



NEUROSCIENCES 2014



University of Colorado Hospital

UNIVERSITY OF COLORADO HEALTH



“WHEREVER THE ART OF MEDICINE IS LOVED,
THERE IS ALSO A LOVE OF HUMANITY.”

~ Hippocrates



3	LETTER FROM THE CHAIRS
5	NEUROSCIENCES OVERVIEW
7	AWARDS
9	QUALITY & PATIENT SATISFACTION
13	BRAIN TUMORS
19	CEREBROVASCULAR & STROKE
25	COGNITIVE DISORDERS
29	EPILEPSY
35	MOVEMENT DISORDERS
39	MULTIPLE SCLEROSIS
43	NEUROCRITICAL
47	NEUROMUSCULAR
51	NEURO-OPHTHALMOLOGY
55	SPINE
61	RESEARCH & INNOVATION
67	SELECTED PUBLICATIONS
73	FACULTY

LETTER FROM THE CHAIRS

Dear Colleagues,
Advancing medicine and achieving excellence in complex clinical care requires outstanding teamwork and collaboration of clinicians, researchers, staff and leaders. At University of Colorado Hospital, we are privileged to have such a team, all focused on the needs of the patient and engaged in excellence. We are pleased to share with you their efforts and achievements in quality, safety, clinical care and research from January through December 2013.

University of Colorado Hospital is the largest provider of comprehensive neurological and neurosurgical care in the Rocky Mountain region. We lead the state in the amount and quality of care provided to patients with epilepsy, movement disorders, neuroimmunology/multiple sclerosis, neuro-oncology, behavioral neurology/dementia, neuro-ophthalmology and neuro-critical care. In 2013, we provided over 41,000 outpatient visits, and our neurosciences units accounted for 3,215 admissions, 1,971 major Neurosurgical and Spine procedures and 16,068 patient days.

Our neuroscience services include a newly designed state-of-the-art 24-bed Neurosurgical Critical Care Unit, along with dedicated cerebrovascular and stroke services in our JCAHO-certified Comprehensive Stroke Center. The University of Colorado pioneered the first tissue transplants for treatment of Parkinson's disease and today we have the region's largest deep brain stimulation program. We are a Level 4 National Association of Epilepsy Center with a comprehensive Epilepsy Monitoring Unit. Our Neurology department is proud to be a National Multiple Sclerosis Society Collaborative Research Center, an American Stroke Association-Bugher Foundation Center of Excellence in Stroke Collaborative Research, a Muscular Dystrophy Association Clinic, an NIH-funded Parkinson's Disease Clinical Research Program Center, and an NIH-funded Network for Excellence in Neuroscience Clinical Trials (NEXT) site. We are the only program in the region to be ranked by U.S. News and World Report as one of the top 50 programs in Neurology and Neurosurgery in the nation. Not surprisingly, more neurologists and neurosurgeons in our Neuroscience Program are individually recognized by U.S. News and similar national ranking groups, than any other program in the Rockies.

The Department of Neurosurgery is home to the region's only comprehensive stereotactic radiosurgery program using both Gamma Knife and Novalis BrainLab technology. In addition, the Department is proud of its innovative programs in minimally invasive spine surgery, treatment of complex skull base tumors and its multidisciplinary programs in the treatment of pituitary and malignant brain tumors. Our rapidly expanding program in Neuro-Critical Care includes the open and endovascular treatment of cerebral aneurysms and vascular malformations and innovative treatment of strokes.

We continue to experience tremendous growth and recognition for the entire program, with the addition of many new faculty members in hospital neurology, neuroimmunology, neurosurgical critical care, neuropsychiatry, neuromuscular disease, Alzheimer's disease, epilepsy, and stroke. We welcome our recently inaugurated program for the treatment of headaches and the establishment of an Alzheimer's Disease Research and Clinical Center.

One of the highlights of our accomplishments over the past year has been the awarded designation as one of the few elite Joint Commission certified Comprehensive Stroke Centers. This designation recognizes not only our ability to deliver advanced stroke therapies and meet best practices for stroke care, but also the deep knowledge and experience of our staff – particularly their ability to recognize and respond to the often-subtle signs of stroke.

Advancing Discovery

The Neurology Clinical Research program, led by Timothy L. Vollmer, M.D., and the Neurosurgery Research Program, led by Aviva Abosch, M.D., Ph.D., have continued to be a major engine of research growth, providing "bench-to-bedside" translation of the newest therapeutic advances. Neurology and Neurosurgery's large and growing clinical research enterprises span diverse subspecialty areas and encompass more than 100 in-progress clinical trials.

In 2013, the Department of Neurology received nearly \$14 million in research grant awards, making it the fourth-largest department in research funding at University of Colorado School of Medicine and 27th nationally among neurology departments in NIH funding. The breadth and depth of these activities is highlighted in the lists of current research and recent peer-reviewed publications included in this book.

Our success this past year has been due to the hard work of our physicians, nurses, researchers, and staff. Our promise continues to be the provision of exceptional, patient-centered care and the best possible outcomes. Watch for new programs and services in 2015, as we take on the challenge of value in medicine progressing towards our vision "from healthcare to health" – a challenging and inspiring journey.



Kevin Lillehei, M.D.
Chair, Neurosurgery

A handwritten signature in black ink, appearing to read "K. Lillehei".



Kenneth Tyler, M.D.
Chair, Neurology

A handwritten signature in black ink, appearing to read "K. Tyler MD".

The Neurosciences Center at University of Colorado Hospital

Advancing care at the Neurosciences Center at University of Colorado Hospital (UCH) requires a team of world class clinicians, researchers and educators seeking discovery while valuing the individual needs and interactions of each and every one of our patients. Such collaboration and focus on the patient experience has led us to be one of the top performing centers in the country for neurological and neurosurgical care. Sharing our performance and outcomes, both those that exceed state and national benchmarks and those that continue to challenge us, creates an environment of continuing improvement. As this book demonstrates, these efforts have guided us to new innovations, accomplishments and the discovery of new opportunities.

At UCH, patients have access to the latest treatments and medical therapies, many of them developed and tested here. Those with small brain tumors can have them destroyed noninvasively on an outpatient basis using Gamma Knife and Novalis® Radiosurgery. UCH is also the only academic center in the state with an electroencephalographic (EEG) biofeedback program for patients with epilepsy, providing a nonsurgical option for patients who do not respond to medication.

The ongoing quest for excellence fosters the pursuit of change in all our areas. Here, there is a continued focus on improvement, with every subspecialty participating in at least one ongoing performance improvement project.

We are particularly proud of the following:

- » One of the highest 5-year survival rates for brain cancer in the country
- » Over 40 active clinical and laboratory trials for multiple sclerosis
- » Offering percutaneous endoscopy discectomy/decompression of the spine
- » 76% of eligible ischemic strokes patients treated within 60 minutes of arrival
- » One of the most experienced centers in the U.S. in deep brain stimulation surgery, now offering stereotactic guided sedated implantation
- » Pioneering neuro-ophthalmology use of 3D simulation vision testing
- » One of just 18 centers to offer ACGME-accredited fellowships in orthopaedic spine surgery, and spine and pain medicine

Through the robust research program at UCH, patients have access to the latest treatments, including investigational approaches that provide options available nowhere else in the state. While other academic centers find their research funding declining, at UCH it is expanding, with more than \$14 million in research money awarded to the Neuroscience Center in 2013.

Mission We improve lives. In big ways, through learning, healing and discovery. In small, personal ways through human connection. But in all ways, we improve lives.

Vision From healthcare to health.

Values Patients first. Integrity. Excellence.



The UCH Neurosciences Center has received numerous awards, certifications and other recognitions.

Among them:

- » Designated the #1 hospital in Colorado by U.S. News and World Report.
- » Three-time Magnet Award Recipient.
- » University HealthSystem Consortium, top 10 for Quality 2010, 2011, 2012, 2013.
- » Joint Commission certified Comprehensive Stroke Center.
- » American Heart Association Target Stroke Gold Plus 2011, 2012, 2013, 2014.
- » Designated as the only National Cancer Institute Comprehensive Cancer Center in the Rocky Mountain region (one of only 41 in the United States).
- » Received the Blue Distinction® Center+ for Spine Surgery, the only hospital in the state with this designation.
- » Designated a Neurosciences and Spine Center of Excellence by NeuStrategy.
- » Awarded the Society of Interventional Radiology Gold Medal Award. The award was given to Interventional Radiology Director, David Kumpe, M.D., one of only 34 American physicians to ever receive the honor.
- » Designated as one of only two National Association of Epilepsy Centers (NAEC) Level 4 programs in the state.
- » Certified as the only MDA/ALS research and clinical program in the state.
- » Awarded the Beacon Award for Excellence, Gold Level, from the American Association of Critical Care Nurses, one of only seven neuro-intensive care units in the country to receive the award.
- » U.S. News and World Report Top 50 in Neurology and Neurosurgery.

These accomplishments, as well as many more, are highlighted throughout the rest of this book.



University of Colorado Hospital

UNIVERSITY OF COLORADO HEALTH



Becker's Hospital Review
100 Great Hospitals
In America



American Heart Association
American Stroke Association
CERTIFICATION
Meets standards for
Comprehensive Stroke Center



Designated as a
Blue Distinction®
Center +
for Spine Surgery

Anthem. BlueCross BlueShield
An Independent Licensee of the
Blue Cross and Blue Shield Association



QUALITY & PATIENT SATISFACTION



As we take on the bold and challenging vision of “from healthcare to health,” the focus on disease prevention, total patient care management, quality outcomes, safety, and the patient experience have increasing importance. University of Colorado Hospital continues to challenge itself to lead the academic health care community in advancing these efforts.

In 2014, the University HealthSystem Consortium (UHC) named University of Colorado Hospital as one of the highest-performing academic hospitals in the U.S. for delivering quality healthcare. In fact, we have placed in the top 10 for the past four years, including an unprecedented consecutive two years as the #1 ranked hospital. UHC is an alliance of 120 academic medical centers and over 300 of their affiliated hospitals, which represent approximately 90% of the nation's nonprofit academic medical centers. The award is given to the academic hospital with the best outcome scores in patient safety, clinical effectiveness, clinical efficiency, patient experience, mortality and equity, the latter a measure of whether outcomes differ for patients of different ethnicities and socioeconomic backgrounds.

According to UHC, the nation's top performing academic medical centers possess a core set of organizational characteristics that include: a shared sense of purpose; an interactive leadership style; a system to promote accountability for service, quality and safety; a focus on results; and collaboration across clinical and administrative leadership and staff. This award is a reflection of the values that are embedded in the culture at University of Colorado Hospital and reflect the daily efforts of our physicians, nurses, ancillary care providers and staff across the organization to advance patient care.

A Mission of Patient Centered Care

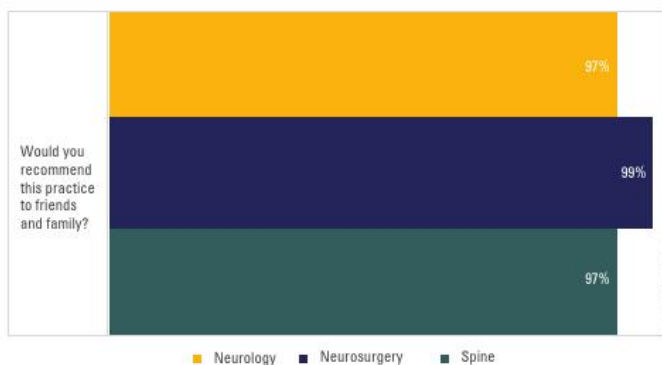
University of Colorado Hospital's Neurosciences Center is committed to the mission of "healing the whole patient" and ensuring that the patient experience receives just as much attention as the clinical services. This means providing patient-centered care, involving patients in any decisions about their care, listening to their concerns, answering every question, and ensuring patient satisfaction in everything from staff communication to the quiet of the inpatient setting. Studies show this approach not only increases patient satisfaction, but also results in higher quality care and more cost-effective outcomes.

HCAHPS Exceed Colorado and National Averages

The Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) is a standardized survey instrument for measuring patient perspectives on hospital care. It contains 18 patient perspectives on eight key topics:

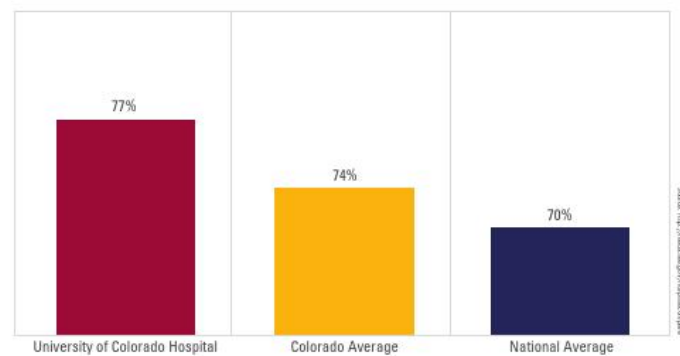
1. Communication with doctors
2. Communication with nurses
3. Responsiveness of hospital staff
4. Pain management
5. Communication about medicines
6. Discharge information
7. Cleanliness of the hospital environment
8. Quietness of the hospital environment

OUTPATIENT SATISFACTION BY PRACTICE



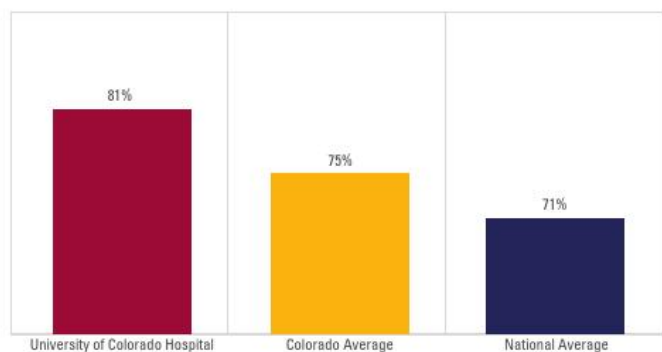
HOSPITAL RATING

Percentage of inpatients who gave their hospital a 9 or 10 out of 10



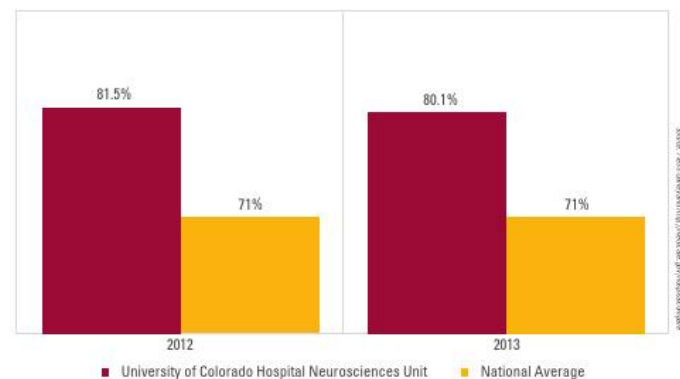
WOULD RECOMMEND

Percentage of inpatients who would "definitely" recommend their hospital



WOULD RECOMMEND

Percentage of inpatients who would "definitely" recommend their hospital



QUALITY & PATIENT SATISFACTION

Overall, University of Colorado Hospital scored in the 80th percentile when patients rated the hospital a 9-10 (10 being the highest rating), and 90th percentile for patients who reported they definitely would recommend the hospital, as reported over the period of July 1, 2013-June 30, 2014. These scores greatly exceed both Colorado and national averages.

High Patient Experience Scores with Inpatient and Outpatient Services

Another indicator of the outstanding service and quality of the patient experience offered by the Neurosciences Center can be seen in our inpatient and outpatient care survey results. Inpatient satisfaction is measured by written satisfaction surveys collected post-discharge via Avatar Solutions. When compared to academic hospitals, our neuroscience unit at UCH scored in the 85th percentile on the overall rating. Our Neuro ICU ranked in the 99th percentile among other teaching hospitals overall, with 92% of patients saying they would definitely recommend the hospital to others. For outpatient satisfaction, as measured by the UCHA Patient Pulse, 97% of patients highly recommend Neurology and Spine, and 99% of patients highly recommend Neurosurgery.

Three Time Magnet Award Recipient

This commitment to quality of care, outcomes, and patient satisfaction is also represented by our designation as a Magnet facility by the American Nurses Credentialing Center. This award reflects excellence in nursing, the promotion of nurse autonomy and growth, and high levels of collaboration across the entire clinical team. UCH is a three-time Magnet Award recipient, reflecting a long standing commitment to collaborative patient care and outcomes.

"Quality, safety and satisfaction will continue to be a major driving factor in healthcare delivery in the years to come. While we are proud of our achievements to date, there is always an opportunity to improve. We strive every day to put our patients first, incorporate evidence-based practice into clinical care and identify areas for improvement. We have an obligation to use our growing therapeutic armamentarium wisely, so we are developing high quality, cost effective models of neurological care."

– Steven P. Ringel, M.D., Vice President, Clinical Effectiveness & Patient Safety, University of Colorado Hospital

97% of patients highly recommend Neurology

97% of patients highly recommend Spine

99% of patients highly recommend Neurosurgery



“THE GREATEST EVIL IS PHYSICAL PAIN.”

~ Saint Augustine

BRAIN TUMORS



The Right Level of Care, Tailored to the Patient

As the only National Cancer Institute-designated Comprehensive Cancer Center in the Rocky Mountain region (and one of only 41 in the United States), the specialized surgeons, oncologists, radiotherapists, neuropathologists, physicists, neuropsychologists and nurses at the University of Colorado Cancer Center care for more patients with brain tumors than any other hospital in the region. It also has one of the highest 5-year survival rates in the United States. UCH's 5-year survival rate for brain and other nervous system cancers is 47%, compared to the national rate of 25%.

Among the important ways the UCH brain tumor team leverages its broad expertise is through its weekly multidisciplinary “tumor board” conference, during which radiation oncologists, neuro-oncologists, neurosurgeons, neuropathologists, neuroradiologists and others consider treatment options for particularly tough cases.

The UCH Cancer Center also offers one of the largest neuroendocrinology programs in the country, where a close team of pituitary endocrinologists and neurosurgeons surgically treat 80 to 100 patients with pituitary tumors a year in a shared weekly clinic. In the operating room, UCH neurosurgeons use stereotactic guidance during brain tumor surgery, an option available only in the top cancer centers in the country. This system maps the cortex in three dimensions, enabling surgeons to aggressively resect even very small tumors while navigating around critical brain structures. Many such surgeries are performed while the patient is awake, which helps map their speech and motor cortex. The team is also expert in minimally invasive brain surgeries performed via the skull base. These surgeries, performed on tumors such as craniopharyngiomas, demand the close collaboration of neurosurgeons and ear, nose and throat specialists.

3,224 OP Visits **94%** of Pituitary Tumor patients have a 5-year survival rate
47% Malignant Brain & CNS patients have a 5-year survival rate (25% Natl)
Pioneering research on tumor vaccine
NeuStrategy Center of Excellence Cranial Tumor

Virtual Scalpels: Noninvasive Radiosurgery

University of Colorado Hospital’s remarkable survival rate is due in part to its access to two major tools enabling noninvasive outpatient radiosurgery: the Gamma Knife and the Novalis Radiosurgery units.

UCH is just one of two Colorado hospitals offering Gamma Knife treatment. This device focuses cobalt-60 radioactive sources into 192 guided beams, which converge in precise patterns to destroy tumors and other malformations deep inside the brain, with minimal collateral damage. Approximately 300 patients yearly receive treatment with the Gamma Knife at UCH. Although used primarily to destroy benign and malignant tumors, UCH neurosurgeons are among the few in the country using it to treat trigeminal neuralgia.

The Novalis system is best for patients whose tumors or arteriovenous malformations (AVM) require more than a single dose of radiation. This tool shapes the radiation beam to match the contour of the tumor or lesion, which helps target the dose and avoid irradiating nearby healthy tissue. Having both options available allows clinicians to individualize treatments for each patient.

Malignant Melanoma: Exceptional Outcomes

One of the largest areas of interest in the UCH brain tumor program is treating melanoma that has metastasized to the brain. While the median survival for these patients after stereotactic radiosurgery is about four months, the median survival for patients seen at UCH is more than twice that—8.7 months, with an average survival of 21 months. 6% of UCH patients survived 10 years—a length of time rarely seen in patients with melanoma that has spread to the brain.

The University of Colorado Cancer Center’s teams of specialists aims to provide each of its brain tumor patients the safest, most effective combination of care – whether that’s observation, chemotherapy, radiosurgery, or surgery – the goal being to do what’s best for each and every individual.

BRAIN TUMORS

Ninety-Eight Lesions, One Gamma Knife, and One Survivor

Leland Fay had taken one hit after the next. Diagnosed with malignant melanoma in April 2012, he underwent surgeries of the neck and the scalp. That August, a scan confirmed that the cancer had spread to his lungs, stomach and liver. He joined a clinical trial at The Angeles Clinic with Dr. Omid Hamid for an experimental BRAF inhibitor and PD-L1 antibody. Two months after that, another scan showed suspicious lesions in his brain.

"The hits kept coming," said Fay, now 43. "It was a parade of hits."

In this case, Fay's scan delivered another 98 hits – each one a brain lesion. He got the news on Christmas Eve.

Fay was 41 at the time, an aerospace engineer with a wife and two young boys. UCH oncologist Rene Gonzalez, M.D., a renowned melanoma specialist, referred him to a man with a 42,000-pound knife.

That's neurosurgeon Robert Breeze, M.D., co-medical director of the Rocky Mountain Gamma Knife Center at UCH. The knife in question was a Leksell Gamma Knife Perfexion. One of just two Gamma Knives in Colorado, the device focuses cobalt-60 radioactive sources into 192 guided beams that converge in precise patterns to destroy tumors and other malformations deep inside a patient's brain, noninvasively and with minimal collateral damage. Patients usually go home the same day.

Breeze was uniquely qualified for a case like Fay's. In his two decades of Gamma Knife experience, Breeze has pioneered procedures for those with heavy metastatic tumor burdens in the brain. He takes cases like Fay's, which, as Fay put it, "normally, when you have that many lesions, they just send you to hospice."

During most of 2013 and early 2014, Fay spent hours at a time in the Gamma Knife, a head frame isolating his movements. Conscious, he simply closed his eyes and waited as Breeze and the machine did their work. In the longest of the seven sessions – four-and-a-half hours – Breeze treated two dozen lesions. In another session, Breeze targeted another 18 lesions. Most sessions targeted eight to ten lesions. In each case, Breeze worked in close cooperation with the Gamma Knife Center's co-medical director, UCH radiation oncologist Brian Kavanagh, M.D., in identifying the individual lesions.

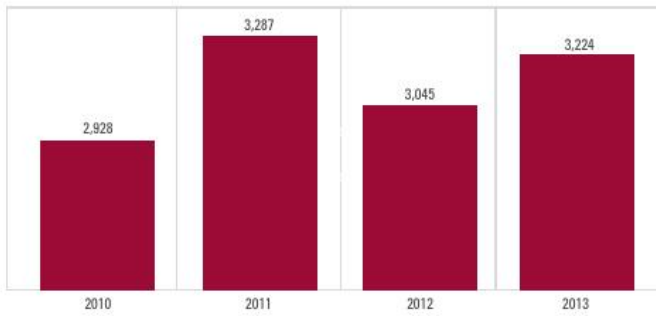
A scan at the end of 2013 showed no brain-tumor growth. A February 2014 follow-up noted that one of the 98 tumors was growing, a result in itself that Breeze and staff deemed "miraculous;" Fay went back under the Gamma Knife to retreat the lesion. If, after the next MRI, the lesion has continued to grow, surgery will be required.

"Dr. Breeze said it was an easy procedure, which I find humorous because it's brain surgery," Fay said. "But it's in the frontal lobe and it's small."

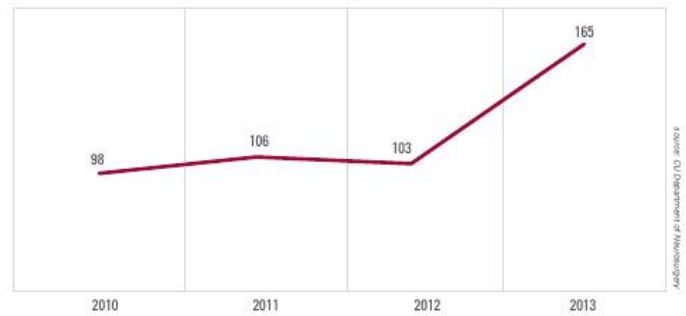
So far, so good. There have been two courses of ipilimumab and, more recently, a return to the care of Dr. Hamid as part of Merck's compassionate use program for pembrolizumab. Fay has changed his diet, too – no sugar and no meat, despite a professed love for cheeseburgers. He's doing it all for his family.

"That's the thing that will bring me to tears, just thinking about my kids and not being there. My personal goal is to get the boys through high school – that would be pretty awesome," Fay said. "We'll see. There are a lot of smart people trying to solve this problem – Hamid, Gonzalez, Breeze and their staffs, those largely unsung heroes in the pharmaceutical labs and research institutions. These folks are phenomenal."

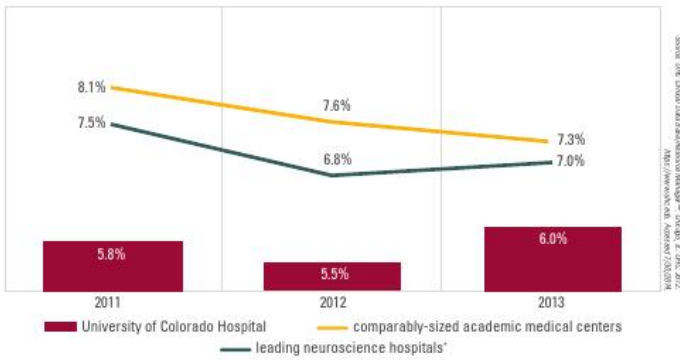
OUTPATIENT VISITS



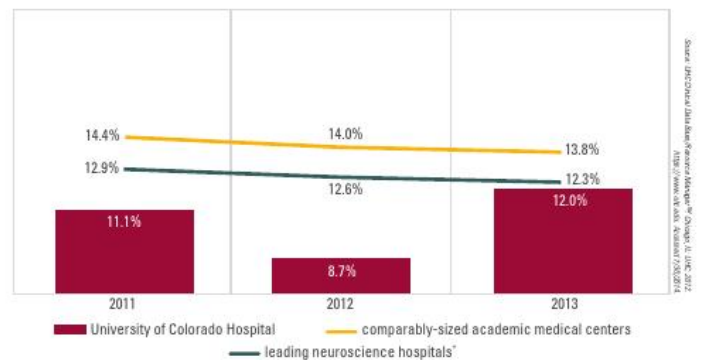
GAMMA KNIFE PROCEDURES (performed by UCH Neurosurgeons)



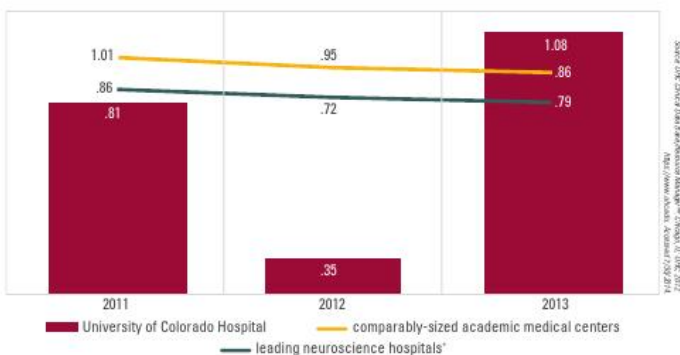
30 DAY READMISSION RATES – RELATED CAUSE



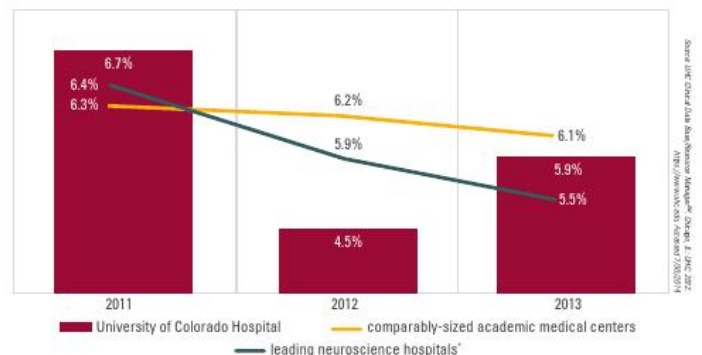
30 DAY READMISSION RATES – ALL CAUSE



MORTALITY INDEX



COMPLICATION RATES

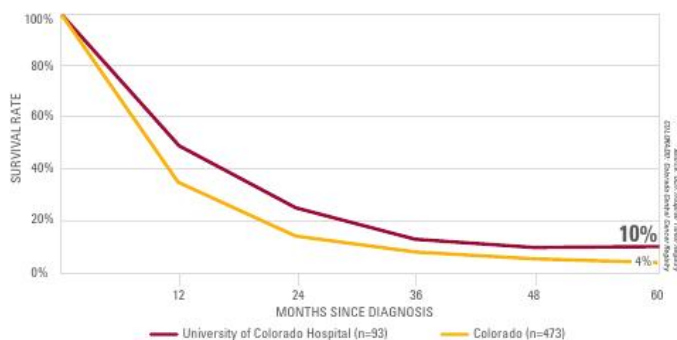


Mortality Index is the ratio of observed to expected mortality based on a risk adjustment algorithm. An index score of 1 indicates observed and expected mortality are equal. Values below 1 are desirable.

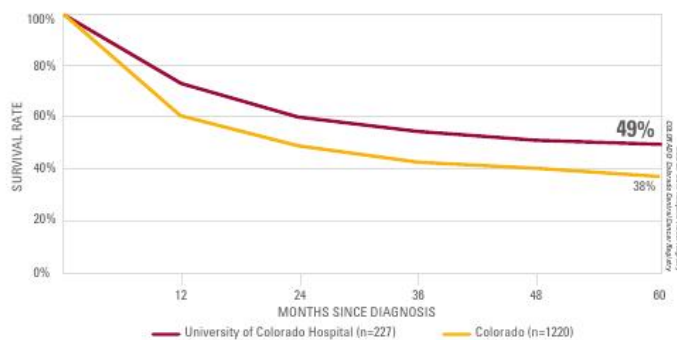
*Leading neuroscience hospitals is an aggregate of top ranked hospitals from sources such as US News & World Report, Becker's 100 Great Hospitals, and NeuStrategy Centers of Excellence.

BRAIN TUMORS

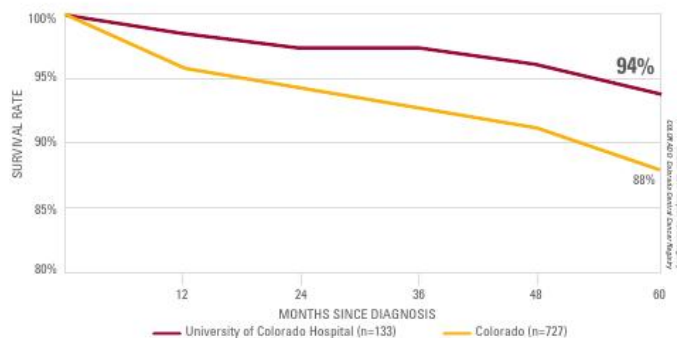
BRAIN TUMOR (GBM ONLY) 5-YEAR SURVIVAL



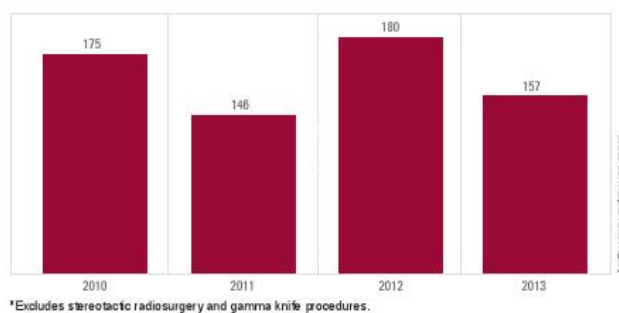
BRAIN (INCLUDING BENIGN) 5-YEAR SURVIVAL



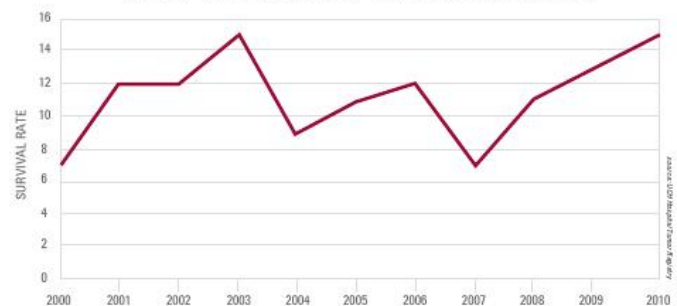
PITUITARY GLAND 5-YEAR SURVIVAL



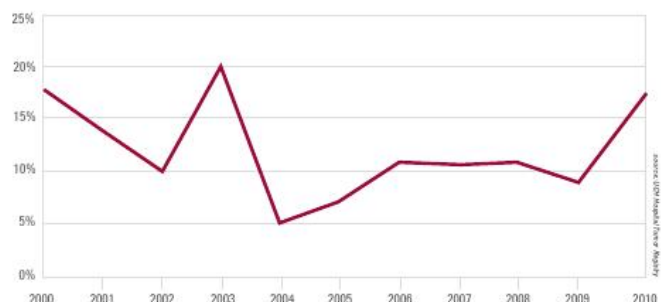
BRAIN TUMOR PROCEDURES*

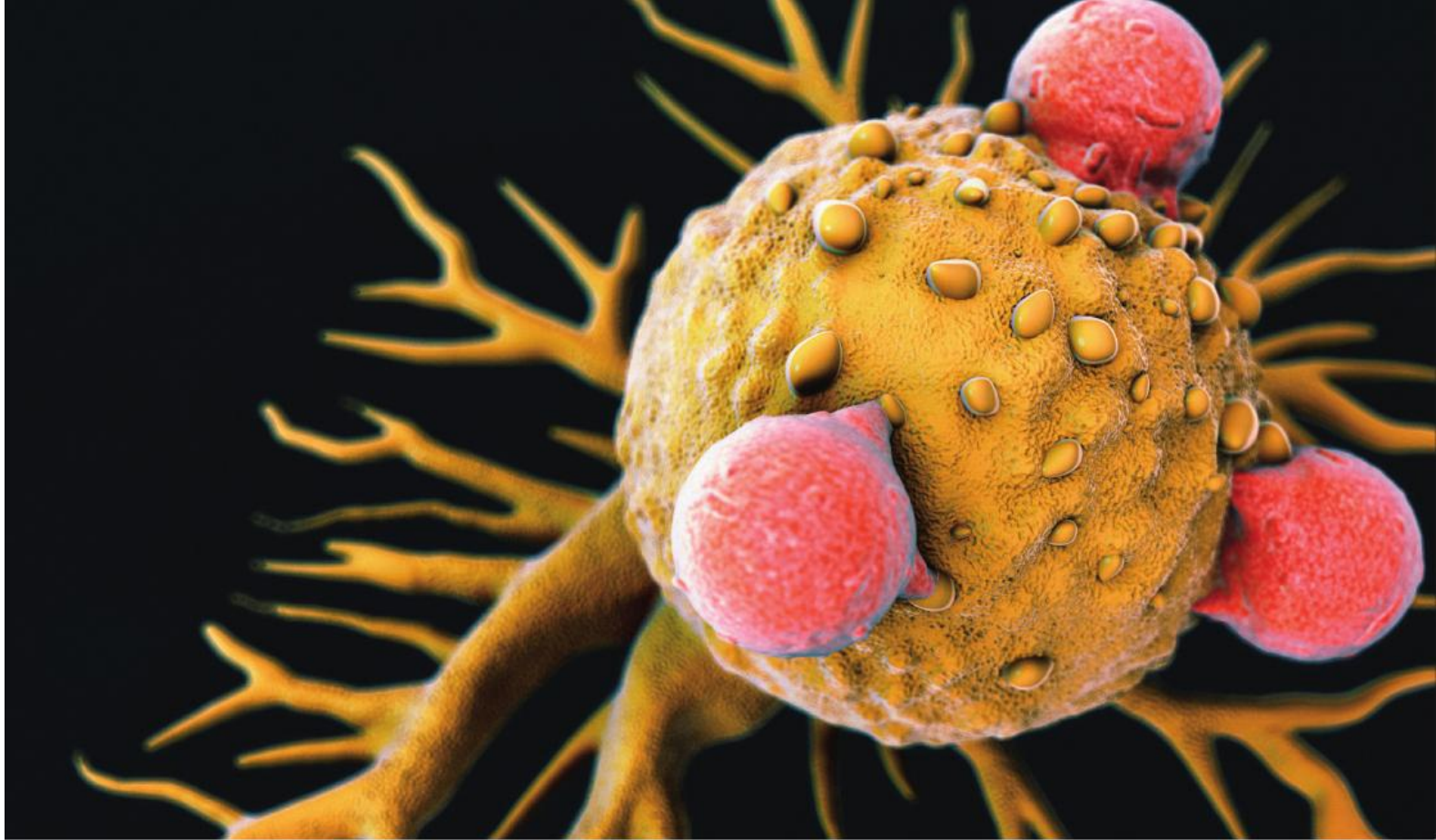


MEDIAN SURVIVAL FOR GBM (MONTHS)



LONG TERM SURVIVAL FOR GBM
(% of patients living at least 3 years after diagnosis)





BRAIN TUMOR DIAGNOSIS DISTRIBUTION



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

*annualized based on 6 months of data source: UCH Hospital Tumor Registry

LENGTH OF STAY (DAYS) 6.1 Observed 5.2 Expected

Source: UCH Clinical Data Base/Resource Manager[®]. Chicago, IL: UHC; 2012. <https://www.uch.edu>. Accessed 7/30/2014.

*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.

CEREBROVASCULAR & STROKE

Leading the Way in Stroke Care

Stroke care at UCH begins with the multidisciplinary Primary Stroke Response Team, which converges within minutes of a patient's arrival in the emergency department. "Time is brain," and providing optimal, safe, treatment as quickly as possible epitomizes the underlying philosophy of UCH's emergent stroke care. Once stabilized, patients are admitted to the hospital's 24-bed neuro-ICU for observation and intensive medical management, and when stable, are moved to a dedicated neurosciences unit to begin the recovery process. When discharged, they receive state-of-the-art rehabilitative care. The hospital also hosts a stroke support group for patients and their families.



American Heart Association
American Stroke Association
CERTIFICATION
Meets standards for
Comprehensive Stroke Center



97% of patients that arrive by 2 hours are treated within 3 hours of symptom onset

1.9% related cause readmission rate for Hemorrhagic Stroke, **0%** for Ischemic Stroke

JC Comprehensive Stroke Center

NeuStrategy Center of Excellence Neurovascular/Stroke

American Heart Association **Target Stroke Gold Plus** 2011, 2012, 2013, 2014

The overall quality of stroke care provided is one of the major reasons UCH was named as one of the elite Joint Commission certified Comprehensive Stroke Centers in 2013. Just 1.4% of U.S. hospitals can boast this designation, earned only after demonstrating the delivery advanced stroke therapies, the consistent use of best-practices stroke care, the engagement of knowledgeable staff capable of recognizing and responding to the often-subtle signs of stroke, and the provision of effective long-term management after discharge.

Quality, Measured

An unrelenting focus on quality is central to maintaining exacting standards across the many fronts of stroke care. Continuous quality improvement is a cornerstone of the UCH cerebrovascular and stroke program. Among the metrics employed to gauge care quality are the percentage of eligible patients who receive clot-busting intravenous tissue plasminogen activator (tPA) during a stroke, and the time from arrival to the drug's delivery. In 2013, 76% of eligible patients at UCH received tPA within an hour, and the UCH stroke team's overall median of 48 minutes "door-to-needle" time was significantly faster than the national rate. In stroke care, this sort of speed can translate directly into better outcomes for our patients.

In July 2014, UCH launched its telestroke program, availing the expertise of its team of board-certified vascular neurologists and stroke specialists to Memorial Hospital in Colorado Springs, its University of Colorado Health partner. With the telestroke program's planned expansion, patients in hospitals across the region will benefit from care typically available only to those with immediate access to a major academic medical center.



Advancing the Science

The UCH Stroke Center is involved in two active multi-center trials. One, ICTuS, is studying the effect of intravascular cooling during the administration of tPA. The goal is to understand whether a combination of thrombolysis and hypothermia is superior to thrombolysis alone for the treatment of acute ischemic stroke. An adjunct to this study, called HASTIER, considers whether and how this cooling affects advanced perfusion imaging. The second study, POINT, is measuring the effectiveness of anti-platelet treatments, such as aspirin alone versus an aspirin-plus-clopidogrel combination among patients with transient ischemic attack (TIA) or minor stroke.

On the strengths of these and other research efforts, the UCH Stroke Center in April 2014 became one of three American Stroke Association-Bugher Foundation Centers of Excellence in Stroke Collaborative Research for Regeneration, Resilience and Secondary Prevention. Awardees were chosen based on their capability to not only train fellows in stroke research, but also for their commitment to collaborate with scientists outside their institutions.

CEREBROVASCULAR & STROKE

Rapid Response, Quick Recovery

Between helping raise five kids ages two-and-a-half to 14 and running his own business, Jason Tarves didn't have many opportunities to slow down and didn't really need to. He was a healthy 36-year-old who looked a bit like Clark Kent, his wife Meadow joked, with the glasses and all.

The day before Father's Day, a previously undiagnosed hole in his heart nearly became his Kryptonite.

It had started the previous night, June 13, 2013. He had invited a few colleagues from his business, Mad Dog Dents, for a barbecue at the house in Superior. During the cookout, he noticed he had double vision and he felt like his eyes were crossing. He found himself stumbling as if he were drunk, which he wasn't.

Tarves fell asleep on the couch and was up at 5 a.m. He felt OK again. Before he left for work, he kissed his wife's forehead and told her he would be home in the early afternoon.

Hailstorms had pocked the sheet metal of hundreds of rental cars at Denver International Airport. Tarves, with his business Mad Dog Dents, had been busy smoothing them out. He was finishing up on a car when he lost his balance and fell into it. His brother-in-law, Shiloh Mielke, was working on the next car over.

"Hey, man, I've got to sit down," Tarves told him. "Something's not right with me."

He called his wife. It was about 8:30 a.m. Tarves was slurring. When they hung up, Meadow googled "stroke" and saw that he was in trouble. She called her brother. "Jason is having a stroke," she said. "You have to call 9-1-1."

When Tarves arrived at University of Colorado Hospital at 9:10 a.m., an Emergency Department team led by Michael Jobin, M.D., assessed him. By then Tarves's left side had gone slack. They sent out a Stroke Alert, mobilizing the Stroke Team of neurologists, neuroradiologists, and ED pharmacy staff, who would join the ED staff already treating Tarves. The goal was to assess the need for – and, if appropriate, administer – clot-busting tissue plasminogen activator (tPA) within an hour of Tarves's arrival.

Things happened fast. Tarves was in a CT scanner 20 minutes after arrival; neuroradiology resident Naomi Saenz, M.D., had read the scan within nine minutes of the first slice. Minutes after that, Sharon Poisson, M.D., the neurohospitalist stroke team's attending physician, and neurology resident Cliff Hampton, M.D., had called for tPA. It began flowing just 38 minutes after arrival, far faster than the UCH stroke team's 60-minute goal and below even the 46 median minutes the stroke team had achieved year-to-date.

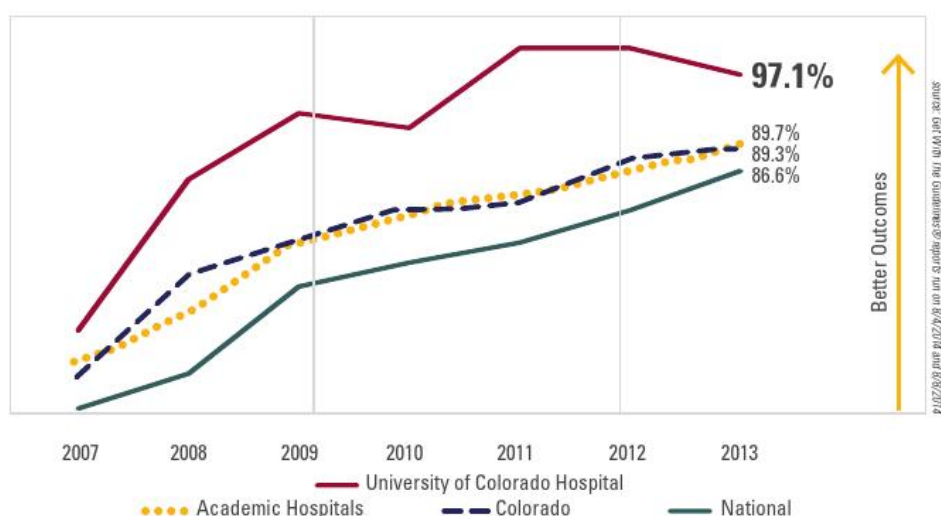
A follow-up MRI pinpointed the problem as a small acute infarction in the anteromedial aspect of the right thalamus. A previously undiagnosed patent foramen ovale (PFO) had given passage to the seed of a small clot, which the lungs might otherwise have harmlessly captured, the providers surmised.

Tarves arrived at the hospital as a "9" on the National Institutes of Health Stroke Scale (NIHSS); 48 hours later, he left as a "1," with the mildest symptoms of a minor stroke. Two weeks later, he was back at work.

"I can't say enough about the nurses and doctors who took care of me," Tarves said.

IV rt-PA ARRIVE BY 2 HOURS, TREAT BY 3 HOURS

The percentage of acute ischemic stroke patients who arrive at University of Colorado Hospital (UCH) within 2 hours of time last known well and for whom IV t-PA was initiated within 3 hours of time last known well is consistently higher than aggregate rates for academic hospitals, all Colorado hospitals, and hospitals across the country. Faster intervention means better outcomes.



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THE JOINT COMMISSION CORE MEASURES

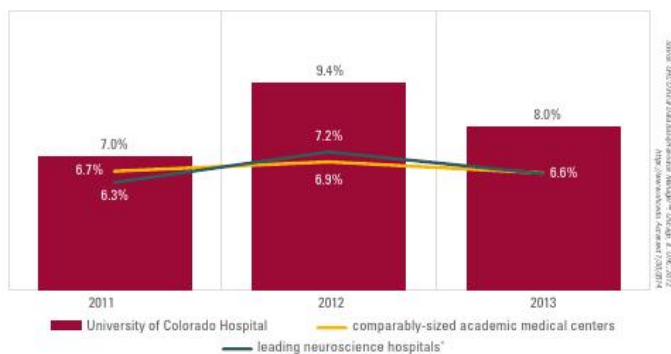
The University of Colorado Hospital scored well above national averages on all Joint Commission Core Measures for Stroke in the past three years, and continues to focus on this critical service for the future.

	UNIVERSITY OF COLORADO HOSPITAL			2013 NATIONAL AVERAGE
	2011	2012	2013	
VTE Prophylaxis within 48 hrs of Admission	98.6%	98.3%	98.6%	95.3%
Antithrombotic Therapy at Discharge	100%	100%	100%	98.4%
Anticoagulation Therapy for A Fib/Flutter	100%	100%	100%	94.5%
IV tPA Arrived by 2 Hr, Treated by 3 Hrs	100%	100%	97.1%	86.6%
Antithrombotic Tx by End of Hospital Day 2	98.6%	100%	99.1%	97.6%
Statin Therapy at Discharge	97.4%	100%	100%	94.2%
Stroke Education Teaching	99.2%	98.3%	97.2%	91.7%
Rehab Considered	99.3%	100%	100%	97.7%
Dysphagia Screening	96%	86.6%	91.7%	83.2%
Smoking Cessation	100%	90.6%	97.5%	97%

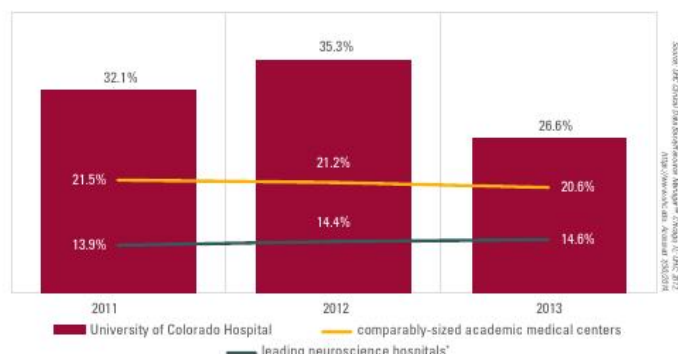
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CEREBROVASCULAR & STROKE

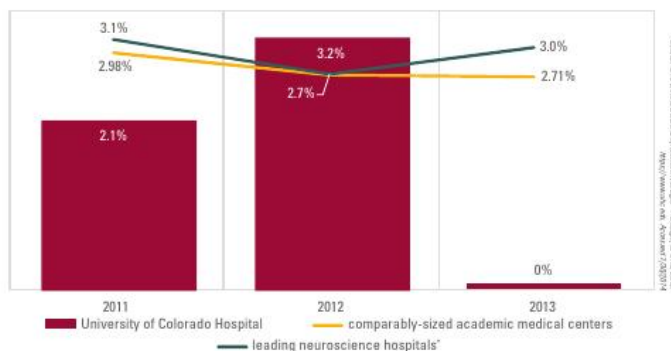
COMPLICATION RATES – ISCHEMIC STROKE



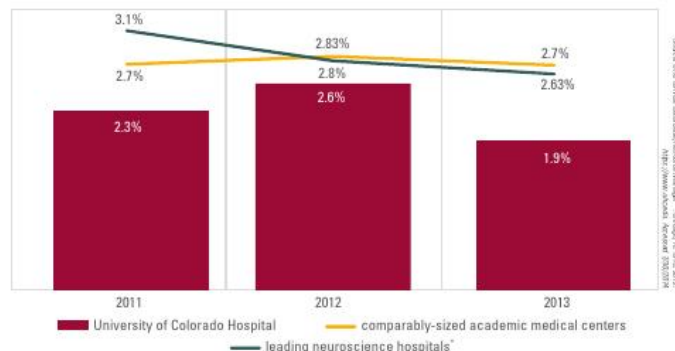
COMPLICATION RATES – HEMORRHAGIC STROKE



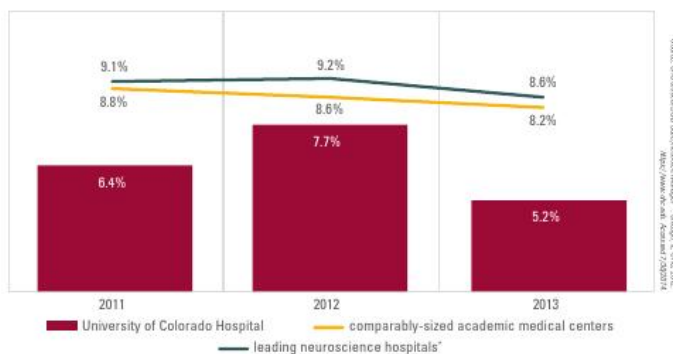
30 DAY READMISSION RATES – RELATED CAUSE ISCHEMIC STROKE



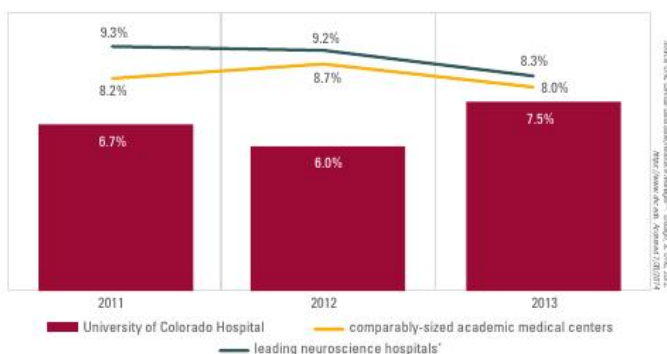
30 DAY READMISSION RATES – RELATED CAUSE HEMORRHAGIC STROKE



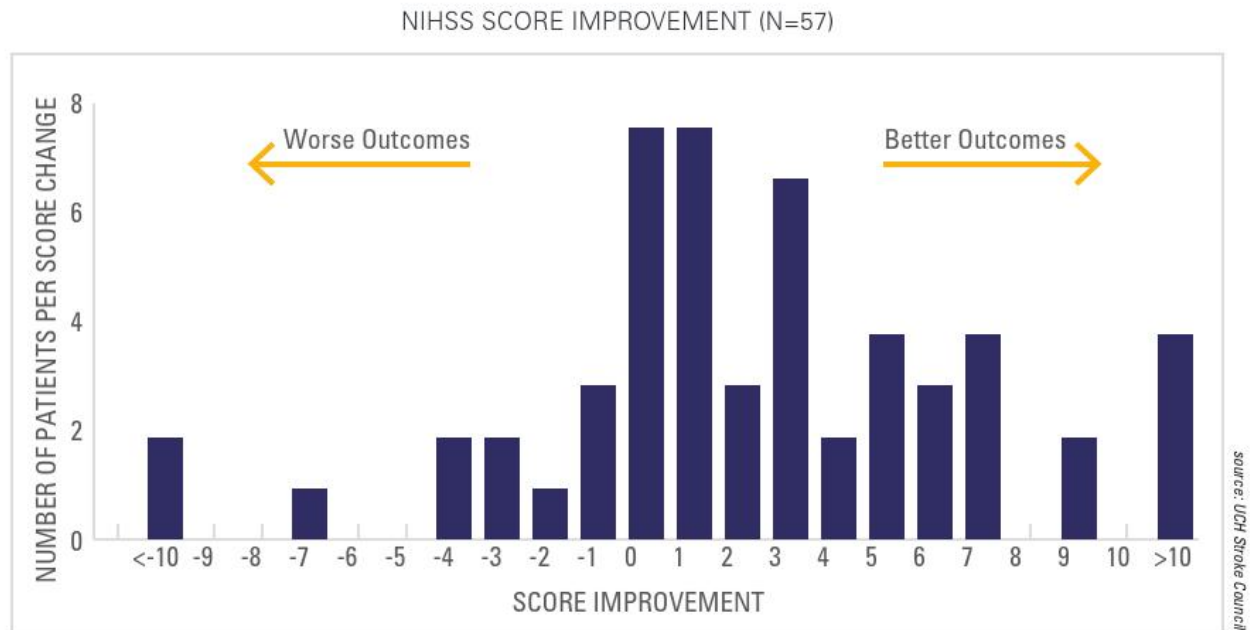
30 DAY READMISSION RATES – ALL CAUSE ISCHEMIC STROKE



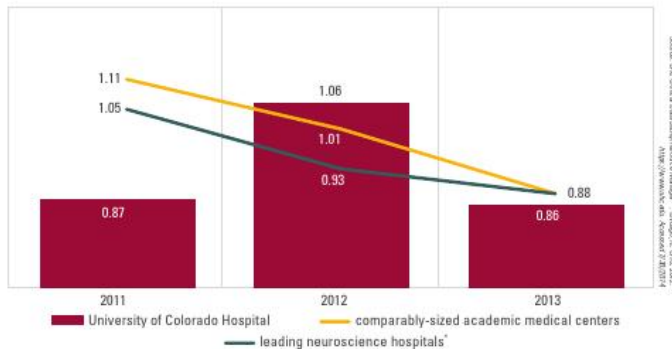
30 DAY READMISSION RATES – ALL CAUSE HEMORRHAGIC STROKE



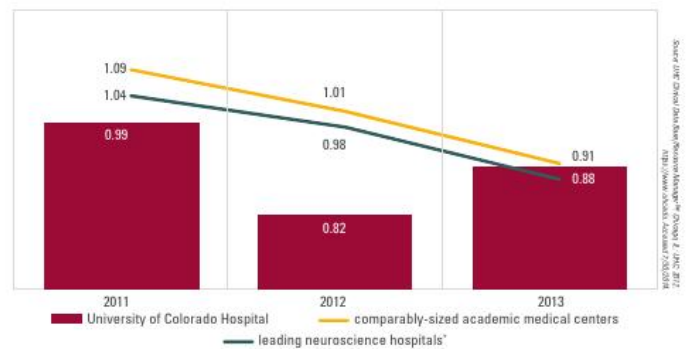
IN 2013, **76%** OF ALL ELIGIBLE ISCHEMIC STROKE PATIENTS WHO ARRIVED IN THE EMERGENCY DEPARTMENT WERE TREATED WITH tPA WITHIN 1 HR.



MORTALITY INDEX – ISCHEMIC STROKE



MORTALITY INDEX – HEMORRHAGIC STROKE



LENGTH OF STAY (DAYS) ISCHEMIC STROKE **5.8** Observed **5.8** Expected

LENGTH OF STAY (DAYS) HEMORRHAGIC STROKE **20.4** Observed **14.9** Expected

Source: UHC Clinical Data Base/Resource Manager™. Chicago, IL: UHC; 2012. <https://www.uhc.edu>. Accessed 7/30/2014.

*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.

COGNITIVE DISORDERS



UCH Alzheimer's Program Takes Off

The UCH Alzheimer's Clinical and Research Program is on a fast track toward national prominence in neurodegenerative disease care and research, to the benefit of patients in Colorado and beyond. The state's need for Alzheimer's care is exceptional and growing: the 2010 census showed Colorado has the nation's largest increase in Alzheimer's patients since 2000, and the state's Alzheimer's cases are predicted to double by 2050.

It's more about age than altitude, according to Huntington Potter, PhD, a University of Colorado neuroscientist and Director of Alzheimer's Disease Research for both the University of Colorado Department of Neurology and the Linda Crnic Institute for Down Syndrome. Half of those 85 and older have Alzheimer's disease, and people come to Colorado and seldom leave, he said.

Potter, who came to Colorado in mid-2012, is a big reason behind the growth of the neurodegenerative disease program at UCH. His aim is to establish a National Institute on Aging-funded Alzheimer's Disease Center at the University of Colorado and UCH. There are 29 such centers in the United States, each aiming to translate scientific advances into improving patient care and, ultimately, preventing and curing Alzheimer's disease. Potter, who established an Alzheimer's Disease Center at the University of South Florida, filed the 598-page application for the Rocky Mountain Alzheimer's Disease Research Center in May 2014.

The proposed center will have a special focus on Alzheimer's patients with Down syndrome, as well as special cohorts including American Indian and Hispanic/Latino populations. It will build on an expanding clinical and research core at UCH and the University of Colorado School of Medicine. On the clinical side, the November 2012 arrival of neurologist Jonathan Woodcock, M.D., led to the creation of the UCH Memory and Dementia Clinic. Woodcock, a neurobehavioral rehabilitation specialist who also serves as Clinical Director of Alzheimer's Disease Research, has enabled a seven-fold increase in capacity for patients with neurodegenerative diseases like Alzheimer's, memory problems and other types of dementia, to about 1,000 patients a year.

The boost in clinical capacity goes hand-in-hand with the expanding research enterprise Potter is driving. Alzheimer's patients and their families are hungry for clinical trials. Having a larger clinical population is helping present clear-cut patient cohorts for pharmaceutical companies wanting to test new therapies. The hardware available at an academic medical center is also helping clinical research: the onsite cyclotron has enabled local production of Pittsburgh compound B, meaning quicker access to PET amyloid scanning.

Promising Research

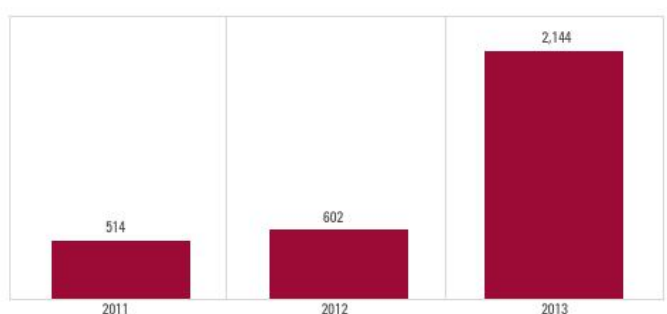
Potter is doing pioneering work in the Alzheimer's-Down syndrome, connection (*see story, on next page*), and the UCH Alzheimer's Clinical and Research Program has launched several promising research initiatives in this and other areas.

One example is a clinical trial of granulocyte macrophage colony-stimulating factor (GM-CSF), better known as Leukine. FDA-approved in 1995 for bone-marrow-transplant patients, Leukine fuels the creation of certain white blood cells. Potter Lab research associate, Tim Boyd, PhD, found that mice preprogrammed to develop Alzheimer's disease showed striking improvement when given the drug, with roughly half the amyloid load disappearing within a week followed by a return to normal cognition.

A second clinical project is using SomaLogic, Inc.'s aptamer-based technology to screen roughly 3,300 proteins in plasma samples to look for biomarkers in subjects with and without Down syndrome and with and without Alzheimer's-associated cognitive impairment. The goal, Potter says, is to develop a blood-based fingerprint to identify people at risk for dementia.

A third project is assessing the role of postsynaptic calcineurin signaling with regard to amyloid beta toxicity in animal models of Alzheimer's disease and in human brain samples. The 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 synaptic interaction could become a future therapeutic target.

OUTPATIENT VISITS



COGNITIVE DISORDERS

Exploring the Alzheimer's–Down Syndrome Connection

Alzheimer's disease and Down syndrome would seem to have little in common. One manifests in the womb; the other with age. But dig deep into cells and the connection couldn't be clearer: many patients with Alzheimer's disease have three copies of chromosome 21 rather than two – the same trisomy 21 as those born with Down syndrome.

Neuroscientist Huntington Potter, PhD, first suggested the Downs-Alzheimer's connection in the early 1990s while a faculty member at the Harvard Medical School. It wasn't until 2010 that his team of researchers, then at the University of South Florida's USF Health Byrd Alzheimer's Institute, established the connection definitively.

Now, attracted by a combination of the nation's only Down syndrome institute and the clinical and research infrastructure needed to build a world-class Alzheimer's research and treatment center, Potter aims to advance the science behind – and care for – both conditions at University of Colorado Hospital.

The link between these two neurodegenerative disorders could unravel mysteries of both, says Potter, director of Alzheimer's Disease Research for both the Department of Neurology at the University of Colorado School of Medicine and the Linda Crnic Institute for Down Syndrome.

Mysterious Link

Everyone with Down syndrome exhibits Alzheimer's disease neuropathology by age 40; surprisingly, though, nearly 40% of these patients never develop Alzheimer's-related dementia.

Potter says the apparent disconnect between Alzheimer's pathology and dementia is also seen in karyotypically normal individuals with typical age-related Alzheimer's, although a much smaller percentage of the elderly show Alzheimer's pathology for a significant time without developing dementia. Another wrinkle: many elderly Alzheimer's patients have been found to have trisomy 21 cells that developed in the brain and elsewhere, and autopsies have shown that some 90% of neuronal death attributed to Alzheimer's disease involves the loss of these and other aneuploidy cells.

The upshot, Potter says, is that individuals with Down syndrome offer a unique window into potential protective mechanisms that may allow a subset of all individuals with Alzheimer's pathology to avoid dementia.

His research to this end involves the identification of different classes of biomarkers – plasma biomarkers, chromosomal aneuploidy biomarkers, and cognitive biomarkers – that Potter and his team believe can shed light on why many Down syndrome and karyotypically normal individuals with Alzheimer's pathology are resistant to developing dementia.

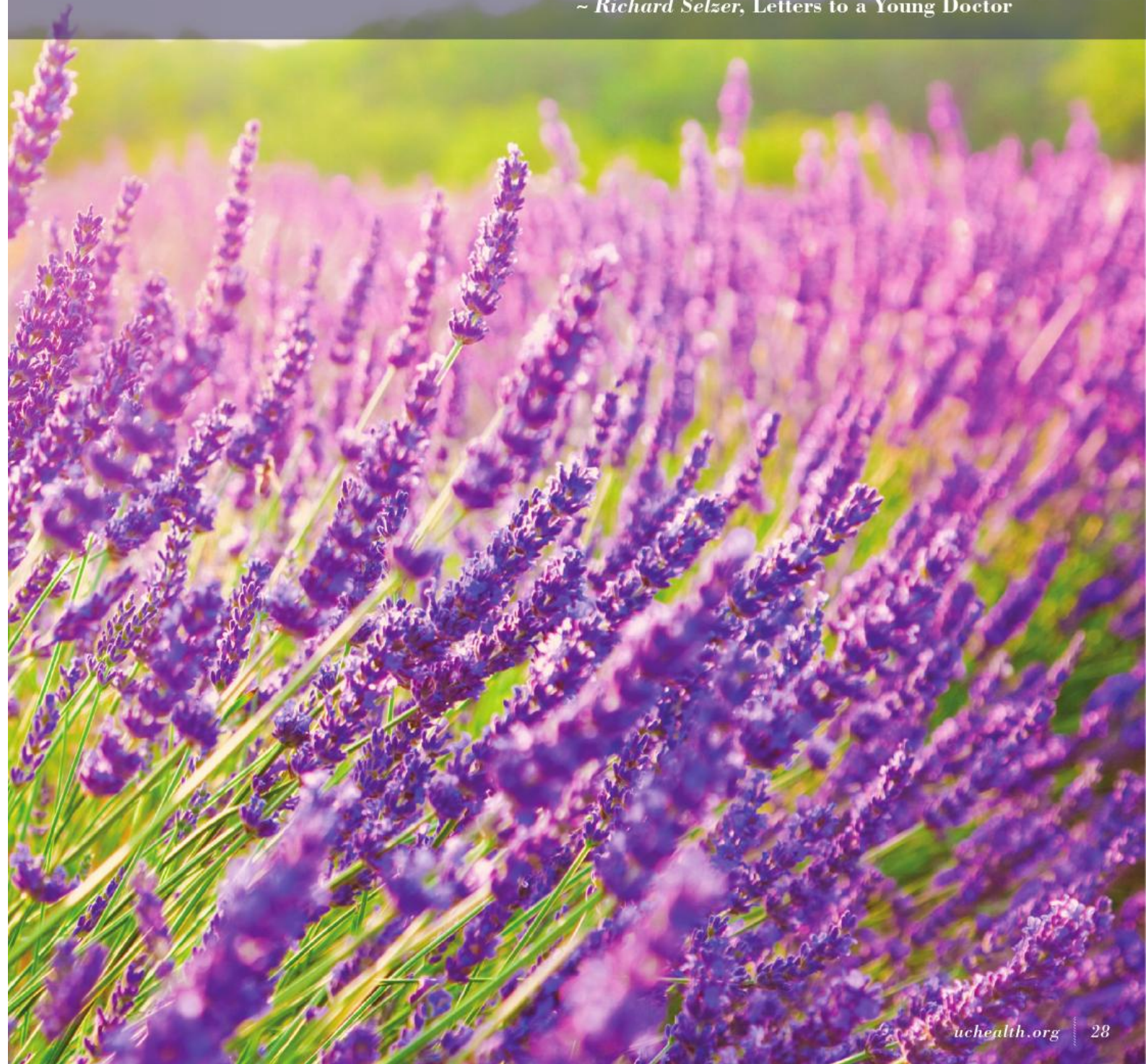
Potter and his UCH Alzheimer's Clinical and Research Program are starting with the recruitment of study subjects with Down syndrome, mild cognitive impairment, and mild Alzheimer's disease. These will be compared with age-matched controls for longitudinal studies. The team aims to determine the combination of clinical, medical imaging and neuropsychological test results that best predict whether patients will experience cognitive decline in the next five years.

A firmer grasp of the Down syndrome-Alzheimer's connection for the benefit of so many patients can't come soon enough, says Tom Blumenthal, PhD, the Linda Crnic Institute's executive director.

"We're so far behind where we should be by now, and there are more and more people with Alzheimer's," he said.

“YOU CANNOT SEPARATE PASSION FROM PATHOLOGY
ANY MORE THAN YOU CAN SEPARATE
A PERSON’S SPIRIT FROM HIS BODY.”

~ Richard Selzer, *Letters to a Young Doctor*



EPILEPSY



The Region's Largest, Most Comprehensive Epilepsy Center

University of Colorado Hospital's Comprehensive Epilepsy Center is a national leader in the diagnosis and comprehensive management of epilepsy. The region's largest and most comprehensive epilepsy center, UCH treats more patients than any other institution in the region. In 2013, the center provided 4,480 patient visits, including care for 513 new patients.

The UCH Epilepsy Center's eight fellowship-trained epileptologists (with two available 24 hours a day, seven days a week) and three specialized neurosurgeons are only part of the care picture. Patients receive multidisciplinary management, with physicians supported by neuropsychiatrists, neuropsychologists, and neurodiagnostic technologists, as well as certified neuroscience registered nurses. In addition to their day-to-day collaboration, these experts assemble for a weekly case-care conference, focusing on the most challenging patients.

Our program is one of just three Level 4 National Association of Epilepsy Centers (NAEC) in the state.

Level 4 centers provide the most complex forms of intensive neurodiagnostic monitoring. They also provide more extensive medical, neuropsychological and psychosocial treatment than lower-ranked programs. A robust clinical trials program at University of Colorado School of Medicine, coupled with progressive research, provides unparalleled treatment options for patients with some of the most challenging types of seizures and epilepsy.

The Region's Largest Epilepsy Monitoring Unit

More than 300 patients a year are admitted to the center's Epilepsy Monitoring Unit, where continuous video EEG monitoring provides critical data about provoked and unprovoked seizures for up to eight patients at a time. The information enables clinicians to more accurately diagnose, evaluate and treat patients with epilepsy. At least two specially trained staff members provide around-the-clock monitoring, something only a handful of inpatient epilepsy monitoring units in the country offer.

Dedicated Surgeons for Epilepsy Procedures

UCH neurosurgeons performed 55 epilepsy related surgeries in 2013, including 16 resections. The hospital's surgeons have extensive experience in the full spectrum of epilepsy related procedures, along with a unique expertise in neocortical resections for complex partial seizures. This involves resecting parts of the brain beyond the temporal lobe.

The surgeons are supported by advanced imaging technology available at UCH, including ictal-SPECT, PET and 248-channel magnetoencephalography (MEG) neuroimaging. MEG technology uses the brain's own magnetic fields to pinpoint brain activity. MEG neuroimaging's extreme sensitivity and precision can detect changes in brain waves within milliseconds and requires no radiation or invasive dyes or tracers, providing a safer experience for patients.

Neurofeedback for Nonsurgical Treatment of Resistant Epilepsy

The UCH Epilepsy Center's electroencephalographic (EEG) biofeedback program, a.k.a. neurofeedback, found strong patient demand within months of its launch in late 2012. This approach provides a nonsurgical option for the approximately 30% of epilepsy patients who do not respond to medication. Numerous studies find it can significantly reduce the incidence of seizures.

UCH's epilepsy neurofeedback service is one of the few programs in the country operating within an academic medical center. Patients here receive intensive neurofeedback training for 20 weeks or more, with the goal of reducing seizure frequency and improving cognitive function.

Level 4 Epilepsy Center **4,480** Outpatient visits

Surgical patients achieved a **98%** reduction in seizures

64% of patients with surgical intervention are seizure free

Neurofeedback Trains Brain to Stop Seizures

Margaret is 58 years old and has suffered grand mal epileptic seizures since she was 35. There's no aura anymore, no warning at all. No time to get to the floor before the lights go out.

She has broken teeth and bones, sustained several concussions and dislocated her shoulder "more times than she can count." She has not tolerated anti-seizure medications well.

Margaret had been working with Lauren Frey, M.D., a University of Colorado associate professor of neurology, for eight years. For much of that time, Frey adjusted medications and discussed other ways to cut back Margaret's seizures: lobectomies and vagus nerve stimulation among them. Margaret looked into them.

"I knew the state-of-the-art was limited. It's either drugs, or they start cutting parts of your brain out," Margaret said.

Frey suggested electroencephalogram (EEG) biofeedback. Margaret was skeptical at first. But when Frey explained the science behind neurofeedback, and it made sense. Plus, Margaret was desperate.

"I had arrived at a point by then that I was so beaten down by the seizures and the drugs. It was attractive because there were no new drugs and no scalpel," she said.

Margaret has been doing once-a-week neurofeedback sessions with Frey for 14 months now. She used to have five or six seizures a year. As of June 2014, she hadn't had one in seven months, despite cutting back on her medications.

Frey came across neurofeedback at an American Epilepsy Society meeting in 2009. She was intrigued and looked into the procedure. Studies had shown it to work. By summer 2012, she was ready to offer it to patients, opening the Neurofeedback Clinic at UCH, which she directs. While psychologists and psychiatrists in the region offer neurofeedback, she's the only neurologist doing it, she says.

"I feel I have a different perspective. I am a neurologist and take care of a lot of patients with seizures. I know how aggressive I can be and I have very clear treatment goals with them. I'm not only able to work with this, but also medications."

It's a big commitment. Sessions last 90 minutes, and patients typically come in once a week (early on, many come in twice a week) at least 20 times. But it seems to have worked for the majority of the 20 or so patients Frey has seen since mid-2012. And the procedure appears to help more than seizures.

"A lot of people tell me that it sort of changes their outlook," Frey says. "They feel better, have more energy, their cognition is better, fatigue is not quite as prominent. Some of it I think can be attributed to the neurofeedback – I don't drop the medications right away."

Margaret has a hard time describing the neurofeedback process, which involves Frey fitting her with an electrode cap and then emptying her mind. A video of a pair of swimming dolphins appears onscreen in varying degrees, depending on her success in matching her brain waves to a normative sample of "normal" brains.

"It's just enjoying my reward, and trying not to think about much of anything other than how beautiful it is, or how the light plays off the water. The way you might stare at a fire in a fireplace and find it relaxing," Margaret says.

During the session, Margaret does fifteen two-minute rounds. It's working for her, she says. Not only have the seizures gone into remission, but she's feeling less anxiety.

"It's been so many years, I hesitate to say that I'm seizure free," she says. "But I'm optimistic."

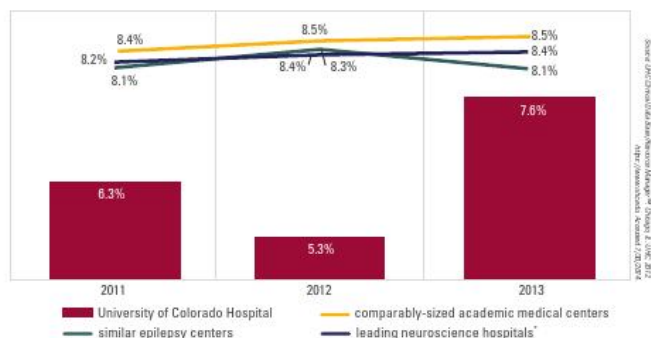
Epilepsy Center Research Spans Pharmaceutical, Behavioral Therapies

UCH Epilepsy Center is involved in multiple major clinical trials of promising new epilepsy therapies. In such trials, center faculty and staff share information about effectiveness and side effects with other national and international study sites. The Epilepsy Center conducts studies assessing medications for daily seizure prophylaxis, medications to acutely stop seizures as they occur, and neuromodulation devices designed to better control seizures.

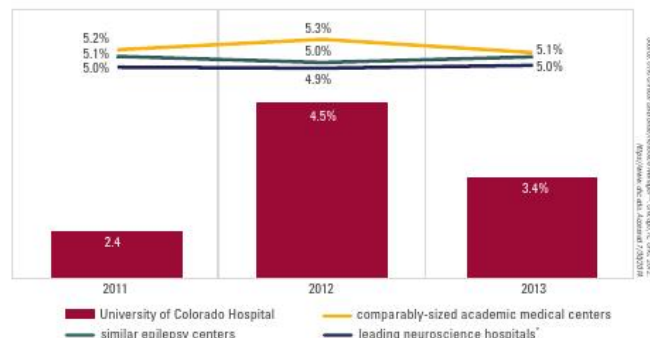
In addition, the Center's epileptologists are involved in other clinical research and quality improvement initiatives. For example, neurologist Mark Spitz, M.D., who directs the UCH Epilepsy Center, is leading a study to determine the relative accuracy of firsthand patient accounts of their seizures, when compared to the accounts of family members who witnessed those seizures. The study leverages a combination of questionnaires and video with other data from the UCH Epilepsy Monitoring Unit and may ultimately prove the importance of witness accounts when taking a seizure history.



30 DAY READMISSION RATES – ALL CAUSE



30 DAY READMISSION RATES – RELATED CAUSE



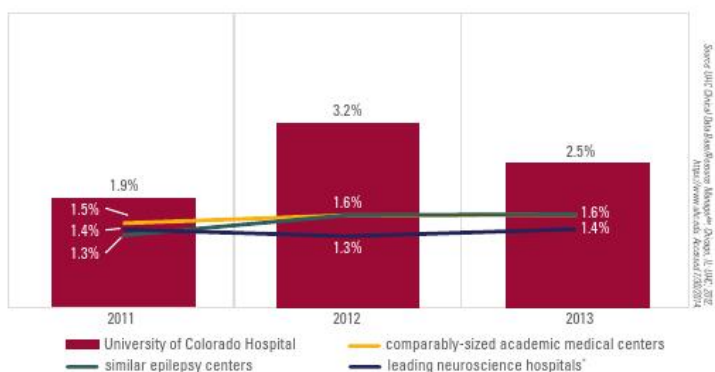
*Leading neuroscience hospitals is an aggregate of top ranked hospitals from sources such as US News & World Report, Becker's 100 Great Hospitals, and NeuStrategy Centers of Excellence.

“THE PHYSICIAN SHOULD NOT TREAT THE DISEASE
BUT THE PATIENT WHO IS SUFFERING FROM IT.”

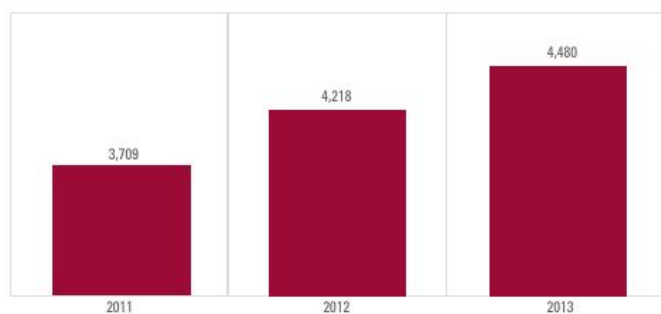
~ Maimonides



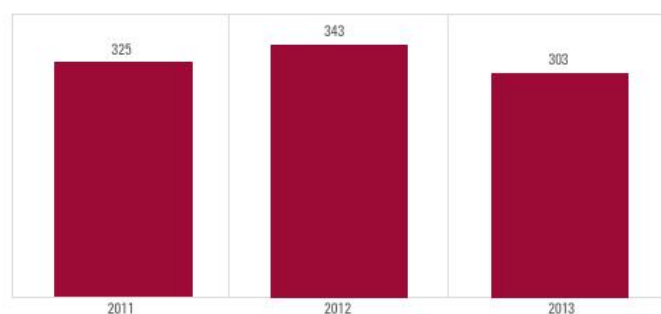
COMPLICATION RATES



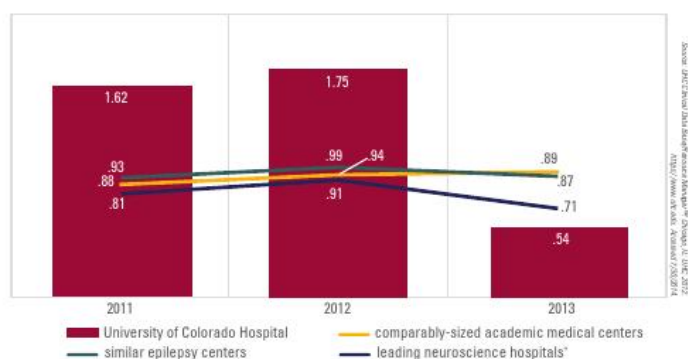
OUTPATIENT VISITS



EMU ADMISSIONS



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.

SURGICAL OUTCOMES

IN 2013...

- » **64%** of patients who had resective surgery were seizure free at an average of 7 months after surgery (n=14)
- » Overall **98%** seizure reduction rate was attained and no patients experienced increased seizures
- » Patients that did not achieve seizure freedom enjoyed a **78%** seizure reduction

LENGTH OF STAY (DAYS) 5.1 Observed 4.5 Expected

Source: UHC Clinical Data Base/Resource Manager. Chicago, IL: UHC; 2012. <https://www.uhc.edu>. Accessed 7/30/2014.

*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.

MOVEMENT DISORDERS



Treating the 'Circuit' with Rare Expertise and the Latest Technology

Patients at the Movement Disorders Center at University of Colorado Hospital receive the latest medical and interventional approaches to treat Parkinson's disease, essential tremor, dystonia, Huntington's chorea, ataxia and other movement disorders. The Center's fellowship-trained movement disorder specialists and nurse practitioners manage more than 2,000 patients a year, most with complex conditions that require specialized care only available at an academic center like UCH. The ultimate goal is to care for movement-disorder patients in a holistic manner, and couple that care with an extensive portfolio of leading-edge research.

The Center's neurosurgeons are among the most experienced in the country at performing deep brain stimulation (DBS). Given the nuances and complexity associated with DBS procedures, their expertise is critical. In October 2013, Steven Ojemann, M.D., performed the Rocky Mountain region's first-ever DBS surgery within an MRI machine. The MRI-based DBS procedure, which enables the use of general anesthetic, shows particular promise for patients whose movement disorders preclude the stillness required for the traditional DBS procedure.

The center has performed more than 500 DBS procedures since 2002. Every patient seen at the center is evaluated and treated by a team composed of a neurosurgeon, a neurologist, neuropsychologists, psychiatrists, physiatrists, and physical therapists. This multidisciplinary approach enables tailored treatments – whether standard or investigational, medical or surgical – to each patient's unique needs.

Active Research Program

The Movement Disorders Center at UCH's research program is active and growing. Of particular note in 2013, was the creation of a new Center for Neuromodulation and Neural Restoration. This multidisciplinary Center hosts investigations into "circuitopathies" – disorders involving the disruption of neural circuits connecting the brain's outer cortex to the deep-brain basal ganglia and thalamus – including Parkinson's disease, depression, addiction, and obsessive-compulsive disorder. Key to these efforts is a better understanding of the electrical signatures of Parkinson's disease and other movement disorders, which will yield smarter therapeutic devices that can improve future care for these patient populations.

Most active surgical program for DBS in the Rocky Mountain region with **601** lead placements performed

Over **3,000** patient visits

NeuStrategy Center of Excellence Neuroscience

82% of patients experience improvement in PDQ-39 scores post implantation



On Many Fronts, Unraveling the Mysteries of Movement Disorders

Faculty at the Movement Disorders Center at UCH are engaged in a wide-ranging palette of academic research, from molecular studies to clinical trials. The work's common denominator is the drive to improve the lives of patients today and in the future. Among other accolades, the Center recently earned recognition from the Michael J. Fox Foundation for Parkinson's Research as the highest-recruiting site in the United States in the Foundation's "Fox Trial Finder Challenge." The goal of the challenge was to build a registry of Parkinson's disease patients who can be matched to available clinical trials. Some other highlights:

- » Researchers in the new Center for Neuromodulation and Neurorestoration recently filed a patent for an adapter to affix a stereotactic head frame to the MRI imaging table, which eliminates image blur from deep brain stimulation (DBS) patient tremor. They are also working to automate DBS electrode placement using signal-processing techniques.
- » Movement Disorder Center researchers are engaged in a major study of creatine, an organic acid used to supply energy to the body that has helped Parkinson's patients increase upper-body strength, in addition to a smaller study testing the drug pioglitazone in early Parkinson's patients. Researchers are also studying the effects of phenylbutyrate, a naturally produced substance already approved by the FDA to treat urea cycle disorders, on Parkinson's disease progression.
- » Doctors are examining the use of magnetoencephalography to understand the physiology of thinking and memory problems in Parkinson's disease patients, insights from which may apply to future treatment of the cognitive as well as the physiological effects of the movement disorders, which can include dementia, hallucinations, psychosis and mood disorders, as well as severe fatigue and loss of motivation.
- » Lifestyle and wellness research is also a focus. A Movement Disorder Center-led study is testing the effects of moderate to vigorous exercise on patients recently diagnosed with Parkinson's disease. Researchers are also studying the effectiveness of acupuncture in mitigating chronic fatigue, which affects roughly half of all Parkinson's patients.

MOVEMENT DISORDERS

MRI-Based DBS a Life-Changer for Mother of Four

Traci Bartalo was an athlete. She had played volleyball at Colorado State University and made a point of staying fit. Fourteen years ago, when she was 32, Bartalo was out on a run. She noticed that, with each step, her left foot slapped to the ground rather than rolling heel-toe. Maybe it was the shoes, she thought. New ones didn't help.

The problem lay far deeper than a rubber sole. Five years later, Bartalo was finally diagnosed with Parkinson's disease. It was devastating for her, her husband and her four daughters.

"I spent a lot of time crying," she said.

Medications controlled it at first; then less so. By early 2013, when she rolled into the Movement Disorders Center at UCH in a wheelchair, Bartalo was taking six medications. On meds, she felt fine, but was experiencing moderate to severe dyskinesia when she took them. Off the meds, she could hardly move and felt just awful.

UCH neurologist Olga Klepitskaya, M.D., listened to Bartalo's story and recommended that she undergo deep-brain stimulation (DBS) within a year. The problem with traditional DBS was that, when off her medications, Bartalo suffered physical and emotional distress. On them, her dyskinesia would render impossible the MRI-based mapping required in advance of the procedure, much less the actual placement of DBS electrodes.

Fortunately, there was another option. In October 2013, UCH neurosurgeon Steven Ojemann, M.D., performed the Rocky Mountain region's first DBS procedure using the ClearPoint system. It's DBS in an MRI machine, the MRI enabling the surgeon to track the location of DBS electrodes in real-time on a monitor in the room.

Typical DBS procedures involve two steps – MRI-based mapping of deep-brain structures comes first, followed by the implantation of electrodes during the main procedure in an OR. During implantation, the awake patient performs movements to help fine-tune the final placement, which the surgeon does using microelectrode recording.

With ClearPoint, the imaging is in real-time. The patient can be anesthetized. There's no stereotactic frame affixed to the patient's skull during imaging and no microelectrode recording.

"This was my only option, as far as I was concerned," Bartalo said.

Bartalo went in for the procedure in November 2013, which was performed in an MRI suite. The ClearPoint stereotactic guidance system enabled Ojemann's use of real-time MRI visualization to place the DBS electrodes with an accuracy of less than a millimeter.

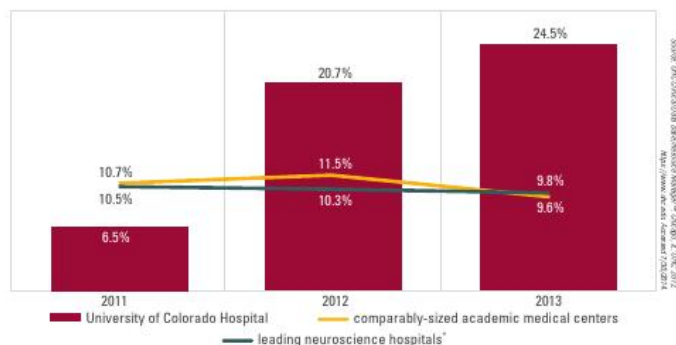
Ojemann says MRI suites could become a nexus for neurosurgeries from DBS to deep-brain drug delivery and biopsies. But the traditional approach still has one big advantage, he says. With the patient awake and providing feedback, the surgeon knows immediately that the electrode is doing its job. With the MRI-based surgery, one can't be assured until the pulse generator and its wires are installed a couple of weeks later.

"I guess my feeling is a lot of this is going to be driven by patients and what they want, and what I'm encountering is there's a good population of patients who would prefer to have the operation done using ClearPoint technology," Ojemann said.

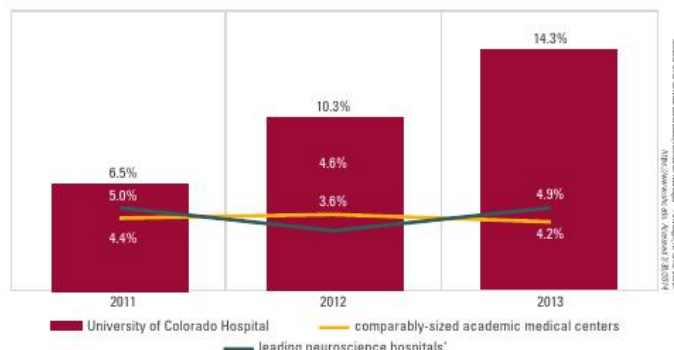
For Bartalo, ClearPoint was a godsend. She has cut back her medications two-thirds. She's out of the wheelchair. In fact, her daughters bought her a pair of running shoes for Christmas the month after her surgery, and she recently ran a mile without stopping. She has a 5K in her sights.

"I've got a new lease on life," Bartalo said. "I'm ready to move forward and do whatever I want."

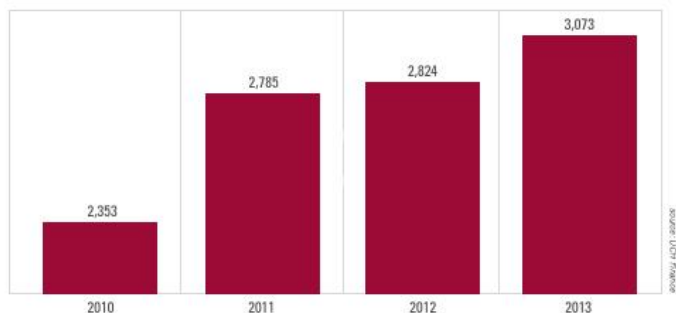
30 DAY READMISSION RATES – ALL CAUSE



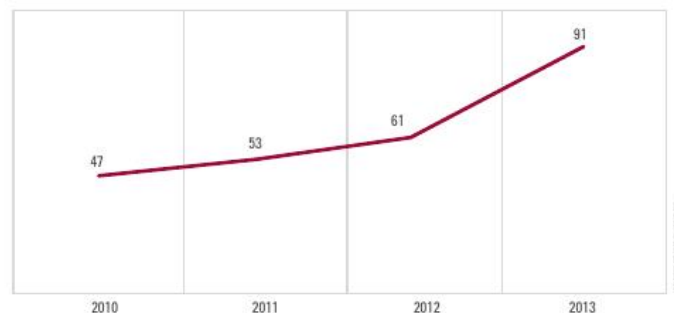
30 DAY READMISSION RATES – RELATED CAUSE



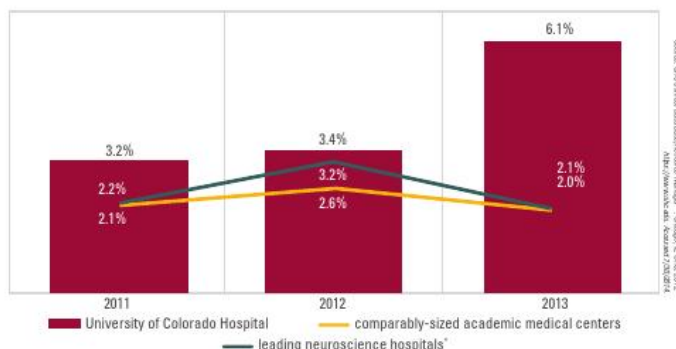
OUTPATIENT VISITS



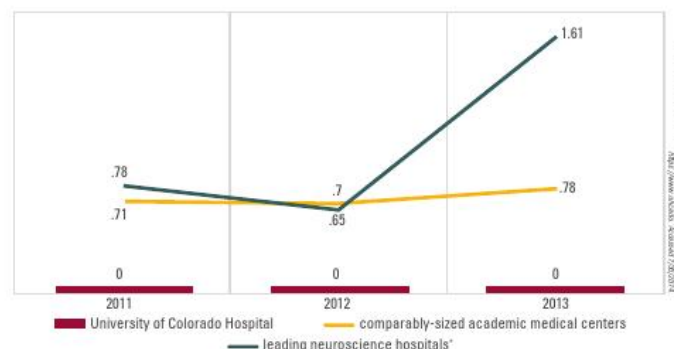
DBS PROCEDURES (excluding Battery implants/explants)



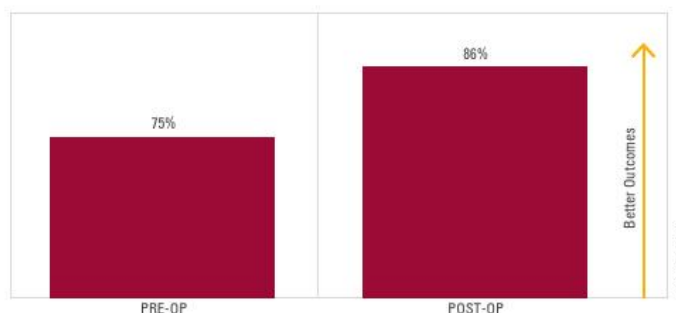
COMPLICATION RATES



MORTALITY INDEX



ACTIVITIES SPECIFIC BALANCE CONFIDENCE (N=28) (high and moderate range)



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 yet common scenarios ranging from walking around inside the home to shopping at the mall to 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 86% (24 of 28), indicating that 3 patients increased from very little confidence to either moderate or high confidence.

PDQ-39 SUMMARY INDEX SCORE (N=39)



MOVEMENT DISORDERS

The average PDQ-39 Summary Index score decreased significantly by 9 points ($p=0.008$) after DBS implant mean post-operative duration of 10 months. 82% of patients showed improvement while 18% remained stable or had increasing symptoms after DBS. Lower scores reflect better health and fewer symptoms.

LENGTH OF STAY (DAYS) 3.6 Observed 5.3 Expected

Source: UHC Clinical Data Base/Resource Manager™, Chicago, IL: UHC; 2012. <https://www.uhc.edu>. Accessed 7/30/2014.

*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.

MULTIPLE SCLEROSIS



World-Class Research Informs Patient-Centered Care

The Rocky Mountain Multiple Sclerosis Center at UCH combines one of the most robust MS research programs in the nation with an innovative care model serving more than 3,000 patients a year. The Center's patients gain from consultations with world-renowned MS experts, as well as from access to therapies and investigational treatments available nowhere else in the Rocky Mountain region. UCH's breadth of service provides MS patients access to a multidisciplinary suite of subspecialty expertise, including:

- » neuroradiology
- » neurology
- » neurourology
- » neuro-ophthalmology
- » speech pathology
- » physical therapy
- » behavioral neurology

That care includes treatment for neuromyelitis optica (NMO), infusions of the most advanced therapies, and, for those enrolled in one of the dozens of research studies the Center conducts each year, access to investigational compounds.

Treating the Whole Patient

A major goal of all treatment is, of course, to help patients obtain and maintain remission of their MS. However, that is just part of the Center's treatment philosophy. Patients with MS experience a variety of other conditions that require attention and management, including fatigue, movement and balance disorders, and vision and speech problems. They also are prone to many of the chronic health conditions that plague people without MS, including obesity, diabetes, and hypertension, all of which increase the risk of MS-related disabilities. Thus, the team works with patients to develop personalized, evidence-based physical activity regimens that enable them to recover function and minimize the impact of the disease, while nutritionists teach them how to maintain a healthy weight and reduce their risk of diabetes and hypertension.

Data-Driven, Patient-Centered Care

To further unify the many elements of effective MS treatment, the Multiple Sclerosis Center at UCH is moving to a patient-centered medical home (PCMH) model. Care philosophy is among the most important of the PCMH program's structural elements. Rather than focusing on relapses and prescribing medications to treat symptoms, the MS Center at UCH is focusing on preserving long-term brain health as a key therapeutic goal.

The care provided in the UCH MS Center is based on national and international guidelines, best practices, and internal data on the thousands of patients who pass through the Center each year. The Center's patient-reported outcomes assessment program, launched in 2013, is among the Center's PCMH pillars. Patients evaluate their own status so clinicians can better understand how they respond to treatment.

Traditional centers base response only on clinical signs: Did the patient go into remission? Does the MRI scan show fewer lesions? But quality-of-life scales are just as important. These include employment status, pain and fatigue levels, cognition, enjoyment of life, and emotional well-being. Such factors can affect clinical response to even the most effective medications.

Researchers and clinicians use this qualitative, patient-provided data together with quantitative outcomes to identify patient characteristics associated with treatment response. The information will be used to build an algorithm that will allow the team to improve its ability to match the right drug with the right patient at the right time.



Applying PT, MRI and More in Multiple Sclerosis Research

The Rocky Mountain Multiple Sclerosis Center at UCH is one of the nation's premier MS research institutions, with about 40 active clinical trials and laboratory investigations underway. The work runs the gamut of MS inquiry, covering pediatric MS, brain-volume studies using magnetic resonance imaging, reparative drug therapies, and the effects of physical activity on disease progression, among other areas. Here's a sampling of some of the pioneering science happening at UCH:

- » Two studies are considering the nuances of the connections between physical activity and MS. One considers the value of physical rehabilitation as a means to improve a patient's balance, in addition to reducing fatigue. Another looks at motor physiology and MS. The goal here is to optimize exercise and rehabilitation strategies to maximize function in MS patients.
- » Reparative therapies are the focus of two clinical trials, which involve drugs that induce nervous-system repair and regeneration. Both therapies show promise in blocking certain signaling pathways in MS plaques that are inhibiting remyelination. The Center is pursuing various strategies to enhance cortical reorganization, providing vital cognitive reserve to stave off symptomatic disease progression.
- » Two additional studies are using magnetic resonance imaging to understand the connection between well-established MS therapies and the pace of brain atrophy, which occurs at accelerated rates among those with MS.
 - » One study considers long-term (greater than two years), whole-brain, neocortical and subcortical atrophy rates among patients with relapsing remitting MS who take natalizumab. The Center has treated more than 600 patients with the drug; based on how well they have done, the CU team suspects that the drug may slow – or even halt – long-term whole-brain atrophy. The study also tracks quality of life based on Neuro-QoL self-report measures to see if measures of atrophy correlate with patient-reported quality-of-life status.
 - » A second MRI-based study looks at the comparative impact of long-term (greater than two years) treatment with fingolimod versus glatiramer acetate on brain atrophy rates. As with the natalizumab study, this observational study will also report on Neuro-QoL patient-reported outcomes and consider the relationship these patient reports have to the measured changes in whole brain volume. The study will also consider objective measures of cognition, patient-reported disability levels, and patient-reported measures of active and passive cognitive reserve.

MULTIPLE SCLEROSIS

The Goal: Maximize Cognitive Reserve

As diverse as the research at the Rocky Mountain Multiple Sclerosis Center at UCH is, a common thread runs through it all, says Timothy Vollmer, M.D., the Center's director of clinical research. The overarching goal is to develop an understanding of the impact diverse interventions (from drugs to exercise) have on long-term brain health – and then to optimize those therapies to maximize cognitive reserve and long-term mental and physical health.

This approach differs starkly from conventional treatment, which has emphasized the suppression of MS attacks, Vollmer says. His philosophy, and that of the Center, is focused on preventing the loss of brain substance (brain atrophy) that goes on silently early in the disease but is the cause of disability in later stages.

Time shrinks brains – it's inevitable, Vollmer says. But for healthy individuals, the decline is subtle – perhaps 0.1% of brain volume a year. The brains of MS patients, in contrast, atrophy six to 10 times faster. This accelerated pace of decline in MS patients is attributable to MS-related recurrent inflammation attacks on the brain, the majority of which are clinically unapparent in early-phase disease.

Without the aid of MRI scans, 95% of these lesions go unnoticed by physicians as well as patients – that is, there's no apparent clinical progression despite the disease's neurological advance. Vollmer believes this disconnect lies in the brain's ability to sidestep lesions via cortical compensation and reorganization. The sum total of these neurological work-arounds – cognitive reserve – allows for normal functioning despite progressing damage to the brain in early disease. But once this "reserve" capacity of the brain is exhausted, persons with MS enter the progressive disability phase of the disease, which is currently irreversible.

Brain volume and cognitive reserve being tightly linked, the Rocky Mountain MS Center at UCH team has established preserving brain volume as a key therapeutic goal – and as early as possible in the life of a person diagnosed with MS.

The clinical implications are profound. Traditional escalation therapy, the MS-treatment mainstay, involves deploying increasingly potent therapies only when MS patients fail older, less effective therapies that have little ability to preserve brain volume. At the Center, the aim is to preserve brain volume and thus cognitive reserve by using newer immunological therapies with superior abilities to prevent brain atrophy, thereby delaying or preventing future progression. In addition to drug therapies, the Center also encourages its MS patients to maximize lifelong brain health through an active, healthy lifestyle.

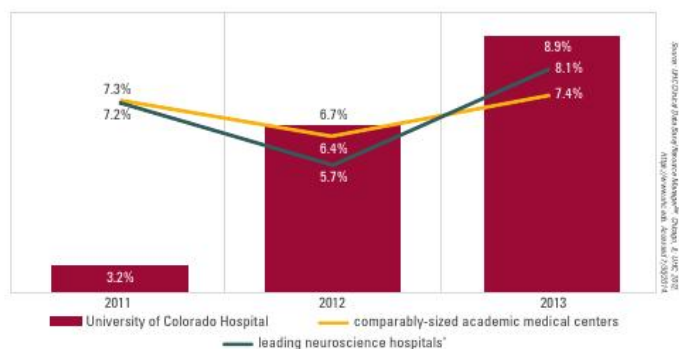
"The brain-reserve concept implies that you want to safely treat patients as early as you can with the most effective therapy that you can," Vollmer said.

9,241 Outpatient visits

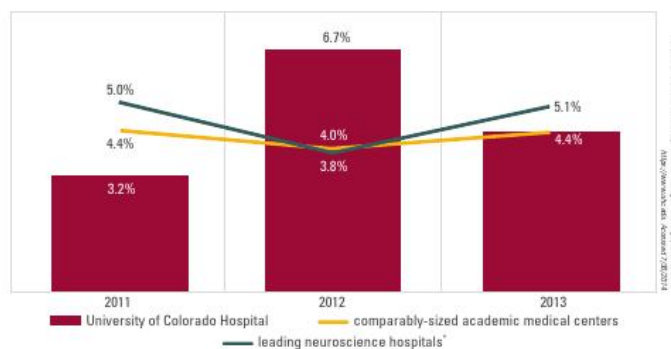
40 active clinical and laboratory trials

Largest brain tissue bank in the country

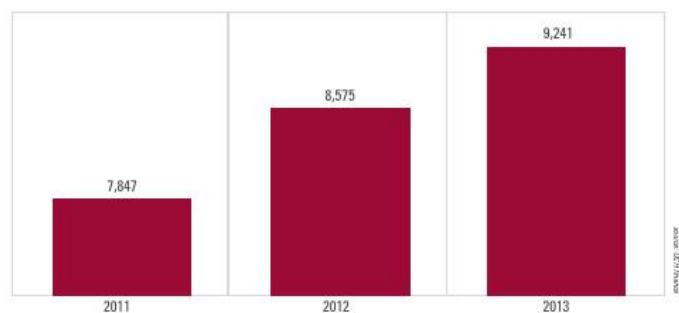
30 DAY READMISSION RATES – ALL CAUSE



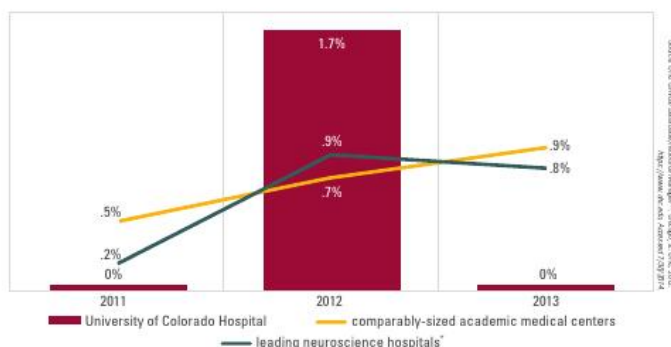
30 DAY READMISSION RATES – RELATED CAUSE



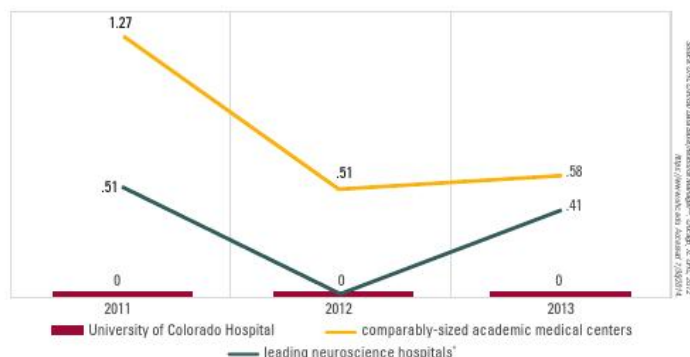
OUTPATIENT VISITS



COMPLICATION RATES



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.

LENGTH OF STAY (DAYS) **4.1** Observed **4.4** Expected

Source: UHC Clinical Data Base/Resource Manager™. Chicago, IL: UHC, 2012. <https://www.uhc.edu>. Accessed 7/30/2014.

*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.

NEUROCRITICAL CARE

Unsurpassed Care for the Most Critical Cases

The UCH Neuro Intensive Care Unit (ICU) is one of only a handful in the United States and the only one in Colorado. Its medical director, Robert Neumann, M.D., PhD, who counts among the country's first board-certified neurointensivists, also co-directs UCH's Comprehensive Stroke Center. A multidisciplinary team of physicians and nurses provide highly specialized critical care with an emphasis on preserving and optimizing the function of the central and peripheral nervous system. The Neuro ICU's physician team includes three board-certified neurointensivists (on call 24/7) and up to two fellows. This team works hand in hand with the UCH Stroke team in the care of patients suffering ischemic and hemorrhagic strokes. All the unit's nurses have received specialty training in neurocritical care. UCH also runs one of the leading training programs in the country for critical care residents and neurointensivist fellows.



American Heart Association
American Stroke Association
CERTIFICATION
Meets standards for
Comprehensive Stroke Center



CAUTI rate of **1.35/1,000 days**, significantly lower than the national benchmark

Beacon Award, Gold Level

1st Neurocritical care unit in Colorado

616 Patients admitted in 2013

Hired the **first** neurointensivist in the Rocky Mountain region

Such specialized care enables the unit to take a proactive approach to patient care, anticipating complications and addressing them before they become critical.

Multidisciplinary Care Throughout the Hospital

The unit, housed in the hospital's new Anschutz Inpatient Pavilion 2, can serve 24 critically ill patients in spacious comfort, combined with state-of-the-art equipment including intracranial and non-invasive cerebral blood flow monitors, cerebral oxygenating monitors, cooling helmets for patients who require decompression craniectomies, and a portable CT scanner.

The Neuro ICU's patients arrive with conditions ranging from trauma to subarachnoid hemorrhage, intracerebral hemorrhage, ischemic stroke, subdural and epidural bleeds, brain tumors, spinal cord injury and brain tumors. The staff also cares for patients with medical neurological conditions such as meningitis, myasthenia gravis, and Guillain Barre Syndrome. In addition, the team provides neurologic consulting services for patients in UCH's cardiothoracic, transplant, pulmonary critical care, and cardiology units.

Among other specialized techniques, Neuro ICU clinicians are assertive in their use of induced coma and systemic cooling to reduce inflammation and induce healing. Whereas other hospitals typically only use cooling for 24 hours, UCH can safely maintain patients in this state for weeks.

Among the unit's recent achievements:

- » Catheter-Associated Urinary Tract Infections (CAUTI) rate of 1.35/1,000 days, compared to the national benchmark of 5.0/1,000 days
- » Ventilator Associated Pneumonia and Central Line-Associated Bloodstream Infection rates below national averages
- » Receipt of the prestigious three-year Beacon Award for Excellence from the American Association of Critical Care Nurses

The Beacon Award

The UCH Neuro ICU is just one of seven neurology/neurosurgery units in the country to earn a three-year Beacon Award for Excellence from the American Association of Critical Care Nurses (AACN) at the "gold" designation level – the highest the organization bestows. This designation means the unit achieved the highest scores in five areas:

- » Leadership structure and systems
- » Staffing and staff engagement
- » Effective communication, knowledge management, learning and development, and best practices
- » Evidence-based practice
- » Outcomes

The scores "reflect a unit with outstanding processes that are fully applied through the unit and across key stakeholders," the AACN wrote.

Visit to Neuro ICU Brings Patient Full Circle

Simon Paton and his wife Liz had flown in from Australia to ski Steamboat. Skiing, as the fine print reminds us, is dangerous. So is the black ice that can lurk on driveways in Colorado's central mountains. Paton, 68, slipped and smashed his head. He was unconscious, flat on his back. Liz, walking behind him, dialed 9-1-1.

Their vacation was over, but they weren't going home.

Brain scans showed a massive hemorrhage, and providers quickly made plans to airlift Paton to Denver. There were doubts he would make it there alive.

University of Colorado neurosurgeon Joshua Seinfeld, M.D., treated the subarachnoid hemorrhage and placed Paton in a medically induced coma. Paton spent the next 49 days in the Neuro Intensive Care Unit at University of Colorado Hospital, the only Neuro ICU in the state.

Three years later, at the tail end of another U.S. visit, Simon and Liz Paton stopped by to meet with Neuro ICU Medical Director Robert Neumann, M.D., and neurosurgeon Joshua Seinfeld, M.D.. They knew him well; he was meeting them for the first time.

That Paton was alive, let alone in good spirits, was remarkable. Neumann said Paton endured renal failure, acute respiratory distress syndrome, and hydrocephalus, among other problems, as a result of the brain injury. He was in a medically induced coma for most of it. He lost 55 pounds and required four months of physical and occupational therapy after returning to Australia. Liz Paton says Neumann, Seinfeld and the team no doubt saved her husband's life.

Neumann deflected the credit.

"We help people along and do what we're trained to do," Neumann said.

While the Neuro ICU became a second home to Liz, Simon remembered nothing until he woke up in a hospital in Melbourne.

"It was like coming out of sleep," he said. "There were tubes and bottles all around me. I couldn't figure out why I couldn't move. Then they told me I'd had a fall."

He had a long road back to health. "I had no strength," he said. "I had to learn to walk up and down stairs again and didn't feel very confident." But after a final month in the hospital in Mount Beauty, Victoria, where the Patons live, Simon finally returned home.

Three years later, the most prominent signs of his ordeal are the scars on the top of his head, reminders of drains inserted to remove cerebrospinal fluid from his skull. He's kept off most of the weight he lost, at least partly because he doesn't have much sense of taste anymore.

The injury did nothing to his wit, however.

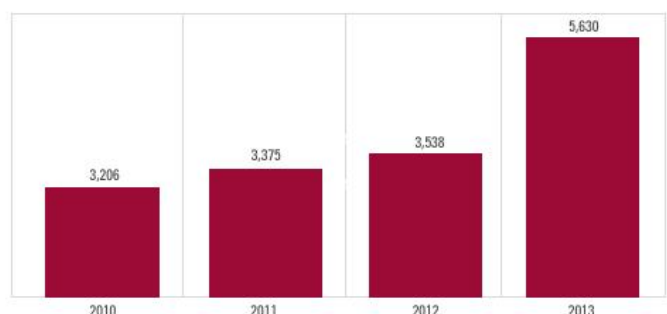
"Lovely hospital," he said to Neumann and Seinfeld. "This is my first look at it."

Diverse Research on Many Fronts

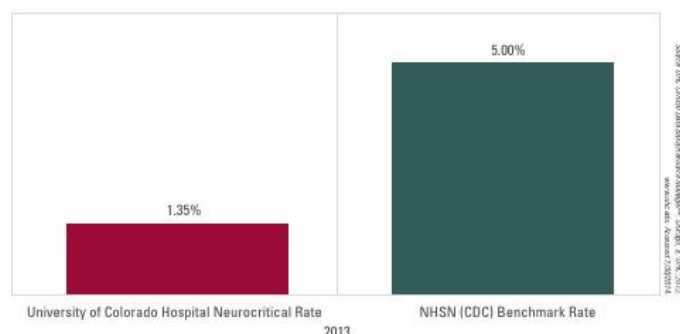
In conjunction with its renowned patient care, UCH's neurocritical care team is engaged in nine active research studies – a number poised to double in the next year. Many involve collaboration in multi-center trials as well as with other UCH specialists. They include:

- » A study of the physiological effects of intrathoracic pressure regulation in patients with decreased cerebral perfusion due to brain injury or intracranial pathology.
- » The TOP UP study, a randomized trial of supplemental parenteral nutrition in under- and overweight critically ill patients (in collaboration with Anesthesiology).
- » A comparison of continuous infusion versus intermittent vancomycin with standardized protocols in neurosurgical ICU patients (in collaboration with Pharmacy).
- » The NUTRIATE Study, a randomized double blind, placebo-controlled trial of the motilin receptor agonist GSK962040 to assess its ability to improve the effectiveness of enteral feeding (in collaboration with Anesthesiology).
- » Intravascular cooling in the treatment of stroke (in collaboration with Neurology).
- » Platelet-oriented inhibition in new TIA and minor ischemic stroke (in collaboration with Neurology).
- » The assessment of neuromuscular dysfunction in critically ill patients (funded by an NIH R01 grant; in collaboration with the UCH Medical ICU).
- » A phase 2, randomized, placebo-controlled, single-blind pilot study of GSK1278863, a prolyl hydroxylase inhibitor, to limit ischemic events from thoracic aortic aneurysm repair (in collaboration with Cardiothoracic Surgery).
- » The early pneumococcal vaccine treatment with PPSV23 in patients in the neuro ICU (in collaboration with Pharmacy).

PATIENT DAYS

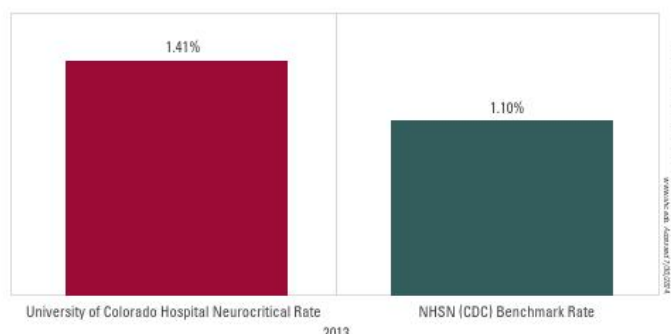


CATHETER-ASSOCIATED URINARY TRACT INFECTIONS



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, 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



Central line-associated bloodstream infections (CLABSI) typically cause prolonged hospital stay, increased cost and risk of mortality. CLABSI rates are expressed as the number of infections per 1000 central-line days. In 2013, the Neurocritical Intensive Care Unit at UCH hovered near the national benchmark provided by the National Healthcare Safety Network (NHSN).

NEUROMUSCULAR



Innovative, Interdisciplinary Care Spans a Six-State Region

The Neuromuscular Clinic at University of Colorado Hospital is one of the oldest such programs in the country, offering a comprehensive approach to the diagnosis and treatment of diseases involving the peripheral nervous system. Sponsored by the Muscular Dystrophy Association (MDA), patients from six states come to UCH, with more than 1,000 new patients and 6,000 follow-up visits seeking services each year. Here, clinicians provide multidisciplinary, integrated care for patients with muscular dystrophies, amyotrophic lateral sclerosis (ALS) and other motor neuron diseases, myopathies, neuropathies, and myasthenia gravis, among others. The UCH team has expertise in treating extremely rare conditions such as familial amyloid neuropathy and critical illness neuromyopathy. The program also performs muscle and nerve biopsies on tissue sent from around the state and region.

The UCH Neuromuscular Clinic offers the only certified MDA/ALS research and clinical program in the state. Patients receive care from an interdisciplinary team comprising fellowship-trained physicians and mid-level providers, as well as physical, occupational and speech therapists, a dietitian, and durable medical equipment vendors. The team meets weekly to discuss individual patients and their care. This ensures that all patients – and their families – receive the comprehensive medical, behavioral, and social services they require.

Transitioning from Pediatric to Adult Care

The clinicians at UCH and Children's Hospital Colorado collaborate closely to help pediatric patients with neuromuscular disorders transition from pediatric to adult care, sharing information about patient cases, patient populations, and research.

Research Focused

A strong research focus underlies the clinical components of the UCH Neuromuscular Clinic, enabling it to offer patients access to novel therapies. Its faculty founded the Western ALS (WALS) study group, which runs multi-university clinical trials on new treatments for ALS. The clinic is also a member of the Northeast Amyotrophic Lateral Sclerosis Consortium (NEALS), a large international group of researchers that collaborates on clinical research in ALS and other neuromuscular diseases. The UCH Neuromuscular Clinic has trained over 50 fellows in neuromuscular medicine. Fellows must complete a performance improvement project and may participate in clinical research. Over the years, several have conducted independent research in their second year of fellowship. Many are now academic physicians at other universities.



Muscular Dystrophy Association Center Regional ALS Center

66% patients improve in depression

Continual Process Improvement — Key to Quality Patient Care

A major initiative in the Neuromuscular Clinic and throughout the UCH neurosciences program is continual process improvement. Professor and Vice Chair of Neurology and Vice President of Clinical Effectiveness and Patient Safety, Steven P. Ringel, M.D., leads the department's efforts in developing and managing quality and safety programs.

One such project is designed to improve the detection and management of depression in patients with chronic neurological diseases. Since depression in patients with ALS is correlated with faster disease progression and reduced limb function, screening processes to identify these patients and institute evidence-based management approaches should slow disease-related morbidity.

A photograph of the University of Colorado Hospital, a large multi-story building with a red facade and blue-tinted glass windows. The building is reflected in the sky. In the foreground, there is a lush green courtyard with a winding path, several trees, and a small pond. The sky is blue with scattered white clouds. The text "UNIVERSITY of COLORADO HOSPITAL" is visible on the top of the building.

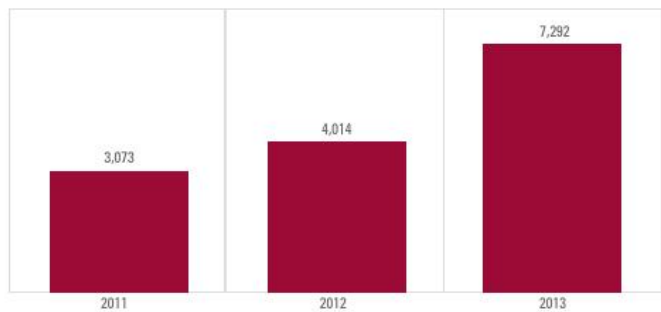
UNIVERSITY of COLORADO HOSPITAL

“THE GOOD PHYSICIAN TREATS THE DISEASE,
THE GREAT PHYSICIAN TREATS
THE PATIENT WHO HAS THE DISEASE.”

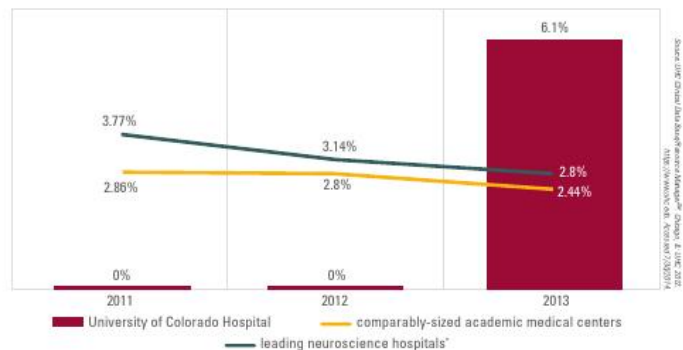
~ William Osler

NEUROMUSCULAR

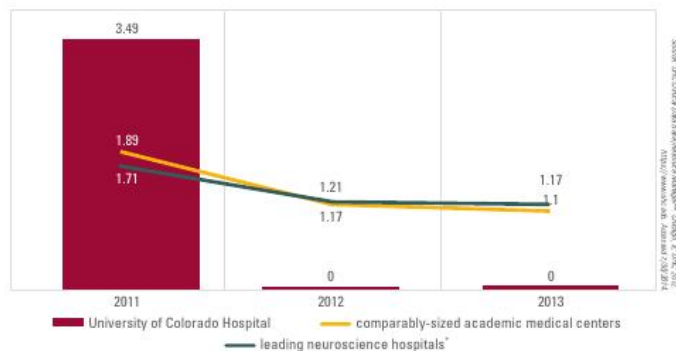
OUTPATIENT VISITS



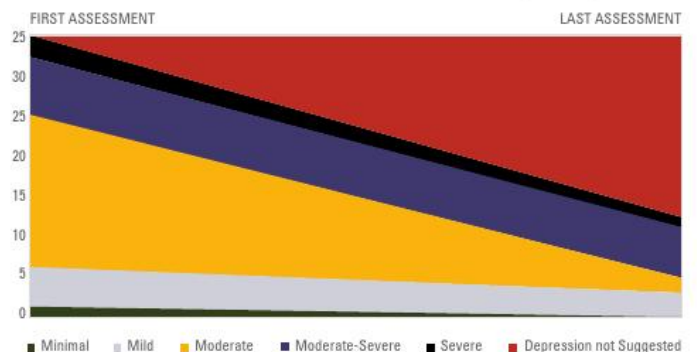
COMPLICATION RATES



MORTALITY INDEX

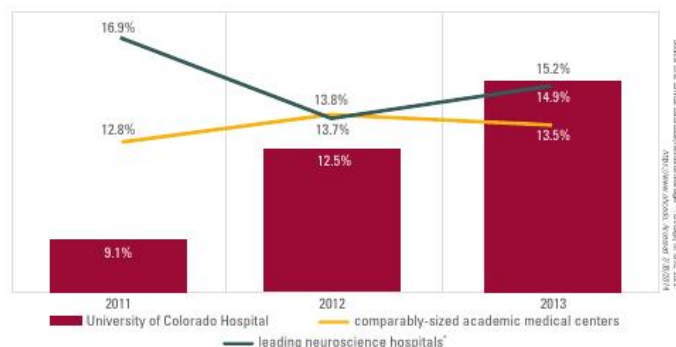


IMPROVEMENT IN PHQ-9 SCORES (N=35)

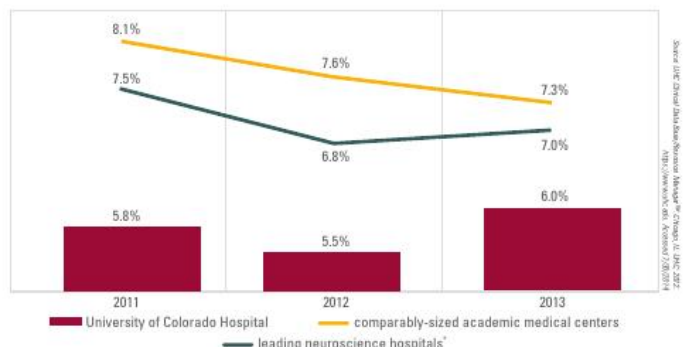


Patients whose PHQ-9 scores initially suggested possible depressive disorder showed significant improvement. Sixty-six percent of patients' (n=23) moved out of the "Depression Suggested" category. Six patients had continued symptoms but moved from higher to lower severity levels with an average score decrease of 5 points. Six patients remained stable or worsened with an average score increase of 2 points.

30 DAY READMISSION RATES – ALL CAUSE



30 DAY READMISSION RATES – RELATED CAUSE



*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.

NEURO-OPHTHALMOLOGY



The eye as a window to some of neurology's toughest challenges

Nearly half the brain is involved in visual processing; the UCH Neuro-Ophthalmology program focuses on the many places where the brain and eye meet. The Neuro-Ophthalmology team of fellowship-trained subspecialists sees patients with a host of conditions, from neurodegenerative diseases to head trauma, brain tumors, maladies of the optic nerve, orbital disease, myasthenia gravis, unusual visual phenomena, and unexplained vision loss, among many others. UCH's Neuro-Ophthalmology patients tend to be complex cases, suffering from disorders affecting the body and nervous system as a whole.

The clinical work of Jeffrey Bennett, M.D., PhD, and colleague Victoria Pelak, M.D., involves thorough diagnostics and a variety of vision-sparing treatments. Referrals come from colleagues in ophthalmology who recognize that a patient's vision problem has roots deeper than the eye itself; and from neurologists seeking to nail down the true nature of problems such as inflammatory optic nerve injuries, double vision, orbital diseases, pupil abnormalities and occult chorioretinal disorder.

Drs. Bennett and Pelak are steeped in the complexities spanning the ocular and neurologic systems and, in a single consultation, can often diagnose problems that would otherwise require multiple visits. In addition to diagnosing complex medical problems, UCH's Neuro-Ophthalmology program helps its patients, and the medical system, avoid unnecessary medical costs.

Neuro-Ophthalmology's diagnostic toolset combines an extensive patient history, physical examinations, lab tests, neurologic tests and vision tests to pinpoint the primary cause or causes of a visual disorder.

The team also works with colleagues in neurosurgery, radiation oncology and other specialties to unravel the causes of tough-to-diagnose vision problems and to develop treatment plans – for example, when a patient wakes up from a coronary artery bypass grafting and suddenly has double vision or vision loss. In other cases, the inquiry leads to the diagnosis of chronic disease.

On the research side, the Neuro-Ophthalmology program's work is diverse, but in general focuses on the diagnosis and, ultimately, the treatment of chronic neurologic disease through the window of the eye.

A major thrust of Bennett's research involves inflammatory injuries of the brain and, in particular, optic nerves. Such inflammation is often a precursor symptom to multiple sclerosis and related demyelinating disorders such as neuromyelitis optica. Optic neuritis, for example, is the initial manifestation of MS in 25% of affected individuals. Identifying the drivers of the autoimmune response behind these demyelinating diseases can improve our understanding of disease pathogenesis and drive the development of novel targeted therapies. The ultimate goal here is to identify at-risk patients, diagnose neuro-inflammatory disorders at the earliest phase, and treat patients with therapies designed to target the molecular pathways driving the autoimmune response.

Pelak's research focuses on the roots of cortical visual processing and dysfunction. To that end, she developed a virtual reality suite designed to immerse patients in pioneering tests designed to test vision through simulated motion. Pelak's recent research has shown that her tests, projected in 3D on either a wall-size screen or, more recently, 3D stereoscopic workstations, show promise in detecting early Alzheimer's disease before it is picked up by conventional testing or diagnostic imaging. In fact, Pelak's functional MRI work has confirmed that these virtual-reality tests stress brain regions shown to be affected by Alzheimer's disease.

1,896 Outpatient Visits

Pioneering tests of vision through 3D simulation

Pioneering methodology for early detection of Alzheimer's

Eye-brain connection may be a key to Alzheimer's diagnosis

Diagnosing Alzheimer's disease can be a complicated affair, involving memory and problem-solving tests, blood and urine tests, and diagnostic imaging via MRI and CT scans. Definitive diagnosis must often wait until autopsy.

There may soon be a better way. Certainly it's a much more interesting way – and one that could discern Alzheimer's at an earlier stage than is possible today.

Victoria Pelak, M.D., a University of Colorado School of Medicine neuroophthalmologist, has developed a virtual-reality based system that many a gamer would envy. This isn't about Call of Duty marathons, though. Rather, the 10.7-foot by eight-foot stereo-reflective screen and dual Panasonic projectors in the University of Colorado's Brain and Vision Research Laboratory is akin to the mass spectrometer or CT scanner: an elaborate vehicle for medical testing.

Pelak's sees all kinds of patients, but her research focuses on using virtual reality to diagnose neurodegenerative disease – in particular Alzheimer's disease.

She and colleagues recently wrapped up a four-year National Institutes of Health- and Alzheimer's Association-funded study, "Virtual Reality Assessment of Visuospatial Disorientation in Alzheimer's Disease." The data point to impaired visual processing that might otherwise evade notice as being an early sign of Alzheimer's disease.

Pelak came to the study of Alzheimer's disease, which afflicts more than 5 million in the United States alone, through a rare subtype of it called posterior cortical atrophy, or PCA.

PCA is hard to diagnose, as Mike Franck's case illustrates. Franck, 67, was first diagnosed with PCA in 2007, shortly after he quit driving. He quit driving because he was doing 85 on the way home from work when the truck in front of him disappeared.

"There wasn't anything there. And after about 45 seconds, the truck popped back into place," Franck recalled. For years, ophthalmologists and others had focused on his eyes, performing cataract surgeries, vitrectomies and other eye procedures.

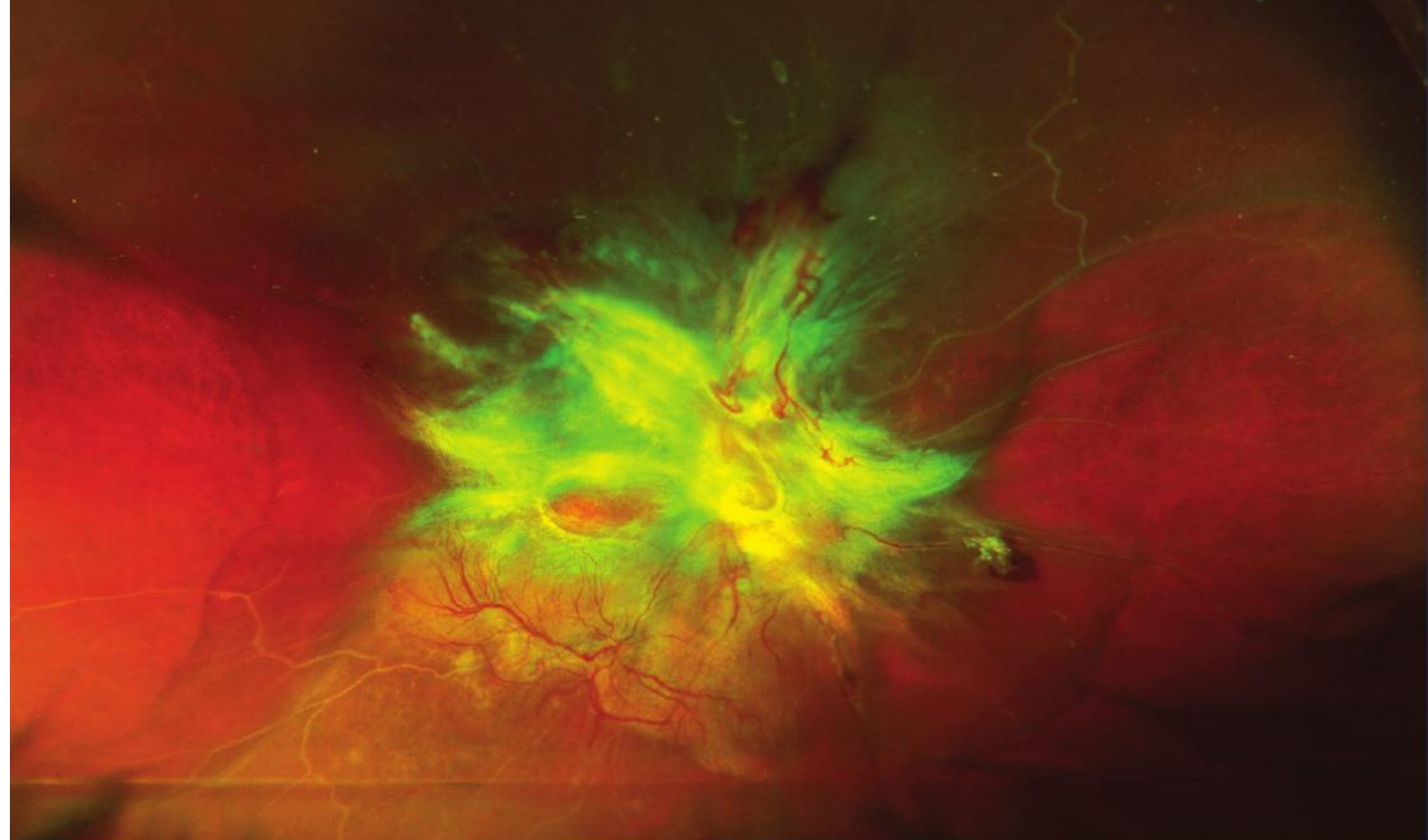
Franck lived in California at the time; he moved to Colorado in 2010 in part because he read up on PCA and found Pelak to be "if not the best, then one of the best people researching the disease."

Among other testing, Franck spent time in the Brain and Vision Research Laboratory, where he took three tests Pelak developed.

Franck donned 3D glasses like those in digital movie theaters and sat in an office chair close enough that the experience was immersive. One test seemed to send him through hyperspace on the Millennium Falcon, stars passing on all sides. The idea is to simulate motion, Pelak says, the patient's job being to determine where that motion appears to originate by moving an onscreen marker and clicking.

A second test involved rotating object identification; a third combined elements of the first two to simulate sense-of-direction illusion. Franck failed them all. PCA affects the brain regions the tests were designed to challenge. But seeing how Franck failed helped Pelak fine-tune the virtual-reality testing protocol to better detect PCA where other diagnostic approaches – vision checks, how the eyes look when dilated, paper-and-pencil tests – had largely failed.

"What Mike told us was that once patients have enough of a problem to be diagnosed with PCA, they perform worse than early Alzheimer's patients," Pelak said.



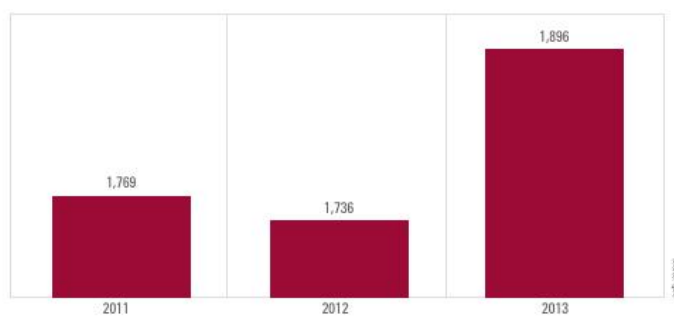
Pelak has since tested many Alzheimer's patients as a part of her four-year study, enrolling 110 people in all, including healthy controls as well as those with mild memory impairment and Alzheimer's diagnoses.

"We were able to find that we may have an ability to use virtual reality to diagnose visual brain dysfunction well before a person develops a lot of the other signs of Alzheimer's disease," Pelak said.

Pelak still sees Franck, though both know there's no magical cure for his PCA. But for him and many other Alzheimer's patients, just having clarity about what they're facing is a big step forward.

"Often, just making that diagnosis relieves the tremendous burden of not knowing what's wrong with them," Pelak said.

OUTPATIENT VISITS



The Spine Center at the University of Colorado strives to be the leading spine center in the Rocky Mountain region through its high quality clinical care, innovative research and education of the next generation of physicians at the University of Colorado School of Medicine.

University of Colorado Hospital's nationally recognized Spine Center offers expert care of simple and complex spinal disorders. The Spine Center's unique patient-centered care model is provided through a comprehensive and multi-disciplinary approach. The team is led by internationally-recognized surgeons and physicians. Services are provided through a complement of physiatry, orthopedic spine and neurosurgery, physical therapy, musculoskeletal radiology, anesthesiology, integrative medicine, and world-class nursing.



Designated as a

**Blue
Distinction®**
Center +
for Spine Surgery

Anthem. 
BlueCross BlueShield

An Independent Licensee of the
Blue Cross and Blue Shield Association

15,069 OP Visits **0%** mortality rate

True integration of Neurosurgery, Orthopedic Surgery and PM&R

81% post surgical patients report being free of work restrictions

NeuStrategy Center of Excellence Spine

The Spine Center continues to receive accolades for the program's quality and comprehensive services. The BlueCross BlueShield Association has named UCH the state's only Blue Distinction® Center+ for Spine Surgery. Recently, NeuStrategy has recognized the service as a Center of Excellence at the institute level with silver status.

Blue Distinction® Centers demonstrate overall quality measures for patient safety and outcomes. Blue Distinction® Center+ also meets cost measures that address consumers' need for affordable healthcare. NeuStrategy evaluates programs in the areas of clinical and research programs, medical staff, leadership, governance, and finance, along with facility and technology.

The University of Colorado School of Medicine is one of just 18 centers to offer an ACGME accredited orthopaedic spine surgery fellowship. The Spine Center also houses an ACGME accredited spine and pain medicine fellowship, whose graduates work in academic institutions across the country.

Surgery a Last Resort

The entry point of the UCH Spine Center is an aggressive non-surgical physical medicine and rehabilitation (PM&R) program. Board-certified physiatrists, fellowship trained in spine and pain medicine, are the first to evaluate new patients. Then, through collaboration with the multidisciplinary spine team, the best course of action is identified for each patient. The team's decisions are guided by years of data that identify the most appropriate course of action for each condition. This helps ensure that only those patients who absolutely need surgery will get surgery.

Patients who do need surgery see either an orthopaedic spine surgeon or a neurosurgeon with expertise in that patient's particular condition. The seven orthopaedic spine and neurosurgeons at the UCH Spine Center perform more than 900 surgeries a year, ranging from simple micro-discectomies to complex procedures involving computer-assisted, three-dimensional surgical navigation. As a tertiary referral center, many UCH Spine Center patients present with complex spinal conditions or significant medical comorbidities that can complicate their management.

The Spine Center surgeons have particular expertise in:

- » Spinal deformity, including scoliosis and adult deformities
- » Revision surgery
- » Minimally invasive and endoscopic spine surgery
- » Disc replacement and other motion preservation techniques
- » Complex reconstruction after trauma
- » Intradural spinal tumors

Access to Progressive Approaches

The Spine Center at UCH is the only one in the region offering a full array of complete endoscopic and endoscopic-assisted procedures – including transthoracic procedures and percutaneous endoscopy discectomy/decompression (PELD).

Cooled radiofrequency ablation procedures are also available for patients with chronic sacroiliac (SI) joint pain. The procedure is performed with a special probe that creates targeted lesions on specific nerve branches to the sacroiliac joint, disrupting pain signals to the brain.

Research Driving the Innovations of Tomorrow

The Spine Center has an extremely active and dynamic clinical research program. Advancement of the science, along with a focus on long term clinical and functional outcomes, drives these efforts. Some of our current studies include:

- » evaluating epidural effectiveness for spinal stenosis
- » physical therapy as a first-line option for patients with sciatica and weakness
- » new devices and materials for disc replacement
- » fusion to stabilize sacroiliac joints

Four decades later, Vietnam remnants threaten vet they saved

Lou Nonay was a 19 year old U.S. Marine walking through a rice paddy on the outskirts of the village of Tan Han, South Vietnam. A breeze riffled the leaves of a tree line a few hundred yards away. On Feb. 6, 1968, a week into the Tet Offensive, he and his fellow Marines had been sent on a scouting mission.

The sounds of AK-47 shots tore through the air. A corporal was hit in the forehead. Nonay and a comrade tried to lift him over an earthen dike toward cover. It was the last time Nonay would ever stand on his own.

A bullet tore into his spine, paralyzing him.

His fellow soldiers didn't think he would live. Surgeons in nearby Da Nang pulled him through. He returned to his native Denver, married, had two children, and became a Jehovah's Witness minister. He took up painting. "Somebody said it's cheaper than a therapist," he said.

By summer 2010, it was clear that something was wrong. He hadn't felt himself for years, and for a few months now, he had been ill. A local hospital had prescribed antibiotics and sent him home. But his spine seemed to be collapsing under him. "I feel like a disjointed caterpillar," Nonay told his wife.

Evalina Burger, M.D., a University of Colorado School of Medicine senior orthopedic spine surgeon, took one look at the scans and told Nonay: "This is not an elective surgery."

In November 2010, Burger and colleague Vikas Patel, M.D., performed a 10-hour surgery at University of Colorado Hospital. A complicated infection had destabilized and dislocated the spine, with multiple abscesses along the supporting musculature. In addition, Nonay, being a Jehovah's Witness, declined blood transfusions, adding significant risk to the surgery. Burger staged the procedure to minimize blood loss, starting posteriorly and placing several screws on either side of the vertebrae. Once the vertebrae were realigned, they opened up the paraspinal gutters to clean out major abscesses.

They found what looked like pieces of stone and granulated tissue, sometimes the product of high-velocity gunshot wounds in which air and surrounding debris can enter and lodge in the body. Proper debridement probably wasn't the standard in 1968, particularly with spine wounds, Burger figured. And then, on the right side, Burger found flakes, green-mustard in color. This was, she figured, debris from a flak jacket. She put them in a bottle for Nonay.

"It was such an amazing find, and I also thought it would give him some psychological closure," Burger said.

The flak jacket had probably saved Nonay; four decades later, it had nearly killed him.

A month later, after recovering from the first procedure and taking more erythropoietin injections to boost his blood count, Nonay went in for a second surgery to finish the cleanup and repair, again without transfusions. Four years later, he is still feeling good.

Burger says she and Patel couldn't have done it alone.

"This type of surgery can only be done in a team approach," she said. We had a great anesthesia team, great interventional radiology, and great nursing, which all contributed to Mr. Nonay having a great outcome."



‘Miracle’ back-pain cure, made in Germany

Scotty Brown’s back had been hurting since 2007. Then on August 2, 2013, he got a most unwelcome 55th birthday present. He twisted just the wrong way getting into a car.

Pop.

Brown spent several days on the ninth floor of University of Colorado Hospital’s Anschutz Inpatient Pavilion 2. Three surgeons looked at his scans; all recommended UCH Spine Center surgeon J. Peter Witt, M.D., who was now offering a minimally invasive technique pioneered in his native Germany. But Witt, the only doctor in the region performing the procedure and one of very few in the United States, was off teaching a course on the technique at a Minimally Invasive Neurosurgery Society meeting in Detroit.

Witt is director of the Neuro Spine program in CU School of Medicine’s Department of Neurosurgery. He is using new endoscopic hardware developed by Germany medical device maker Karl Storz to perform more exacting spine surgeries with less collateral damage. Called PELD, it can stand for percutaneous lumbar endoscopic discectomy or decompression.

The approach that Brown waited for advanced the state-of-the-art in a couple of ways. The incision was tiny – the 0.6-centimeter-diameter endoscope needs at most a centimeter-long incision as a point of entry. Typical endoscopic spine surgery uses an endoscopic camera for guidance, but involves a 4 cm or larger incision. In addition, the Storz devices are optimized to let surgeons access the spine through any of three approaches: transforaminal, interlaminar and posterolateral.

“It allows you to get to discs that were, before, very hard to reach,” Witt said.

Before the Storz tools arrived, the best-case endoscopic spine surgery for herniated discs involved penetrating the flawed disc and scooping out some of its jelly-like center. Witt called this the “iceberg method.” With the new tools, Witt’s approach is direct.

“This set of instruments allows me to pull out of the disc space itself and then take a look at the disc herniation from the top – so you look at the iceberg from the top – and you see the anatomy around it,” Witt said. Then he can directly remove the errant disc material. In addition to minimal access trauma, PELD has shown to yield reduced intraspinal scar tissue formation.

“Literally, these options weren’t available before,” he said.

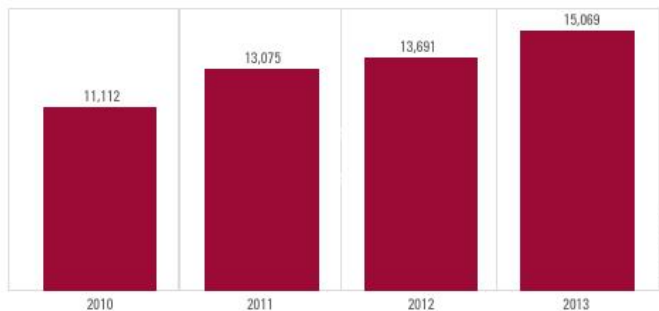
Scotty Brown, who had lived in pain for years, went under the endoscope on August 16, 2013.

“I came out of anesthesia and the pain was 100% gone,” Brown said. “I mean gone. Completely gone. The incision never hurt, I never felt any pain. I didn’t even have soreness. I was just up walking.”

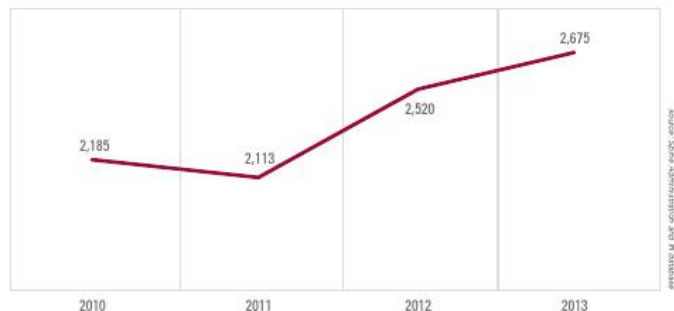
Any sufficiently advanced technology is indistinguishable from magic, Arthur C. Clarke once said.

“I feel like I’m sitting here telling the story of a miracle, but for me, every day I wake up and I can’t believe it,” Brown said.

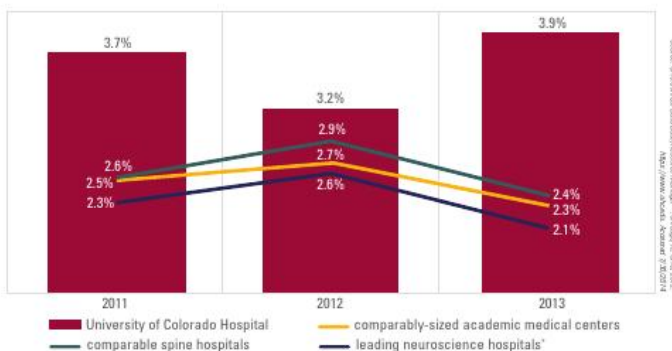
OUTPATIENT VISITS



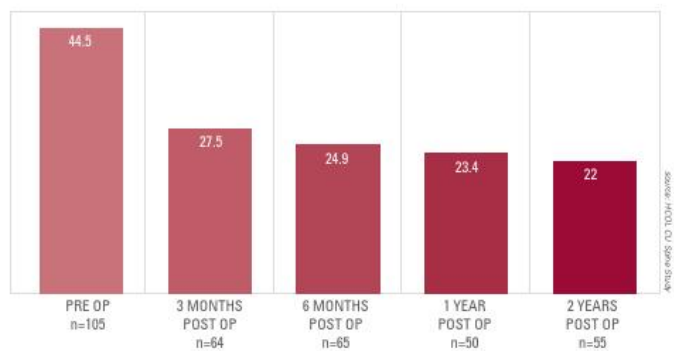
OUTPATIENT PROCEDURES (EMG, Injection, Kyphoplasty, RFA)



COMPLICATION RATES

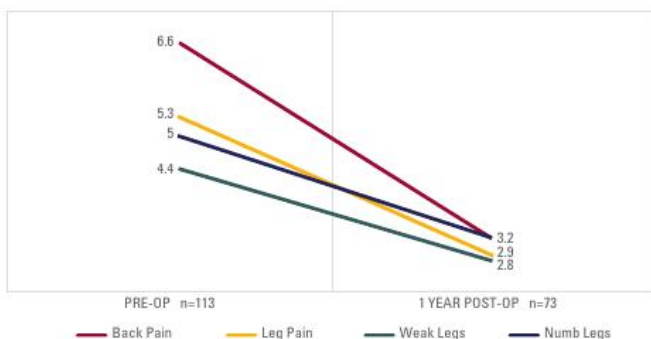


PRE AND POST OPERATIVE ODI SCORES

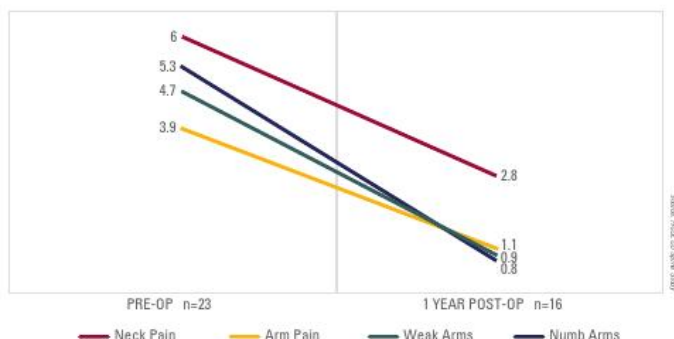


The Oswestry Disability Index (ODI) is the 'gold standard' of low back functional outcome measures. Patients who had surgery at UCH between October 2011 and December 2013 showed an average ODI score reduction of 20 points after surgery; well above the minimum clinically important difference of 15 points.

PRE AND POST OPERATIVE SYMPTOM SEVERITY

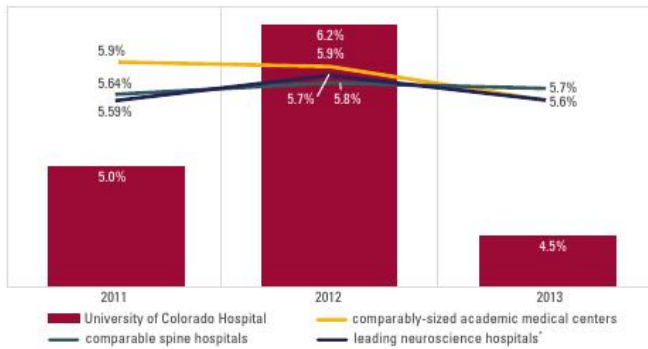


PRE AND POST OPERATIVE SYMPTOM SEVERITY

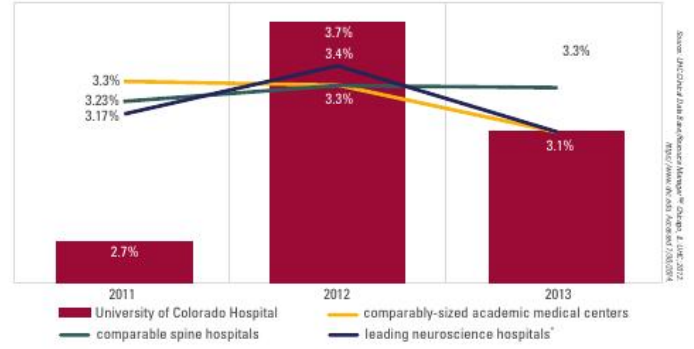


Patients were asked to rate the severity of their pain, weakness, and numbness both pre-operatively and at one year post-operatively. Using a 0-10 visual analog scale where 0 means no symptom occurrence, post-operative scores improved dramatically.

30 DAY READMISSION RATES – ALL CAUSE



30 DAY READMISSION RATES – RELATED CAUSE

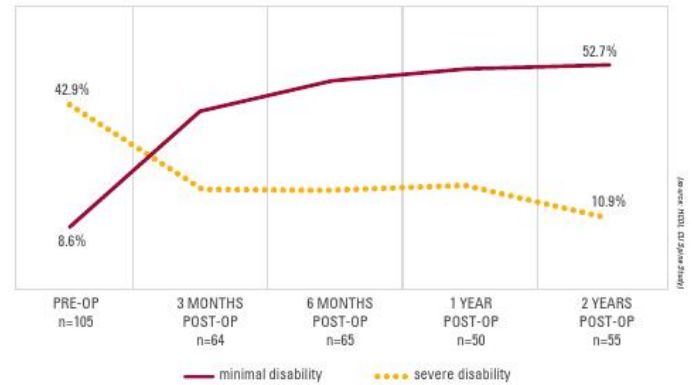


PRE AND POST OPERATIVE WORK LIMITATIONS



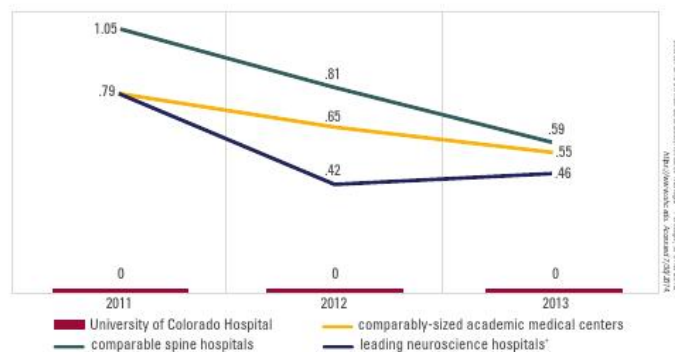
Prior to surgery, 61% of surveyed patients who were employed had been placed on limited or light duties due to their spine conditions. Two years after surgery, 81% of respondents were free of work restrictions.

PRE AND POST OPERATIVE LEVEL OF DISABILITY



Based on ODI interpretation ranges, the largest percentage of patients rated themselves as severely disabled prior to surgery. Post-operatively, the majority improved to minimally disabled, the best possible category on the ODI. (Not all interpretation ranges are shown on graph.)

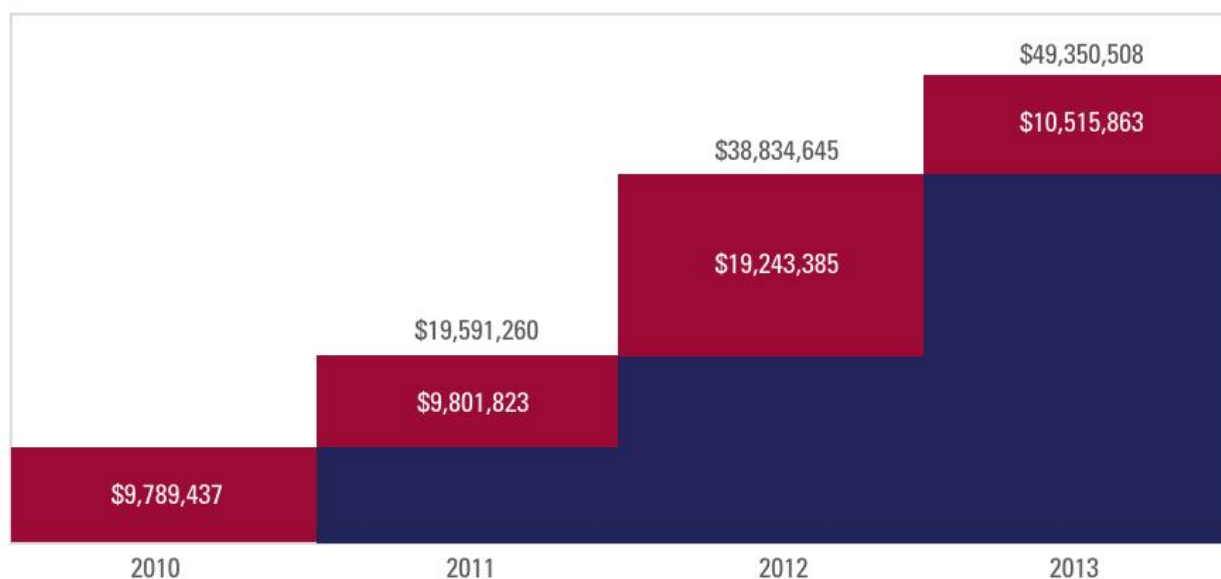
MORTALITY INDEX



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. Since the Spine service at UCH had no mortalities over the past three years, the mortality index is zero.

*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.

NEW AND CUMULATIVE FUNDS BY YEAR



\$49m clinical research funding
27th nationally in NIH funding for Neurology

Brain Tumors

A Phase II Study of Rindopepimut/GM-CSF in Patients with Relapsed EGFRvIII-Positive Glioblastoma
 Principal Investigator: Denise M. Damek

Everolimus, Temozolomide, and Radiation Therapy in Treating Patients with Newly Diagnosed Glioblastoma Multiforme
 Principal Investigator: Laurie Gaspar

Radiation Therapy With or Without Temozolomide in Treating Patients With Anaplastic Glioma
 Principal Investigator: Laurie Gaspar

A Randomized Phase I/II Study of ABT-888 in Combination With Temozolomide in Recurrent (Temozolomide Resistant) Glioblastoma
 Principal Investigator: Laurie Gaspar

Study of a Drug (DCVax®-L) to Treat Newly Diagnosed GBM Brain Cancer

Principal Investigator: Kevin Lillehei

Effect of NovoTTF-100A Together With Temozolomide in Newly Diagnosed Glioblastoma Multiforme (GBM)

Principal Investigator: Douglas E. Ney

Cerebrovascular and Stroke

Hypothermia in Acute Stroke with Thrombolysis Imaging Evaluation of Revascularization (HASTIER): An Ancillary Imaging Study To The Intravascular Cooling in the Treatment of Stroke 2 (ICTus 2) Trial, An NIH-Funded Project on the Safety and Efficacy of Hypothermia Combined with Thrombolysis
 Principal Investigator: William J. Jones

Phase 2/3 Study of Intravenous Thrombolysis and Hypothermia for Acute Treatment of Ischemic Stroke
 Principal Investigator: William J. Jones

Cognitive Disorders

Pilot Phase 2 Double Blind Trial of the Safety and Efficacy of GM-CSF (Leukine) in the Treatment of Alzheimer's Disease

Principal Investigator: Huntington Potter

Epilepsy

A Double-blind, Randomized, Placebo-controlled, Multicenter, Parallel-group Study with an Open-label, Extension Phase to Evaluate the Efficacy and Safety of Adjunctive Perampanel in Primary Generalized Tonic-Clonic Seizures.

Principal Investigator: Mark C. Spitz

A Multicenter, Double Blind, Randomized, Placebo-Controlled Trial to Determine the Efficacy and Safety of Ganaxolone as Adjunctive Therapy for Adults with Drug-Resistant Partial-Onset Seizures Followed by Long-term Open-Label Treatment

Principal Investigator: Laura A. Strom

A Randomized, Double-Blind, Placebo-Controlled Study of the Safety and Efficacy of Intranasal Midazolam (USL261) in the Outpatient Treatment of Subjects with Seizure Clusters ARTEMIS-1: Acute Rescue Therapy in Epilepsy with Midazolam Intranasal Spray-1

Principal Investigator: Laura A. Strom

Long Term Eslicarbazepine Acetate Extension Study

Principal Investigator: Laura A. Strom

Efficacy and Safety of Eslicarbazepine Acetate (BIA 2-093) as Adjunctive Therapy for Refractory Partial Seizures in a Double-Blind, Randomized, Placebo-Controlled, Parallel-Group, Multicentre Clinical Trial.

Principal Investigator: Laura A. Strom

An Open-Label, Multicenter, Follow-Up Study to Evaluate the Long-Term Safety and Efficacy of Brivaracetam used as Adjunctive Treatment in Subjects Aged 16 Years or Older with Epilepsy

Principal Investigator: Laura A. Strom

A Randomized, Double-Blind, Placebo Controlled, Multicenter, Parallel Group Study to Evaluate the Efficacy and Safety of Brivaracetam in Subjects (≥16 To 80 Years Old) with Partial Onset Seizures

Principal Investigator: Laura A. Strom

An Open-Label Safety Study of USL261 in the Outpatient Treatment of Subjects with Seizure Clusters

Principal Investigator: Laura A. Strom

An Open-Label Safety Study of USL261 in the Outpatient Treatment of Adolescent and Adult Subjects with Seizure Clusters

Principal Investigator: Laura A. Strom

Multiple Sclerosis

Analysis of B-cell Trafficking in Multiple Sclerosis Patients Receiveing Tysabri(R) (natalizumab) and Gilenya (fingolimod) Immunomodulatory Therapy

Principal Investigator: Jeffrey L. Bennett

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

Principal Investigator: John R. Corboy

A Double-Blind, Placebo Controlled Trial of Estriol Treatment in Women with Multiple Sclerosis: Effect on Cognition.

Principal Investigator: John R. Corboy

Rocky Mountain MS Center Tissue Bank

Principal Investigator: John R. Corboy

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

Principal Investigator: John R. Corboy

A Phase II, Randomized, Double-Blind, Parallel-Group, Placebo-Controlled, Multicenter Study to Evaluate the Safety and Efficacy of Abatacept in Adults with Relapsing-Remitting Multiple Sclerosis

Principal Investigator: John R. 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

Principal Investigator: John R. 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

Principal Investigator: John R. Corboy

A Double-Blind, Randomized, Multicenter, Placebocontrolled, 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

Principal Investigator: John R. Corboy

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

Principal Investigator: John R. Corboy

Does Long-Term Natalizumab (NTZ) Therapy Normalize Brain Atrophy Rates and Quality of Life (QOL) in Relapsing Remitting Multiple Sclerosis (RRMS)? A Longitudinal Study Using Whole Brain, Neocortical and Subcortical Atrophy Rates and Patient Reported Outcomes (PROs)

Principal Investigator: Augusto A. 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

Principal Investigator: Augusto A. Miravalle

RESEARCH

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

Principal Investigator: Augusto A. 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

Principal Investigator: Augusto A. Miravalle

A Multicenter, Open-label, Extension Study to Evaluate the Long-Term Safety and Efficacy of BLIB019, Daclizumab High Yield Process (DAC HYP), Monotherapy in Subjects with Multiple Sclerosis who have Completed Study 205MS301

Principal Investigator: Augusto A. 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

Principal Investigator: Augusto A. Miravalle

A Phase III, Multicentre, Randomized, Parallel-Group, Double-Blind, Placebo-Controlled Study to Evaluate the Efficacy and Safety of Ocrelizumab in Adults with Primary Progressive Multiple Sclerosis

Principal Investigator: Augusto A. Miravalle

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

Principal Investigator: Augusto A. Miravalle

A Randomized, Double-Blind, Placebo controlled Study to Evaluate the Safety, Tolerability and Activity of Ibudilast (Mn-166) in Subjects with Progressive Multiple Sclerosis

Principal Investigator: Augusto A. 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

Principal Investigator: Augusto A. Miravalle

An Open-Label, 26-Week Study Assessing Arbaclofen Placabil Safety and Efficacy in Subjects with Spasticity due to Multiple Sclerosis

Principal Investigator: Augusto A. Miravalle

Environmental and Genetic Risk Factors for Pediatric Multiple Sclerosis

Principal Investigator: Teri L. Schreiner

Pediatric Multiple Sclerosis and other Demyelinating Diseases Database (PeMSDD Database)

Principal Investigator: Teri L. Schreiner

A Multicenter, Global, Observational Study to Collect Information on Safety and to Document the Drug Utilization of BG00012 When Used in Routine Medical Practice in the Treatment of Relapsing Multiple Sclerosis

Principal Investigator: Teri L. Schreiner

A Multicenter, Observational, Open-Label, Single-Arm Study of Tysabri in Early Relapsing-Remitting Multiple Sclerosis in Anti-JCV Antibody Negative Patient

Principal Investigator: Teri L. Schreiner

Cross-Sectional Study of MSDx Complex-1 Association with Gadolinium Enhancing Lesions in Relapsing-Remitting Multiple Sclerosis

Principal Investigator: Teri L. Schreiner

A Two-Year, Open-Label, Rater-Blinded, Randomized, Multicenter, Active-Controlled Study to Evaluate the Safety and Efficacy of Fingolimod Administered Orally Once Daily Versus Interferon B-1a I.M. Once Weekly in Pediatric Patients with Multiple Sclerosis

Principal Investigator: Teri L. Schreiner

Medication Adherence in Pediatric Multiple Sclerosis

Principal Investigator: Teri L. Schreiner

Rocky Mountain Multiple Sclerosis Center (RMMSC) Biorepository for the Study of Neuroimmunological Disorders

Principal Investigator: Timothy L. 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

Principal Investigator: Timothy L. Vollmer

JCV Antibody Program in Patients with Relapsing Multiple Sclerosis Receiving or Considering Treatment with Tysabri

Principal Investigator: Timothy L. Vollmer

The Global Observational Program on the Safety of Tysabri

Principal Investigator: Timothy L. Vollmer

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

Principal Investigator: Timothy L. 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.

Principal Investigator: Timothy L. Vollmer

Determining if B cell-astrocyte interactions initiate CNS pathology in Multiple Sclerosis

Principal Investigator: Timothy L. Vollmer

Exploring the Mechanism of Action of Laquinimod on B Lymphocytes and Astrocytes in Multiple Sclerosis
Principal Investigator: Timothy L. Vollmer

A Phase 1 Randomized Study of MEDI-551 in Subjects with Relapsing Forms of Multiple Sclerosis
Principal Investigator: Timothy L. Vollmer

A Safety and Efficacy Extension Study of ONO-4641 in Patients with Relapsing-Remitting Multiple Sclerosis in Patients with Relapsing-Remitting Multiple Sclerosis
Principal Investigator: Timothy L. Vollmer

A Multination, 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
Principal Investigator: Timothy L. 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.
Principal Investigator: Timothy L. 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
Principal Investigator: Timothy L. Vollmer

Movement Disorders

Functional Connectivity of the Basal Ganglia in Primary Focal Dystonia: A Pilot Project
Principal Investigator: Brian D. Berman

Natural History and Biospecimen Repository for Dystonia
Principal Investigator: Brian D. Berman

Functional Connectivity of the Motor Network in Two Major Subtypes of Parkinson Disease.
Principal Investigator: Brian D. Berman

Neural Mechanisms of Reflexive Blinking and Eye Muscle Spasms in Blepharospasm
Principal Investigator: Brian D. Berman

DYSPOTM for Injection AbobotulinumtoxinA Neurotoxin Clinical & Health Economics Outcomes Registry in Cervical Dystonia (ANCHOR-CD)
Principal Investigator: Olga S. Klepitskaya

Using Multiplex Families to Map Genes that Modify Susceptibility and Age at Onset in Parkinson's Disease (also known as "The PaGeR Study") Parkinson's Genetic Research Study- NIH
Principal Investigator: Olga S. Klepitskaya

A Phase 3b, Multicenter, Randomized, Double-Blind, Placebo-Controlled Study Evaluating the Efficacy and Safety of DYSPOTM Using 2mL Dilution in Adults with Cervical Dystonia
Principal Investigator: Olga S. Klepitskaya

A Phase 2B, Twelve-week Multi-Center, Randomized, Double-Blind, Placebo-Controlled, Parallel Group Study, To Determine the Safety, Tolerability and Efficacy of Two Doses of Once Daily P2B001 in Subjects With Early Parkinson's Disease (PD)
Principal Investigator: Olga S. Klepitskaya

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 Troublesom Sialorrhea in Adult Subjects
Principal Investigator: Olga S. Klepitskaya

Study of the Neurophysiology of Central Fatigue
Principal Investigator: Benzi M. Kluger

Study of the Neurophysiology of Cognitive Dysfunction in Parkinson's Disease
Principal Investigator: Benzi M. Kluger

Functional Neuroimaging of Volitional Action Using Magnetoencephalography and Functional MRI
Principal Investigator: Benzi M. Kluger

Cortical Physiology as a Therapeutic Target in Parkinson's Disease-related Dementia and Cognitive Dysfunction
Principal Investigator: Benzi M. Kluger

Does Prior Acupuncture Experience Bias Subjects' Perception of Real Versus Sham Acupuncture Treatments?
Principal Investigator: Benzi M. Kluger

Acupuncture as a Symptomatic Treatment for Fatigue in Parkinson's Disease
Principal Investigator: Benzi M. Kluger

Genetic and Environmental Risk Factors for PSP
Principal Investigator: Benzi M. Kluger

Defining Palliative Care Needs in Parkinson's Disease
Principal Investigator: Benzi M. Kluger

Long Term Follow-Up Study for rAAV-GAD Treated Subjects
Principal Investigator: Maureen A. Leehey

Memantine Treatment in Fragile X-Associated Tremor/Ataxia Syndrome
Principal Investigator: Maureen A. Leehey

A Multicenter, Double-Blind, Parallel Group, Placebo Controlled Study of Creatine in Subjects with Treated Parkinson's Disease LS-1 (NET-PD)
Principal Investigator: Maureen A. Leehey

Multi-Center, Double-Blind, Placebo-Controlled Phase II Study of Pioglitazone in Early Parkinson's Disease (FS-ZONE)
Principal Investigator: Maureen A. Leehey

Neurocritical Care

Physiological Effects of Intrathoracic Pressure Regulation in Patients with Decreased Cerebral Perfusion Due to Brain Injury or Intracranial Pathology
Principal Investigator: Robert Neumann

Neuromuscular

Use of 3,4-Diaminopyridine, an Investigational new drug, in Lambert-Eaton Syndrome
Principal Investigator: Steven P. Ringel

HDE Post-Approval Study (PAS) of NeuRX DPS (TM) for ALS
Principal Investigator: Teerin Liewluck

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)
Principal Investigator: Dianna Quan

A Phase II Trial of Rituximab in Myasthenia Gravis: They Determine Whether Rituximab is a Safe and Beneficial Therapeutic For MG that Warrants Further Study in a Phase III Efficacy Trial
Principal Investigator: Dianna Quan

Neuro-Ophthalmology

Collaborative International Research in Clinical and Longitudinal Experience for Neuromyelitis Optica (NMO) Studies (CIRCLES)
Principal Investigator: Jeffrey L. Bennett

Prospective Study to Determine the Proportion of Patients with Isolated Third, Fourth and Sixth Nerve Palsies of Microvascular versus Non-Microvascular Etiology
Principal Investigator: Jeffrey L. Bennett

A Phase IV Trial of Neuroprotection with ACTH in Acute Optic Neuritis
Principal Investigator: Jeffrey L. Bennett

A phase 1 open label, dose escalation trial of QPI-1007 delivered by a single intravitreal injection to patients with optic nerve atrophy (STRATUM 1) and acute non-arteritic anterior ischemic optic neuropathy (NAION) (STRATUM II)
Principal Investigator: Jeffrey L. Bennett

A phase 1 open label, dose escalation trial of QPI-1007 delivered by a single intravitreal injection to patients with optic nerve atrophy (STRATUM 1) and acute non-arteritic anterior ischemic optic neuropathy (NAION) (STRATUM II)
Principal Investigator: Jeffrey L. Bennett

Virtual Reality Assessment of Visuospatial Disorientation in Alzheimer's Disease
Principal Investigator: Victoria S. Pelak

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

Development of Visual Perception Tests for Normal Aging, Mild Cognitive Impairment, and Alzheimer's Disease Using Computer Based Graphics and Virtual Reality Applications
Principal Investigator: Victoria S. Pelak

Neurosurgery

University of Colorado School of Medicine Neuropsychology Database
Principal Investigator: Brian Hoyt

Chiari I Malformation and Spinal Cord Syrinx--A case Report of 2 Patients
Principal Investigator: O'Neill

Rate of Vocal Cord Paralysis Associated With Implantable 2mm and 3mm Leads
Principal Investigator: Ken Winston

Management of Aplasia Cutis Congenita
Principal Investigator: Ken Winston

Tamponade for Control of Life-Threatening Intracranial Hemorrhage
Principal Investigator: Ken Winston

Physical Medicine and Rehabilitation

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

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

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

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

Spine – Orthopaedics

Evaluation of the Association Between Melatonin Signaling Impairments with the Promotor of Melatonin Receptor 1b
Principal Investigator: Evalina Burger

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

The Relationship Between Sagittal Plane Correction and Quality of Life in Adult Deformity Patients Treated With Posterior Instrumentation
Principal Investigator: Evalina Burger

Analysis of prognostic cell signaling factors in Adolescent Idiopathic Scoliosis
Principal Investigator: Evalina Burger

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

Biomechanical Evaluation of Anterior Cage-Plate Fixation (ALIF cage and ATB Plate or Synfix)Versus Iliac Screws with TLIF
Principal Investigator: Evalina Burger

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

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

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

Retrospective Review of Minimally Invasive Sacroiliac Joint Fusion using O-Arm and Stealth Navigation
Principal Investigator: Christopher Kleck

Prospective analysis of spine surgery outcomes
Principal Investigator: Emily Lindley

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

Clinical Study to Evaluate the Safety and Effectiveness of the Aesculap Activ-L Artificial Disc in the Treatment of Degenerative Disc Disease
Principal Investigator: Vikas Patel

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

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

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

Investigation of Sacroiliac Fusion Treatment (INSITE)
Principal Investigator: Vikas Patel

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

An in vitro Biomechanical Study of C4-C5 Intervertebral Disc Replacement using a Cadaveric Model
Principal Investigator: Vikas Patel

Porous, Patient Specific Interbody Fusion Cages with Enhanced Loading Characteristics
Principal Investigator: Vikas Patel

Effects of Vitamin D Deficiency on Lumbar Spine Fusion and the Role of rhBMP-2
Principal Investigators: Vikas Patel and Emily Lindley

Postoperative Pain Management following Spine Surgery: Patient-Controlled Transdermal Fentanyl vs Intravenous Morphine Pump
Principal Investigators: Vikas Patel and Emily Lindley

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

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