>
<th>Year</th>
<th>University of Colorado Hospital</th>
<th>Comparably-sized academic medical centers (average value for group)</th>
<th>Leading neuroscience hospitals (average value for group)</th>
<th>Comparable spine hospitals (average value for group)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>3.7%</td>
<td>3.4%</td>
<td>3.3%</td>
<td>3.1%</td>
</tr>
<tr>
<td>2013</td>
<td>3.3%</td>
<td>3.3%</td>
<td>3.3%</td>
<td>3.1%</td>
</tr>
<tr>
<td>2014</td>
<td>3.1%</td>
<td>3.1%</td>
<td>3.1%</td>
<td>2.9%</td>
</tr>
</tbody>
</table>


### Mortality Index

<table>
<thead>
<tr>
<th>Year</th>
<th>University of Colorado Hospital</th>
<th>Comparably-sized academic medical centers (average value for group)</th>
<th>Leading neuroscience hospitals (average value for group)</th>
<th>Comparable spine hospitals (average value for group)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>.81</td>
<td>.65</td>
<td>.59</td>
<td>.75</td>
</tr>
<tr>
<td>2013</td>
<td>.80</td>
<td>.66</td>
<td>.58</td>
<td>.64</td>
</tr>
<tr>
<td>2014</td>
<td>.90</td>
<td>.65</td>
<td>.58</td>
<td></td>
</tr>
</tbody>
</table>


Mortality index is the ratio of observed to expected mortality based on a risk adjustment algorithm. An index score of 1 indicates observed and expected mortality are equal. Values below 1 are desirable.

### Outpatient Visits

<table>
<thead>
<tr>
<th>Year</th>
<th>University of Colorado Hospital</th>
<th>Comparably-sized academic medical centers (average value for group)</th>
<th>Leading neuroscience hospitals (average value for group)</th>
<th>Comparable spine hospitals (average value for group)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>13,075</td>
<td>13,691</td>
<td>15,069</td>
<td>16,966</td>
</tr>
<tr>
<td>2012</td>
<td>15,069</td>
<td>15,509</td>
<td>16,966</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>16,966</td>
<td>17,509</td>
<td>18,966</td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>18,966</td>
<td>19,509</td>
<td>20,966</td>
<td></td>
</tr>
</tbody>
</table>

Source: UCH finance (2011-2012) and Epic query (2013-2014)

Leading neuroscience hospitals is an aggregate of top ranked hospitals from sources such as US News & World Report, Becker’s 100 Great Hospitals, and NeuStrategy Centers of Excellence.
PRE AND POST OPERATIVE NECK DISABILITY INDEX (NDI) SCORE

Source: HCQL CU Spine Study

PRE AND POST OPERATIVE OSWESTRY DISABILITY INDEX (ODI) SCORE

Source: HCQL CU Spine Study

The Oswestry Disability Index (ODI) is the “gold standard” of low back functional outcome measures. Patients who had surgery at UCH between September 2011 and November 2014 showed an average ODI score reduction of 20 points after surgery, well above the minimum clinically important difference of 15 points.

PRE AND POST OPERATIVE SYMPTOM SEVERITY

Source: HCQL CU Spine Study

Patients were asked to rate the severity of their pain, weakness, and numbness both pre-operatively and at one year post-operatively. Using 0-10 visual analog scale where 0 means no symptom occurrence, post-operative scores improved dramatically.

Source: HCQLCU Spine Study

Patients were asked to rate the severity of their pain, weakness, and numbness both pre-operatively and at one year post-operatively. Using 0-10 visual analog scale where 0 means no symptom occurrence, post-operative scores improved dramatically.
OUTPATIENT PROCEDURES
(EMG, Injection, Kyphoplasty, RFA)

2011 2012 2013 2014
2,185 2,520 2,675 3,465

PreOp
n=58
3 Months PostOp
n=28
6 Months PostOp
n=34
1 Year PostOp
n=25
2 Years PostOp
n=32

PreOp 39.7% 35.7% 32.4% 32% 18.8%

Lower is better

Source: Spine Administration and IR database

Source: HCOL CU Spine Study

Prior to surgery, 99% of surveyed patients who were employed had been placed on limited or light duties due to their spine condition. Two years after surgery, 81% of respondents were free of work restrictions.

ZURICH CLAUDICATION QUESTIONNAIRE (ZCQ)
for surgeries between 8/22/2011 and 11/6/2014

PreOp n=113 3 Months PostOp n=65 6 Months PostOp n=66 1 Year PostOp n=62 2 Years PostOp n=75

Symptom Severity Patient Satisfaction Physical Function

Source: HCOL CU Spine Study

The Zurich Claudication Questionnaire (ZCQ) complements existing measures of spine-related disability and health status. The questionnaire evaluates three dimensions: symptom severity, physical function and patient satisfaction with procedure. For all dimensions, lower scores are better.

LENTH OF STAY

Observed
3.6
Expected
3.7

PAIN CATASTROPHIZING SCALE (PCS)
for surgeries between 8/22/2011 and 11/6/2014

PreOp
n=134

3 Months
PostOp
n=77

6 Months
PostOp
n=83

1 Year
PostOp
n=83

2 Years
PostOp
n=94

21.1
10.5
9.8
8.5
10.1

Source: HCOIL CU Spine Study

Pain catastrophizing affects how individuals experience pain. The Pain Catastrophizing Scale (PCS) is one of the most widely used tools for measuring catastrophic thinking related to pain. A score of 30 or higher indicated a clinically relevant level of catastrophizing.

ZUNG SELF-RATING DEPRESSION SCALE (ZDS)
for surgeries between 8/22/2011 and 11/6/2014

PreOp
n=132

3 Months
PostOp
n=76

6 Months
PostOp
n=83

1 Year
PostOp
n=83

2 Years
PostOp
n=94

42.8
37.5
38.1
37.5
37.3

Source: HCOIL CU Spine Study

The Zung Self-Rating Depression Scale (ZDS) is a self-administered survey to quantify the depressed status of a patient. There are 20 items that rate affective, psychological and somatic symptoms associated with depression. Scores at or below 44 are considered in the normal range.

TAMPA SCALE OF KINESIOPHOBIA (TSK)
for surgeries between 8/22/2011 and 11/6/2014

PreOp
n=134

3 Months
PostOp
n=76

6 Months
PostOp
n=82

1 Year
PostOp
n=83

2 Years
PostOp
n=96

42.8
37.1
36.5
36.5
37.3

Source: HCOIL CU Spine Study

The Tampa Scale of Kinesiophobia (TSK) is a 17-item checklist that measures fear of movement and/or injury in adults with acute and chronic low back pain, fibromyalgia, muscle-skeletal injuries and whiplash associated disorders. The total score ranges between 17 and 68, with 37 differentiating between high and low scores.
AT UCH, SCIENCE IS FOUND AT THE BEDSIDE

Those of us who chose a career in the medical field did so for a variety of reasons. Some of us are inspired by our ability to help people, while others are motivated by the noble pursuit of scientific discovery. At University of Colorado Hospital, many of our faculty have a foot in both worlds – and it is this blend of research-driven, community-focused care that differentiates us from other health care institutions.

We cannot highlight the quality of our care and our neurosciences outcomes without acknowledging the valuable clinical research we are conducting together with our academic partner, University of Colorado School of Medicine. Research, after all, is the catalyst for life-changing advancements in medicine. And at UCH, clinical care and research are almost seamlessly integrated: our research informs patient care, and we allow patient care to inform our research.

In 2014 our Neurosciences Center received $13.2 million in clinical research funding, and we are among the top 30 programs funded by the National Institutes of Health. At any given time we have more than 100 active clinical trials spanning all of our neuroscience subspecialties, from epilepsy and multiple sclerosis to neuroradiology and neurocritical care.

While we believe that each of our research endeavors is worthy of recognition, there are several standouts that exemplify how we are introducing innovation to the field of neurosciences – and in some cases, getting recognized for our efforts with substantial grants. In particular, we are proud of the following achievements in 2014 and 2015:

**AMERICAN STROKE ASSOCIATION-BUGHER FOUNDATION GRANT**

In April 2014 we were honored to activate our four-year, $2.4 million grant from the American Stroke Association and the Bugher Foundation, called the Centers of Excellence in Stroke Collaborative Research for Regeneration, Resilience and Secondary Prevention.

This prestigious award was given to only three health care institutions in the country. While each organization is leading its own research, together we comprise a network of three centers collaborating on basic, clinical and population research. Our collective efforts will expand on previous Bugher research into recovery after stroke, including the areas of repair, regeneration, neuroplasticity and rehabilitation.

At UCH, our grant will be used to study how children recover from stroke, through the following individual but parallel research projects led by University of Colorado School of Medicine faculty:

- Childhood Stroke Neuropsychological and Quality of Life Outcomes: Exploring Lesion-Specific Plasticity
- Neuronal Injury and Functional Recovery Following Experimental Pediatric Arterial Ischemic Stroke
- Glial Responses in Pediatric Stroke

Our goal is to better understand the mechanisms of injury, recovery and repair, which may shed light on how we can restore some of the brain plasticity that is lost with age. If we can learn how to alleviate the side effects of stroke, we can help return young stroke victims to long, productive lives.
PCORI-FUNDED NEUROPALLIATIVE CARE RESEARCH

In 2015, UCH received a three-year, $1.9 million award from the Patient-Centered Outcomes Research Institute (PCORI) to study whether outpatient palliative care can improve patient-centered outcomes in people with Parkinson’s disease.

As an independent nonprofit, nongovernmental organization, PCORI funds projects that meet their definition of patient-centered outcomes research, meaning they help address questions and concerns that are most relevant to patients. One of PCORI’s priorities is funding projects that study the efficacy of “alternative” health care programs and services, along with their potential for sustained impact and replication.

At UCH, our study will assess whether Parkinson’s patients benefit from palliative care. While a small but growing group of centers now offers neuropalliative care services, there is no evidence that these programs improve outcomes among Parkinson’s patients compared with standard care. There also is no agreement on which patients should be referred for these additional services, and there is significant variability in the types of services provided.

Over the next three years, our team – including an advisory panel of patients, caregivers and members of health care organizations – will fulfill the following objectives:

» Determine whether an outpatient palliative care team improves patient quality of life and caregiver burden, compared with traditional neurology care
» Identify which patient and caregiver characteristics best predict benefit from palliative care services
» Interview patients and caregivers to optimize service delivery and selection

By testing the effectiveness of palliative care services among Parkinson’s patients and determining who benefits most, we hope to provide a new option to assist patients who are deemed high risk for poor outcomes.

NEW AND CUMULATIVE RESEARCH FUNDS BY FISCAL YEAR
MINIATURE MICROSCOPE REVOLUTIONIZES VIEW OF THE BRAIN

UCH recently put a $1 million grant from the National Science Foundation to good use, unveiling a tiny “deep brain” microscope developed in collaboration with scientists and bioengineers from the University of Colorado Boulder.

The current iteration of the laser-scanning microscope uses fiber-optics and a variable focus liquid lens that can quickly focus in on living tissue. These unique qualities allow researchers to see neurons firing inside a living brain, which is remarkable considering conventional microscopes penetrate only about one millimeter into the brain.

To visualize how the microscope is used, during testing the ½-inch diameter device is mounted onto the head of a mouse. A fiber-optic cord attached to the microscope is long enough to allow the mouse to roam freely, while scientists look inside its brain and record reactions to various stimuli.

As the prototype of this microscope is further refined, parts of the living brain such as the amygdala – which have been virtually off-limits to microscopes – will soon be seen in real-time, and recorded via high-resolution, 3-D images.

This ability to stimulate and measure neurons through optical methods is a major step forward in understanding brain function and disease, and offers tremendous potential for human application, including:

- Screening pharmaceuticals designed to treat brain disorders
- Allowing neurosurgeons to view small brain areas targeted for Parkinson’s disease treatment
- Conducting optical, in situ, biopsies to diagnose brain tumors

More information about this microscope was published in the journal Optics Letters (Volume 40, Issue 11).

PROUD TO MAKE A DIFFERENCE

While other academic medical centers have experienced a decline in research funding, at UCH it is expanding – and for good reason. Our research efforts are managed by passionate and well-rounded faculty who are equal parts scientist, teacher and clinician. Together we’re making meaningful contributions to the field of neurosciences and steadily improving patient care.
NEUROLOGY


Beachamp, K. Pediatric Neurosurgery. Packing to Tamponade Severe Intracranial Hemorrhage in Pediatric Patients.


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Corse-Jensen CE, Goodell DJ, Freund RK, Serbedzija P, Murphy RC, Farias SE, DellAcqua ML, Frey LC, Sergkova N, Heidenreich KA.


Handler, M. Cancer Immunol Res. Interleukin-6/STAT3 pathway signaling drives an inflammatory phenotype in Group A epidermodysplasia.


Hankinson, T. Neurosurgery. Pediatric low-grade glioblastoma: epidemiology, treatments, and outcome analysis on 348 children from the surveillance, epidemiology, and end results database.


Larsen DP, Butler AC, Aung WY, Corboy JR, Friedman DJ, Sperring MR. The effects of test-learning enhancement on long-term retention in AAN annual meeting courses. Neurology. 2015 Feb 17;84(7):748-54.

Leppert MH, Campbell JD, Simpson JR, Burkle JF. Cost-Effectiveness of Intra-Arterial Treatment as an Adjunct to Intravenous Tissue-Type Plasminogen Activator for Acute Ischemic Stroke. Stroke. 2015 Jul;46(7):1870-6.


Lillehei, L. J Neurooncology. Hypofractionated-intensity modulated radiotherapy (hypor-IMRT) and temozolomide (TMZ2) with or without bevacizumab (BEV) for newly diagnosed glioblastoma multiforme (GBM): a comparison of two prospective phase II trials.

Lillehei, L. J Neurooncology. Phase II trial of hypofractionated intensity-modulated radiation therapy combined with temozolomide and bevacizumab for patients with newly diagnosed glioblastoma.

Lillehei, L. Mol Endocrinol. Mammalian Ste20-like kinase 4 promotes pituitary cell proliferation and survival under hypoxia.

Lillehei, L. Endocrine. Growth hormone tumor histological subtypes predict response to surgical and medical therapy.


Neumann, R. Journal of Critical Care. Continuous Infusion versus Intermittent Vancomycin in Neurosurgical ICU.


O'neill, Minim Invasive Neurosurgery. Endoscopic-assisted craniofacial resection of esthesioneuroblastoma: minimizing facial incisions—technical note and report of 3 cases.


Ormond, D. World Neurosurgery. Cerebrospinal Fluid Leaks and Encephaloceles of Temporal Bone Origin: Nuances to Diagnosis and Management.


Winston, K. Pediatric Neurosurgery. Packing to Tamponade Severe Intracranial Hemorrhage in Pediatric Patients.

Winston, K. J Neurosurgery. Relationship of vocal cord paralysis to the coil diameter of vagus nerve stimulator leads.


NEURORADIOLOGY


NEUROSURGERY


**NEUROLOGY**

**Phase III, Randomized, Double-Blind, Double Dummy, Multicenter Trial Comparing the Efficacy and Safety of 2 Doses of Daily Oral ONO 4841 10.05 mg and 0.1 mg versus Interferon-β-1a 30 µg IM Weekly in Subjects with Relapsing Multiple Sclerosis**

**Principle Investigator:** Alvarez

Collaborative International Research in Clinical and Longitudinal Experience for Neuromyelitis Optica (NMO) Studies (CIRCLES)

**Principle Investigator:** Bennett

**Analysis of B-Cell Trafficking in Multiple Sclerosis Patients Receiving Tysabri(R) (natalizumab) and Gilenya (fingolimod)**

**Immunomodulatory Therapy**

**Principle Investigator:** Bennett

**A Phase IV Trial of Neuroprotection with ACTH in Acute Optic Neuritis**

**Principle Investigator:** Bennett

**Functional Connectivity of the Basal Ganglia in Primary Focal Dystonia: A Pilot Project**

**Principle Investigator:** Berman

**Natural History and Biospecimen Repository for Dystonia**

**Principle Investigator:** Berman

**Functional Connectivity of the Motor Network in Two Major Subtypes of Parkinson Disease**

**Principle Investigator:** Berman

**Neural Mechanisms of Reflexive Blinking and Eye Muscle Spasms in Blepharospasm**

**Principle Investigator:** Berman

**Open-label, single-arm extension study to the double-blind, randomized, multicenter, placebo-controlled, parallel-group study comparing the efficacy and safety of 0.5 mg FTY720 administered orally once daily versus placebo in patients with primary progressive multiple sclerosis**

**Principle Investigator:** Corboy

**The role of TH40 cell in Multiple Sclerosis and Type 1 Diabetes**

**Principle Investigator:** Corboy

**A 12-month, randomized, rater- and dose-blinded study to compare the efficacy and safety of fingolimod 0.25 mg and 0.5 mg administered orally once daily with glatiramer acetate 20 mg administered subcutaneously once daily in patients with relapsing-remitting multiple sclerosis**

**Principle Investigator:** Corboy

**A multicenter, randomized, double-blind, parallel-group, placebo-controlled variable treatment duration study evaluating the efficacy and safety of Siponimod (BAF312) in patients with secondary progressive multiple sclerosis**

**Principle Investigator:** Corboy

**A double-blind, placebo controlled trial of estriol treatment in women with multiple sclerosis: effect on cognition.**

**Principle Investigator:** Corboy

**Rocky Mountain MS Center Tissue Bank**

**Principle Investigator:** Corboy

**A double-blind, randomized, multicenter, placebo-controlled, parallel-group study comparing the efficacy and safety of 0.5 mg FTY720 administered orally once daily versus placebo in patients with primary progressive multiple sclerosis**

**Principle Investigator:** Corboy

**A Combination Trial of Copaxone plus Estriol in Relapsing Remitting Multiple Sclerosis**

**Principle Investigator:** Corboy

Vestibular rehabilitation for persons with Multiple Sclerosis: what benefits are possible

**Principle Investigator:** Hebert

**Hypothermia in Acute Stroke with Thrombolysis Imaging Evaluation of Revascularization (HASTEIR): An ancillary imaging study to the Intracranial Cooling in the Treatment of Stroke 2 (ICTaS 2) trial, an NIH-funded project on the safety and efficacy of hypothermia combined with thrombolysis**

**Principle Investigator:** Jones

**Stroke Hyperglycemia Insulin Network Effort (SHINE) Trial**

**Principle Investigator:** Jones

**Phase 2/3 Study of Intravenous Thrombolysis and Hypothermia for Acute Treatment of Ischemic Stroke**

**Principle Investigator:** Jones

**Review of number of microelectrode recording passes performed during subthalamic nucleus deep-brain stimulation surgery**

**Principle Investigator:** Klepsitskaya

**The Burden of Cerebral Diffuse Ischemic White Matter Disease, Measured Quantitatively on MRI, as a Possible Predictive Factor of Cognitive Outcomes after STN DBS Surgery for Parkinson Disease**

**Principle Investigator:** Klepsitskaya

**A Phase 3b, Prospective, Multicenter, Open-Label Extension Study to Assess Long Term Safety and Effectiveness of DYSPORT Using 2mL Dilution in Adults with Cervical Dystonia**

**Principle Investigator:** Klepsitskaya

**A Phase 3b, Multicenter, Randomized, Double-Blind, Placebo-Controlled Study Evaluating the Efficacy and Safety of DYSPORT Using 2mL Dilution in Adults with Cervical Dystonia**

**Principle Investigator:** Klepsitskaya

**A Phase 3, Multicenter, Double-Blind, Placebo-Controlled, Single-Treatment Efficacy and Safety Study of MYOBLOC (Part A) Followed by and Open-Label, Multiple-Treatment Study with MYOBLOC (Part B) in the Treatment of Troublesome Sialorrhea in Adult Subjects**

**Principle Investigator:** Klepsitskaya

Using Multiplex Families to Map Genes that Modify Susceptibility and Age at Onset in Parkinson's Disease (also known as "The PaGeFt Study") Parkinson's Genetic Research Study- NIH

**Principle Investigator:** Klepsitskaya

An objective double blind evaluation of bupiprion and citalopram in an individual with Friedreich ataxia

**Principle Investigator:** Klepsitskaya

**DYSPORTTM for Injection AbobotulinumtoxinA Neurotoxin Clinical & Health Economics Outcomes Registry in Cervical Dystonia (ANCHOR-CDI)**

**Principle Investigator:** Klepsitskaya

**Clinical Research Database for University of Colorado Health System's Outpatient Palliative Care Programs**

**Principle Investigator:** Kluger

**Pilot Investigation of Transcranial Magnetic Stimulation (TMS) as Treatment for Cortical Hyperexcitability Syndromes**

**Principle Investigator:** Kluger

**Study of the Neurophysiology of Central Fatigue**

**Principle Investigator:** Kluger

**Fatigability of Cognitive Performance in Older Adults: Objective Measures and the Impact on Quality of Life and Activity Level**

**Principle Investigator:** Kluger

**Cortical Physiology as a Therapeutic Target in Parkinson's Disease-related Dementia and Cognitive Dysfunction**

**Principle Investigator:** Kluger
Movement Disorders and Behavioral Neurology Research Database
Principle Investigator: Kluger

Acupuncture as a Symptomatic Treatment for Fatigue in Parkinson’s Disease
Principle Investigator: Kluger

Cognitive Dysfunction in Parkinson’s Disease
Principle Investigator: Kluger

Accuracy of PET Scans in the Diagnosis of Dementia in the Community Setting
Principle Investigator: Kluger

Defining Palliative Care Needs in Parkinson’s Disease. Aim 1: Compare the level of palliative care needs of PD patients to patients with advanced cancer. Aim 2: PD patients from Aim 1 will complete the Parkinson Disease Questionnaire (PDQ-39) measure of HRQOL to determine how palliative care needs correlate with HRQOL using linear regression to control for age and motor symptom severity
Principle Investigator: Kluger

University of Colorado Denver Depression Center Repetitive Transcranial Magnetic Stimulation (RTMS) Research Registry
Principle Investigator: Kluger

Test of a novel TMS method
Principle Investigator: Kluger

Functional Neuroimaging of Volitional Action Using Magnetoencephalography and Functional MRI
Principle Investigator: Kluger

Does prior acupuncture experience bias subjects’ perception of real versus sham acupuncture treatments?
Principle Investigator: Kluger

Trajectories and Markers of Neurodegeneration in Fragile X Premutation Carriers
Principle Investigator: Leehey

Memantine Treatment in Fragile X-Associated Tremor/Ataxia Syndrome
Principle Investigator: Leehey

A Multicenter, Double-Blind, Placebo-Controlled Study of Creatine in Subjects with Treated Parkinson’s Disease LS-1 (NETPD)
Principle Investigator: Leehey

Multi-Center, Double-Blind, Placebo-Controlled Phase II Study of Pioglitazone in Early Parkinson’s Disease (FS-ZONE)
Principle Investigator: Leehey

HDE Post-Approval Study (PAS) of NeuRX DPS (TM) for ALS
Principle Investigator: Lievlik

Protocol no. Mn-186-neuronext: A randomized, double-blind, placebo controlled study to evaluate the safety, tolerability and activity of ibudast (mn-186) in subjects with progressive multiple sclerosis
Principle Investigator: Miravalle

A Multicenter, Open-label, Extension Study to Evaluate the Long-Term Safety and Efficacy of BIIB019, Daclizumab High Yield Process (DAC HYP), Monotherapy in Subjects with Multiple Sclerosis who have Completed Study 205M/SM030
Principle Investigator: Miravalle

Improving bladder care for patients with Multiple Sclerosis. Developing a systematic approach for the assessment and diagnosis of neurogenic bladder in Multiple Sclerosis (MS) patients will result in improved bladder care and health related outcomes
Principle Investigator: Miravalle

Multicenter, double-blind, randomized, parallel-group, monotherapy, active-control study to determine the efficacy and safety of Daclizumab High Yield Process (DAC HYP) versus Avonex in patients with relapsing-remitting multiple sclerosis
Principle Investigator: Miravalle

A Multicenter, Randomized, Double-Blind, Placebo-Controlled Study of the Efficacy of Natalizumab on Reducing Disability Progression in Subjects With Secondary Progressive Multiple Sclerosis
Principle Investigator: Miravalle

A Randomized, Double-Blind, Parallel Group Study to Compare the Safety and Efficacy of Increasing Doses of Arbaclofen Extended Release Tablets to Placebo and Baclofen Tablets, USP for the Treatment of Spasticity in Patients with Multiple Sclerosis
Principle Investigator: Miravalle

A Phase III, Multicentre, Randomised, Parallel-Group, Double-Blind, Placebo-Controlled Study to Evaluate the Efficacy and Safety of Orucalizumab in Adults with Primary Progressive Multiple Sclerosis
Principle Investigator: Miravalle

A Randomized, Double-Blind, Double-Dummy, Parallel-Group Study to Evaluate the Efficacy and Safety of Orucalizumab in Comparison to Interferon-Beta-1a (Rebif) in Patients with Relapsing Multiple Sclerosis
Principle Investigator: Miravalle

A multinational, multicenter, randomized, parallel-group study performed in subjects with relapsing-remitting multiple sclerosis to assess the efficacy, safety and tolerability of Glatiramer Acetate (GA) injection 40 mg administered three times a week compared to placebo in a double-blind design
Principle Investigator: Miravalle

Effectiveness Analysis of Natalizumab versus Fingolimod using Patient-Reported Outcomes in Patients with Multiple Sclerosis
Principle Investigator: Nair

Spinal Muscular Atrophy (SMA) Biomarkers in the Immediate Postnatal Period of Development
Principle Investigator: Parsons

Virtual Reality Assessment of Visuospatial Disorientation in Alzheimer’s Disease
Principle Investigator: Pelak

Lumbar Puncture Simulation Training for University of Colorado Hospital Residents in Post-Graduate Year 1 (PGY-1) Training
Principle Investigator: Pelak

Neuroadaptation of Multifocal Intraocular Lenses After Cataract Surgery
Principle Investigator: Pelak

Functional and Neuroanatomical MRI Correlates of Spatial and Other Cognitive Domain Changes Associated with Testosterone Supplementation in Healthy Older Men
Principle Investigator: Pelak

Principle Investigator: Pelak

Virtual Reality Assessment of Visuospatial Disorientation in Patients Undergoing Deep Brain Stimulation (DBS)
Principle Investigator: Pelak

Pilot Phase 2 Double Blind Trial of the Safety and Efficacy of GM-CSF (Leukine) in the Treatment of Alzheimer’s Disease
Principle Investigator: Potter/Woodcock

A Phase II Trial of Rituximab In Myasthenia Gravis: The specific primary objective of this study is to determine whether rituximab is a safe and beneficial therapeutic for MG that warrants further study in a phase III efficacy trial
Principle Investigator: Quan

ALN-TTR02-004 Titled “APOLLO: A Phase 3 Multicenter, Multinational, Randomized, Double-blind, Placebo-controlled Study to Evaluate the Efficacy and Safety of ALN-TTR02 in Transthyretin (TTR)-Mediated Polyneuropathy (Familial Amyloidotic Polyneuropathy)”
Principle Investigator: Quan
A Randomized, Double-Blind, Placebo-Controlled Study of the Safety and Efficacy of Intranasal Midazolam (USL281) in the Outpatient Treatment of Subjects with Seizure Clusters
ARTEMIS-1: Acute Rescue Therapy in Epilepsy with Midazolam Intransal Spray-1
Principle Investigator: Strom

Long Term Esketamine Acetate Extension Study
Principle Investigator: Strom

Efficacy and Safety of Esketamine Acetate (BIA 2093) as an Adjunctive Therapy for Refractory Partial Seizures in a Double-blind, Randomized, Placebo-controlled, Parallel-group, Multicentre Clinical Trial
Principle Investigator: Strom

A Multicenter, Global, Observational Study to Collect Information on Safety and to Document the Drug Utilization of RG00012 When Used in Routine Medical Practice in the Treatment of Relapsing Multiple Sclerosis
Principle Investigator: Vollmer

Long Term Natalizumab Therapy and its Effect on Neocortical, Subcortical, and Whole Brain Atrophy Rates
Principle Investigator: Vollmer

Phase 3, Multi-center, Randomized, Double-blind, Parallel-group, Placebo-controlled Study Followed by an Active Treatment Period to Test the Safety and Efficacy and Tolerability of an Oral Treatment for Patients with Relapsing Remitting Multiple Sclerosis
Principle Investigator: Vollmer

A Double-Blind, Placebo-Controlled, Single Ascending Intravenous Infusion Study of nHlgM22 in Patients with Multiple Sclerosis
Principle Investigator: Vollmer

Rocky Mountain Multiple Sclerosis Center (RM/MSC) Biorepository for the Study of Neuroimmunological Disorders
Principle Investigator: Vollmer

A Phase 1 Randomized Study of MEDI-551 in Subjects with Relapsing Forms of Multiple Sclerosis
Principle Investigator: Vollmer

Retrospective study looking at various MS patients who have been taking Tysabri, Gilenya, Rituxan, Rebif, Avonex, and Betaseron for more than 2 years. Study has been submitted for exempt review to COMIRB
Principle Investigator: Vollmer

A Phase II, Double Blinded, Placebo Controlled, Randomized Study Comparing Rituximab Induction Therapy Followed by Glatiramer Acetate Therapy to Glatiramer Acetate Monotherapy in Patients with Relapsing Forms of Multiple Sclerosis
Principle Investigator: Vollmer

Phase 1, multi-center, randomized, double-blind, placebo-controlled, ascending single dose study of the safety, tolerability, and pharmacokinetics of intravenous VX15/2503 in patients with Multiple Sclerosis
Principle Investigator: Vollmer

JCV Antibody Program in Patients With Relapsing Multiple Sclerosis Receiving or Considering Treatment With Tysabri
Principle Investigator: Vollmer

The Global Observational Program on the Safety of Tysabri
Principle Investigator: Vollmer

An Extension Protocol for Multiple Sclerosis Patients Who Participated in Genzyme-sponsored Studies of Alemtuzumab
Principle Investigator: Vollmer

An exploratory study to evaluate potential virological and immunological markers for the identification of multiple sclerosis (MS) patients at risk of developing progressive multifocal leukoencephalopathy (PML) during continued treatment with natalizumab
Principle Investigator: Vollmer
A Safety and Efficacy Extension Study of ONO-4641 in Patients with Relapsing-Remitting Multiple Sclerosis IN PATIENTS WITH RELAPSING-REMITTING MULTIPLE SCLEROSIS
Principle Investigator: Vollmer

A multinational, multicenter, open-label, single-assignment extension of the MS-LAQ-302 (BRAVO) study, to evaluate the long-term safety, tolerability and effect on disease course of daily oral laquinimod 0.6 mg in subjects with relapsing multiple sclerosis
Principle Investigator: Vollmer

Genetic Evaluation of Natalizumab-Treated Patients With Progressive Multifocal Leuкоencephalopathy
Principle Investigator: West

NEUROBIOLOGY

Insulin inhibitory neuromodulation to reduce cigarette craving and alter brain function in smokers
Principle Investigators: Regner/Tanabe

Effects of acetate and alcohol on brain function
Principle Investigators: Yamamoto/Tanabe

Multivariate pattern analysis approaches to predict Parkinson's Disease
Principle Investigators: Muth/Tanabe/Berman

Neural Correlates of Avoidance Learning in Substance Abuse
Principle Investigator: Tanabe

Does Long Term Natalizumab Therapy Normalize Brain Atrophy Rates and Quality of Life in Relapsing-Remitting Multiple Sclerosis.
Principle Investigators: Miravalle/Hacene

Comparative Effectiveness of Long Term Fingolimod versus Glatiramer Acetate on Brain Atrophy Rates, Cognition and Patient Reported Outcomes in Patients with Multiple Sclerosis.
Principle Investigators: Alvarez/Hacene

The Impact of Switching from Tysabri to Gilenya on Imaging and Clinical Effectiveness Outcomes.
Principle Investigator: Alvarez

Cross-Sectional Study of MSDx Complex-1 Association with Gadolinium Enhancing Lesions and Clinical Relapses in Relapsing-Remitting Multiple Sclerosis.
Principle Investigator: Schiener

Microstructural changes within the basal ganglia differ between Parkinson's disease subtypes
Principle Investigators: Berman/Nagae

DTI in blepharospam
Principle Investigators: Berman/Nagae

 Morphologic Volume and Shape Changes in Primary Focal Dystonia Patients vs. Controls
Principle Investigators: Nyberg/Berman.

NEUROSURGERY

Neuro-Marker Discovery for Accurate Localization of the Subthalamic Nucleus for DBS
Principle Investigators: Absolos with First Ince (University of Houston)

A System that Wirelessly Reports Coordinates for Neurosurgery
Principle Investigators: Absolos/Achim Klug

Sensory Gating with a Microelectrode During Deep Brain Stimulation (DBS) Surgery
Principle Investigators: Absolos with Keeran Maharaj

Neuropathology of Parkinson’s Disease: From Mouse to Man
Principle Investigators: Absolos with Gidon Felsen

Cognitive and Neural Correlates of Inflammation in Healthy Older Adults
Principle Investigator: Bettcher

Deep Brain Stimulation for Schizophrenia
Principle Investigator: Gault

Metabolics of Primary and Recurrent High Grade Gliomas
Principle Investigator: Graner

Tumor Homing Exosomes for Drug Delivery
Principle Investigators: Graner with Tom Anorchouky

Mechanisms of Gliol Injury in Demyelinating Disorders
Principle Investigators: Graner/Wendy Macklin

Can Exosomes Induced by Breast Involution be Markers for the Poor Prognosis and Prevention of Postpartum Breast Cancer?
Principle Investigators: Graner/Virginia Borge

Advancing Treatment for Pediatric CranioPharyngioma
Principle Investigator: Hankinson

Phase II Clinical trial Evaluating DCVax®-Brain
Principle Investigator: Lillehei

CirOlator in Intrathoracic Pressure
Principle Investigators: Neumann/Cava

ME100 Inhalation Solution Clinical Study
Principle Investigator: Neumann

Role of IL-13RA2 as a Functional Biomarker in Breast Cancer Brain Metastasis
Principle Investigators: Ormond/Diana Cittelly

Apollo Onyx Delivery Micro Catheter Post Market Safety Study
Principle Investigator: Seinfeld

SPINE ORTHOPEDICS

Evaluation of the Association Between Melatonin Signaling Impairments with the Promoter of Melatonin Receptor 1b (MTR1b) Gene Polymorphism, Calmodulin Expression in Osteoblasts and Lymphocytes, and Clinical Manifestation of the Disease in Patients with Adolescent Idiopathic Scoliosis (AIS)
Principle Investigator: Evalina Burger

Prospective Analysis of Cell Saver Related Morbidity and Coagulopathy in Spine Surgery
Principle Investigator: Evalina Burger

Pre-op Templating for TDR Alignment: Is it Clinically Relevant?
Principle Investigator: Christopher Cain

Retrospective Review of Minimally Invasive Placement of Pedicle Screws in Spine Surgery
Principle Investigator: Christopher Kleck

Prospective Analysis of Spine Surgery Outcomes
Principle Investigator: Emily Lindley

Reducing surgical site infections among spine patients through the implementation of an evidence-based bundle of care
Principle Investigator: Melanie Sandoval

Quantification of Pain Sensitivity to Controlled Objective Pain Stimuli
Principle Investigator: Vikas Patel

Retrospective Evaluation of 3D Scan Imaging to Define Normal Parameters of the SI Joint
Principle Investigator: Christopher Kleck

Effects of vitamin D deficiency on lumbar spine fusion and the role of rBMP-2
Principle Investigators: Vikas Patel/Emily Lindley

Pedicle Screw Placement in Spine Surgery: A retrospective review of O-arm/Stealth vs Non-Computerized Navigation Techniques
Principle Investigators: Vikas Patel/Christopher Kleck

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Retrospective Review of Outcomes in Complex Spine Surgery  
Principle Investigator: Evalina Burger

The effects of system changes and implementation of an electronic medical record system on the complication rate of adult spinal deformity surgery  
Principle Investigator: Evalina Burger

A Retrospective Examination of Vitamin D in the Spine Surgery Patient  
Principle Investigator: Vikas Patel

Meta-analysis of the Outcomes and Complications in the Spinal Surgery Population Receiving Recombinant Human Bone Morphogenetic Protein-2 vs. Those Receiving Iliac Crest Bone Graft  
Principle Investigator: Vikas Patel

The relationship between Sagittal plane correction and Quality of life in adult deformity patients treated with posterior instrumentation  
Principle Investigator: Evalina Burger

DuraSeal™ Exact Spine Sealant System Post-Approval Study  
Principle Investigator: Vikas Patel

Insite, Investigation of Sacroiliac Fusion Treatment  
Principle Investigator: Vikas Patel

A Retrospective Study Evaluating the Efficacy of the Orthofix Cervical-Stim® Bone Growth Stimulator in Patients that Have Undergone Cervical Fusion Surgery and are at High-risk for Non-fusion  
Principle Investigator: Vikas Patel

A Prospective, Multi-Center, Randomized Study Comparing the Vertiflex® Superion™ Interspinous Spacer (ISS) to the X-STOP® Interspinous Process Decompression (IPD)® System in Patients With Moderate Lumbar Spinal Stenosis  
Principle Investigator: Vikas Patel

Validation of a New Sacroiliac-joint Specific Disability Questionnaire  
Principle Investigator: Emily Lindley

Clinical Study to Evaluate the Safety and Effectiveness of the Aesculap Acti+L Artificial Disc in the Treatment of Degenerative Disc Disease  
Principle Investigator: Vikas Patel

Prospective study of pedicle screw placement using the O-Arm and Navigated Instrumentation  
Principle Investigator: Vikas Patel

**SPINE PM&R**

Clinical Course of Patients with Lumbar Radiculopathy with Motor Deficit  
Principle Investigator: Venu Akuthota

Correlation of PROMIS Short Form to Legacy Functional & Pain Outcome Measures in Individuals Undergoing Interventions for Acute Low Back or Radicular Pain  
Principle Investigator: Venu Akuthota

Lumbar Epidural Steroid Injections for Spinal Stenosis  
Principle Investigator: Venu Akuthota

Long Term Outcomes of Lumbar Epidural Steroid Injections for Spinal Stenosis  
Principle Investigator: Venu Akuthota

Does MRI affect physician treatment for patients presenting with Low Back Pain: A prospective analysis  
Principle Investigator: Venu Akuthota
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