2015 REPORT to the Community

50 YEARS IN THE MAKING
The Department of Neurology turned 50 on June 28th, 2015.

WHAT IT TAKES to Become the Busiest DBS Center in the Intermountain West.

MAKING IT REAL The Role of 3-D Printing in Spine Imaging.
A DAY WITH THE NEUROTRAUMA MASTERS

March 9, 2016
Rice Eccles Stadium, 6th Floor
451 1400 E., SLC, UT 84112
7am - 5:15pm

Join us for a day with the greatest minds in the history of neurotrauma, in conjunction with the Grand Opening of the University of Utah’s Academic Neurotrauma Program.

Sir Graham Teasdale, MD
Inventor of the Glasgow Coma Scale

Michael Fehlings, MD, PhD
The most important surgeon scientist in the history of spinal cord injury research

Ross Bullock, MD, PhD
The most important surgeon scientist in the history of traumatic brain injury research

Andres Rubiano, MD
Thought leader responsible for dramatic improvements in Colombia’s brain injury care

Host: Gregory Hawryluk, MD, PhD
Director of Neurosurgical Critical Care, University of Utah

Seating is limited. Complimentary registration at http://medicine.utah.edu/ncc-launch

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# ANNUAL REPORT TO THE COMMUNITY

## OVERVIEW  CLINICAL NEUROSCIENCES CENTER

Message from the Chairs
2015 Highlights

## SPECIAL SECTION  50 YEARS OF NEUROLOGY

What a Difference 50 Years Make!
Better Treatments for Idiopathic Intracranial Hypertension
Developing New Treatments for Migraine
Unraveling the Mysteries of Post-Traumatic Headache
A New Gene for Migraine
Imaging the Face to Understand Headache Disorders
A Network Approach to Clinical Trials
Enhancing Stroke Recovery: From Bench to Rehab
Innovative Collateral Blood Flow Enhancement Trial Aims to Improve Outcome After Ischemic Stroke
Cutting Edge Treatment for Neurological Catastrophes
Neuroimmunology and Neurovirology Division Role at the VA
Sitting is the New Smoking
Screening Diabetic Patients for Neuropathy by Looking Them in the Eyes
Charting the Course of Myotonic Dystrophy in Childhood
Precision Medicine for Chemotherapy Induced Peripheral Neuropathy
Novel Approaches to Neurodegenerative Diseases
Delaying Cognitive Decline
Pediatric Neurology: Discovery and Treatments for the Youngest Patients
Linking Genes, Brain Imaging, and Behavior

## SELECTED STORIES

Leveraging Technology to Meet the Changing Healthcare Landscape
Learning to Adapt
Refining the Treatment to Fit the Mutation
The Quest for Personalized GBM Treatment
Targeting the Best Approach for Neck Pain
The Gift of Mistaken Identity
Rising to the Top
A Collaborative Effort
A Quest to See the Unseen
A New View to Stroke Research
Making It Real

## BY THE NUMBERS  STATISTICS

- Neurology
- Stroke
- Neurosurgery
- Spine
- Neuroradiology

## NEUROSCIENCES PHYSICIANS & FACULTY

- Physician Bios
- Residents & Fellows
- Community Advisory Board/Mission, Values & Vision
University of Utah Health Care (UUHC) is pioneering ways to improve value of care and is at the leading edge of integrating the ever-changing landscape of healthcare in the United States into superb care for every patient. The Clinical Neurosciences Center (CNC), an integral part of the UUHC family, is proud to be a leader in neuroscience health care transformation as we establish new and innovative ways to provide high-quality, cost-sensitive care for our patients.

Teach. Seek. Heal. These three words express our core values and missions. They are a constant reminder of our obligation to educate and teach the next generation of medical students, nurses, and physicians, engage in innovative and transdisciplinary research designed to seek tomorrow’s solutions to today’s medical complexities, and to help patients heal by providing patient-centered care incorporating the most advanced technologies and methods available today.

In this year’s issue of Convergence, we highlight some of the accomplishments of our faculty and acknowledge the 50th anniversary of the founding of our Department of Neurology. You will find a variety of stories highlighting individuals, services, technologies, and research that make up the fabric of the CNC, one of the most advanced neurosciences centers in the country. For example, you will find out:

**How the Department of Neurology has increased extramurally funded research and has become a nationally recognized center for clinical trials.**

**How neurologists and neurosurgeons at the CNC have developed the Deep Brain Stimulation program at University of Utah Health Care into a national powerhouse.**

**How one neurosurgeon adapting a 100-year-old surgical concept helped a bridegroom walk down the aisle at his wedding and become the first patient to receive a partial Tibialis nerve transfer.**

**How a case of mistaken identity after a longboarding accident saved a Utah teen’s life by leading him to a rare trauma procedure.**

**How neuroradiologists and neurologists are studying vessel wall inflammation utilizing novel MRI technologies as an indicator of stroke recurrence.**

On behalf of everyone at the Clinical Neurosciences Center, we hope you enjoy this year’s edition of Convergence.
CONTINUED INVOLVEMENT WITH A VARIETY OF COMMUNITY EVENTS

• BE WELL UTAH HEALTH FAIR
• SEIZE THE NIGHT 5K WALK/RUN
• SAVING STROKES
• CARS FOR A CURE GOLF CHALLENGE
• TEAM BRAIN CYCLING TEAM

AWARDS AND CERTIFICATIONS

• REMAINED AMONG THE TOP 20 HOSPITALS IN THE COUNTRY FOR SUCCESSFUL DEEP BRAIN STIMULATION
• GEORGE C. COTZIAS AWARD FOR NEUROSCIENCE RESEARCH AWARDED TO STEFAN PULST, MD, DR. MED
• REMAINED ONE OF ONLY TWO NEUROLOGY DEPARTMENTS WEST OF THE MISSISSIPPI THAT IS A MEMBER OF BOTH NEURONEXT AND STROKE NET

PLANNED, EXECUTED AND HOSTED A NUMBER OF REGIONAL AND NATIONAL NEUROSCIENCE CONFERENCES

• 4TH INTENSIVE INTERACTIVE BRAIN & SPINE IMAGING CONFERENCE
• 12TH ANNUAL UTAH STROKE SYMPOSIUM
• INAUGURAL EMERGENCY CARE SYMPOSIUM
• 44TH & 45TH WESTERN INTERMOUNTAIN NEUROLOGICAL ORGANIZATION (WINO) CONFERENCE
• MUSCLE STUDY GROUP 2015 MEETING (ALSO HOSTING IN 2016)
For the sixth year in a row, received the American Heart/American Stroke Association’s Gold Plus Award for Stroke Excellence

- **INAUGURATED A WEB-BASED STATE-WIDE PARKINSON’S DISEASE REGISTRY, A FIRST IN THE NATION**
- **BECAME THE TOP ENROLLING INSTITUTION IN THE COUNTRY PARTICIPATING IN THE NATIONAL NEUROSURGERY QUALITY AND OUTCOMES DATABASE (N2QOD) FOR SPINE SURGERY**

**WELCOMED 6** new physicians to the Clinical Neuroscience Center – 2 in Neuroradiology and 4 in Neurology

**ADDED 4 NEW SITES** over the past year to our growing TeleStroke Network.

**ESTABLISHED A** comprehensive spine program in conjunction with the UUHC Rehabilitation Center and Orthopedic Hospital

**CREATED A** neurosurgery program and partnership with Mountain West Hospital in Tooele, UT

**ESTABLISHED THE** region’s only peripheral nerve surgery program

**HELPED ESTABLISH** a comprehensive neuro-oncology program between University of Utah Health Care, Intermountain Healthcare, and the VA

**EXPANSION OF** the Neuro Critical Care Unit in a joint effort between the departments of Neurosurgery and Neurology

**ESTABLISHED** the Head Trauma Consortium

**EXPERIENCE RECORD** growth and the addition of multiple partner hospitals for the endovascular program
WHAT A DIFFERENCE
50 YEARS MAKE!

by Stefan M. Pulst, MD, Dr. med, Professor and Chair of Neurology

The Department of Neurology turned 50 on June 28, 2015. A neurologist training in 1965 would hardly recognize today’s neurological practice and research. We can imagine joining the team in the neurology library in the newly built hospital on a hot day in July 1965 with the air conditioning not yet ready to kick in. Ted Ajax, MD, is the ward attending, sitting around a small table with two male residents. The light box on the wall illuminates a pneumencephalogram, an invasive and painful procedure, which replaces the spinal fluid in the cerebral ventricles with air. In a few minutes one of the residents will rise from his chair and replace the “pneumo” with an angiogram of the same patient, another invasive and potentially dangerous procedure. But these are the only ways to image the brain in 1965.

It was inconceivable at this point in time that just a few years later the first grainy pictures of the brain obtained by computed tomography would revolutionize imaging and neurologic practice. Multiple sclerosis was untreatable in 1965 and George Cotzias’ seminal trial of L-DOPA in Parkinson patients was still two years away. The identification of the first Alzheimer gene would take another 20 years, and a patient with an acute stroke would more often than not be admitted to internal medicine.

Propelled by basic and translational neuroscience using novel imaging, genetic and molecular tools, and improved methods in clinical trials, the change in neurological practice and treatment has been breathtaking. To recognize the technological innovation in neurological patient care, the ensuing pages highlight some of the diverse research that is currently conducted in the Department of Neurology at the University of Utah and showcase the neurologists leading these projects.

The breadth of these projects – ranging from disease gene discovery and molecular approaches to treatment to novel imaging methods and innovative exploration of the most common neurological disorders such as neuromuscular diseases and stroke – is astonishing.

The Department of Neurology at the University of Utah is only one of two neurology departments west of the Mississippi that is a member of both NeuroNext and StrokeNet, the two clinical trial networks that were recently funded by the National Institute of Neurological Disorders and Stroke. These clinical translational efforts are paired with a department-wide biosampling core that obtains and purifies biological samples from patients admitted to the neurology wards or seen in the outpatient clinic. Combined with precise clinical characterization and continued follow-up of our patients, this sample resource empowers

Faculty in 1965: 16
Residents in 1965: 8
Faculty in 2015: 72
Residents in 2015: 35
clinical and discovery research and recently contributed to the identification of a new gene for ALS.

It is notable that the founding year of the Department of Neurology coincided with the creation of Medicare under the leadership of President Johnson, a program that provided healthcare to people older than 65, regardless of income or medical history. Now 50 years later, we are witnessing another milestone. In June 2015, the Supreme Court upheld a key part of the Affordable Care Act that provides health insurance subsidies to all qualifying Americans, thus expanding access to healthcare for millions of previously uninsured individuals in the U.S. With an estimated 2.5 million increase of the Utah population by 2050 and a disproportionate increase of the senior population, we will need to train a sufficient number of neurologists to bring the expected technological and treatment advances to all Utahns.

The Department of Neurology has proven in the past that it can rise to this challenge. Who could have imagined that 16 attending neurologists and eight residents in 1965 would grow to more than 72 neurology faculty members, 35 residents and 14 fellows by 2015?

I am certain that similar growth and expansion will be possible in the next 50 years. It is difficult to imagine the practice of neurology 50 years from now, and I will refrain from this temptation as it will only produce amusement for those future neurologists who are not even born in 2015.

But what I do know is this: neurologists will remain at the forefront of academic investigative medicine and advance neuroscience innovation at the basic, translational and clinical level.

Our great enjoyment for teaching students about the brain and its disorders will continue, and I see enormous potential to train and empower the next generation of neurologists and to work within a leading health system to transform healthcare. And I am certain that future neurologists will love their profession as much as we do today.
The Department of Neurology is grateful for the vision and generosity of donors who help us on the frontier to a better understanding and treatment of neurological diseases.

**$500,000 AND ABOVE**
- Carol Holding
- G. Mitchell and June M. Morris Foundation
- Rodney H. and Carolyn Hansen Brady Foundation

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- Anita W. Betz
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- Muscular Dystrophy Association
- The Ray and Tye Noorda Foundation
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- Kent Wayne Davis, MD
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- M. Eve Petajan, PhD
- Maddox Ranch House
- Robert Wood Johnson Foundation

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**CHAIRS:**
Idiopathic intracranial hypertension is a disorder of obese women of childbearing age. It has profound effects on vision if not followed appropriately. While weight loss and acetazolamide are often recommended as treatment, there was no randomized controlled trial looking at treatment until the recently completed Idiopathic Intracranial Hypertension Treatment Trial. The University of Utah Neuro-ophthalmology team participated in this multicenter trial, which found that weight loss and acetazolamide were more efficacious than weight loss alone in patients with mild visual loss. They also studied the effect on quality of life at the time of diagnosis and found that visual quality of life is reduced in patients with IIH, similar to patients with visual loss associated with optic neuritis and demyelinating disease. Study performed by Kathleen B. Digre, MD, Judith E. Warner, MD, and Bradley Katz, MD, PhD.

Migraine is in desperate need of new treatments. So far only one class of drug has been developed specifically for migraine – all others have been borrowed from other diseases. This is where Dan Kaufmann, PhD and Jeremy Theriot, PhD (Dr. KC Brennan’s Headache Physiology Lab) come in. Kaufmann trained as a chemist in Israel, and during his doctoral studies he designed a drug (sec-propylbutylacetamide - SPD) that he and Brennan realized could be perfect for migraine. Theriot is a neuro-engineer who adapted techniques used by the Brennan lab for high-throughput drug testing.

Together the three obtained a grant from NIH to develop tools for migraine drug development and use them to find new treatments. SPD – the drug Kaufmann created during his doctoral studies – is the first candidate. Kaufmann used the tests Theriot developed to show that SPD likely works on multiple pathways in migraine. The results are in press now, and the next step is to begin testing in humans. Says Kaufmann, “It is so fulfilling to see new treatments on the horizon for migraine. There is much work yet to do but we have a way forward.”
UNRAVELING THE MYSTERY OF POST-TRAUMATIC HEADACHE

by KC Brennan, MD

Post-traumatic headache is an epidemic in our soldiers returning from battle zones across the world. It also affects far too many young athletes and people of all ages who experience motor vehicle accidents. Yet we know almost nothing about this disease. We do know it is extremely difficult to treat. Though it tends to “act” like chronic migraine, it is less responsive to therapies. A team from the Headache Physiology Laboratory is trying to change this. With funding from the Department of Defense, they are using high-resolution imaging and electrical recording to examine the effects of trauma on individual neurons in the brain, while simultaneously examining headache-related pain behavior. Punam Sawant, PhD, is spearheading the electrical recordings. She uses a tiny electrode to record from single sensory neurons in the brain, a technique called “in vivo whole cell recording” that very few investigators across the world have mastered. She has found changes in how neurons respond to sensory information after injury, and interestingly these changes are worse in “migraine mice” (mice carrying a gene from humans with migraine). Says Sawant, “This is very exciting, because it is exactly what we see in the clinic – people with migraine are much more likely to get post-traumatic headache.” Importantly, her findings offer specific clues about neuronal dysfunction that can be used to develop novel treatments.

A NEW GENE FOR MIGRAINE

by Kathleen B. Digre, MD & KC Brennan, MD

The origins of migraine are obscure, but it is known that the disease can be passed on in families. In a collaborative effort with groups in Vermont, San Francisco, and Los Angeles, KC Brennan, MD, and colleagues identified casein kinase 1 delta as a new gene for migraine and showed how it contributes to the disease by enhancing sensory excitability. This work made the cover of Science Translational Medicine. According to Brennan, one reason the findings are considered important is that “this is the first genetic migraine model that comes from patients with ‘normal’ migraine – other models come from more extreme forms of the disease.” This means their laboratory discoveries are more likely to be relevant to the 36 million women and men who suffer from migraine in the U.S.
IMAGING THE FACE TO UNDERSTAND HEADACHE DISORDERS

by KC Brennan, MD

The face is an eloquent marker of our emotions. Turns out it also has information about headache. Melissa Cortez, DO, assistant professor of neurology and director of the newly established Autonomic Laboratory, has joined her expertise in autonomic regulation with the imaging skills of the Headache Physiology Laboratory. Cortez and Jeremy Theriot, PhD from the Physiology Lab adapted techniques used for brain imaging to examine the faces of patients with headache disorders. Just as the eye recognizes when someone is pale, or blushing, the cameras pick up (in greater detail) changes in skin blood flow that get activated during headache. They also record the pupils, which are another window into sympathetic and parasympathetic control. “The face and head are relatively neglected in the world of autonomic neurology,” says Cortez, “and we know there are profound changes in these regions in the headache disorders.” Dr. Cortez and her team can now distinguish migraine and post-traumatic headache with these techniques, offering important clues about their mechanisms.

KEY PUBLICATIONS AND PRESENTATIONS:


GRANTS:

A multi-center, double-blind, randomized, placebo-controlled study of weight-reduction diet plus acetazolamide vs. diet plus placebo in subjects with idiopathic intracranial hypertension with mild vision Loss, NEI 1U10 EY01728101A1, Site Pi: Kathleen B. Digre; Co-Pi: Judith E. Warner; Treating Physician: Bradley Katz.

American Academy of Neurology Medical Student Summer Research Fellowship, Pi: Natalie Rea.

Mechanism and therapy for the shared susceptibility to migraine and epilepsy after traumatic brain injury, Department of Defense CDMRP PR100060, Pi: KC Brennan.

Dissecting the roles of brain injury and combat-related stress in post-traumatic headache, Department of Defense CDMRP PR130373, Pi: KC Brennan.

NIH Loan Repayment Program L30, Pi: Melissa Cortez.

Sex differences in the basic pathophysiology of migraine, K08NS059072, Pi: KC Brennan.


Sensory Plasticity in Migraine, R01NS085413, Pi: KC Brennan.
The Network for Excellence in Neuroscience Clinical Trials (NeuroNEXT) is an NINDS funded consortium of 25 centers with expertise in clinical trial design and performance. NeuroNEXT supports multicenter phase II clinical trials funded by NINDS, at times in collaboration with an industrial partner.

StrokeNet, funded in 2013, is another national trials network composed of 25 regional coordinating centers (RCCs), but focused on phase II and III stroke trials, in all stages of stroke care: prevention, treatment and recovery. In order to efficiently recruit patients, it requires each RCC to develop and manage a regional network of hospitals.

The University of Utah is one of only a handful of institutions in the nation to be awarded sites in both NeuroNEXT and StrokeNet, in addition to an institutional Center for Translational Science Award.

UR-NEXT has four aims: (1) develop and maintain an integrated infrastructure to facilitate the efficient implementation of clinical studies and trials in both children and adults with neurologic disease; (2) identify, coordinate and recruit investigators with special expertise in a broad spectrum of diseases affecting the nervous system with the knowledge and patient access to ensure both efficient recruitment and collaboration with local and regional clinicians; (3) integrate the
To date NeuroNEXT has performed four clinic trials (one complete and three ongoing) involving spinal muscular atrophy (SMA), multiple sclerosis, stroke and myasthenia gravis. UR-NEXT is one of only a handful of sites that has participated in each trial.

UT StrokeNet is led by Jennifer Majersik, MD, MS, at the University of Utah Stroke Center and includes six hospitals in its network: University Hospital, Intermountain Medical Center, Primary Children’s Hospital, SLC VA Medical Center, Utah Valley Regional Medical Center (Provo, UT), and St. Mary’s Regional Medical Center (Grand Junction, CO). UT StrokeNet aims to efficiently implement pediatric and adult stroke prevention, treatment and recovery trials and to provide access to the high quality, innovative stroke trials to all patients in the Intermountain West. We also aim to leverage collaborations between translational and clinical investigators to develop innovative biomarkers and therapies and to develop a robust integrated neurovascular research training and career development program. We are well on our way to achieving these aims, having this year initiated trials at three of our five adult sites, including Crest-2, a primary prevention study of intensive medical management +/- surgical treatment of asymptomatic carotid stenosis, and Defuse-3, a trial of clot-retrieval in acute ischemic stroke patients presenting more than six hours after onset and with favorable penumbral pattern imaging. There are almost 20 additional stroke trials in the review pipeline. At the University of Utah, we are collaborating with KC Brennan, MD, (see page 36) to translate his animal work on stroke recovery to the neuroscience inpatient unit. We have also trained two fellows – one of whom, Adam de Havenon, MD, has already received funding via the competitive institutional KL2 award to study the improvement of collateral blood flow in acute stroke patients.

**KEY PUBLICATIONS AND PRESENTATIONS:**


**GRANTS:**

UR-NEXT, U10NS077305, PI: Gordon Smith.

UT StrokeNet, U10 NS086606, PI: Jennifer Majersik.
ENHANCING STROKE RECOVERY: FROM BENCH TO REHAB

by Jennifer Majersik, MD, MS & KC Brennan, MD

Though stroke treatment has advanced incredibly, unfortunately stroke survivors still experience significant disability, with 69% requiring rehabilitation services of some sort, and 50% with long-term motor impairment. Fortunately, the brain retains considerable ability to rewire after a stroke has occurred. The lab of KC Brennan, MD, recently showed that memantine, a drug typically used to treat Alzheimer’s disease, enhances the recovery from stroke in mice. Because memantine is already used in patients, he approached Jennifer Majersik, MD, MS, associate professor of neurology, and Lorie Richards, PhD, professor and division chair of occupational therapy. Says Brennan, “The ‘bench-to-bedside’ phrase gets used a lot, but this was an example of the real thing – we had a promising treatment we knew could be taken straight to humans.” Majersik and Richards are running a pilot trial of memantine to enhance stroke recovery in humans. They are using this trial to not only gain preliminary data for a larger trial, but also to train the next generation of stroke researchers. Alicia Bennett, DO, stroke fellow who is funded by StrokeNet, helped get the trial off the ground by obtaining FDA approval for use of memantine, and is now running the day-to-day patient recruitment. Dr. Majersik says, “It is exciting to tell patients with motor impairment from stroke that we are finally exploring medications that may improve their function. I am very hopeful that we will find that memantine facilitates their recovery.”
**INNOVATIVE COLLATERAL BLOOD FLOW ENHANCEMENT TRIAL**
**AIMS TO IMPROVE OUTCOME AFTER ISCHEMIC STROKE**

by Jennifer Majersik, MD, MS

Early neurological deterioration after ischemic stroke affects 30% of all stroke patients, who have a higher rate of death or poor outcome. The most common mechanism of early neurologic deterioration is extension of the stroke into the “penumbra,” a region of salvageable brain tissue surrounding the core of irreversible ischemic infarct. Acute stroke management is primarily focused on recanalizing the occluded artery causing the stroke, but an alternative and relatively unexplored approach is optimization of collateral blood flow.

Adam de Havenon, MD, assistant professor of neurology, has spent his first years as faculty studying techniques to measure collateral cerebral blood flow, such as arterial spin labeling MRI and transcranial Doppler ultrasound. Based on his preliminary data from a retrospective cohort of 325 ischemic stroke patients, Dr. de Havenon hypothesizes that the oral drug midodrine, traditionally used to treat orthostatic hypotension, will optimize collateral blood flow by decreasing the variability of blood pressure, helping salvage the ischemic penumbra. He recently obtained NIH funding from the University of Utah KL2 Scholars Program to conduct a pilot trial of this novel therapeutic approach, with a team of mentors and collaborators including Jennifer Majersik, MD, MS, and Gordon Smith, MD, (Department of Neurology), and Dennis Parker, PhD, and Scott McNally, MD, PhD (Department of Radiology).

**KEY PUBLICATIONS AND PRESENTATIONS:**
de Havenon A et al: Ischemic Stroke Patients with Active Malignancy or Extracardiac Shunts are More Likely to Have a Right-to-left Shunt Found by TCD than Echocardiogram. Translational Stroke Research (2015).

**GRANTS:**
Investigating the basic mechanisms linking migraine and stroke, R21NS070084, PI: KC Brennan.
Midodrine for Ischemic Stroke with Penumbra (MISP), UL1TR001067 University of Utah KL2 Scholars Program, PI: Adam de Havenon.
UT StrokeNet, U10NS086606, PI: Jennifer Majersik.
CUTTING EDGE TREATMENT FOR NEUROLOGICAL CATASTROPHES

by Safdar Ansari, MD

Medical care made a quantum leap forward with the recognition that severely ill patients need specialized care in critical care units. The University of Utah was an early adopter of this movement for neurology patients and has maintained a neurocritical care unit (NCCU) for nearly two decades. Safdar Ansari, MD, assistant professor of neurology and co-director of the NCCU, is also the principal investigator of a groundbreaking clinical trial to study the effects of hypothermia (lowering core body temperature) on status epilepticus (prolonged seizures unresponsive to standard treatment) compared to standard medical therapy alone. This early data will be used to provide new and innovative treatment strategies for this devastating disease.

In collaboration with neurosurgeons Phil Taussky, MD, and Richard Schmidt, MD, PhD, Ansari is also conducting clinical trials on intracranial hemorrhage, a severe and devastating disorder with limited targeted therapies. Intraventricular hemorrhage (IVH) is bleeding into the ventricular system of the brain, often the result of severe intracerebral hemorrhage (ICH). The CLEAR-III trial (Clot Lysis: Evaluating Accelerated Resolution of IVH Phase III) and the follow-up MISTIE-III trial (Minimally Invasive Surgery Plus TPA for Intracerebral Hemorrhage Evacuation) evaluate novel medical and surgical approaches to this devastating illness.

Ishwara R. Sankara, MPH, MBBS, assistant professor of neurology, is the primary site investigator for the multi-center PROSPER study and the ARAMIS registry. These studies emphasize real-world treatment and place the patient at the center of the study – especially women, minorities and the elderly – by incorporating generalizable patient perspectives.

KEY PUBLICATIONS AND PRESENTATIONS:


GRANTS:

- Clot Lysis: Evaluating accelerated resolution of IVH phase III (CLEAR III), 5U01NS062851, Site Co-PI: Safdar Ansari, Richard Schmidt.
- MISTIE III, Lead Grant, Cluster application for the clinical coordinating center, 1U01NS080824, Site Co-PI: Safdar Ansari, Phil Taussky.
The Neurology Service at the George E. Wahlen Veterans Affairs Medical Center (VA) has played a major role in the Department of Neurology since the department’s beginnings by supporting the Department’s teaching and clinical care missions and providing clinical training for roughly half of our medical students and for residents in Neurology and other disciplines.

The Neurology Service, through its Neurovirology/Neuroimmunology laboratories, also has a long tradition of both basic and clinical research. Ongoing research efforts, funded by Department of Veterans Affairs and other awards, currently include work in multiple sclerosis and other autoimmune and neuroinflammatory conditions. We have participated or initiated important clinical trials in Multiple Sclerosis (MS) at the VA, contributing to the development of glatiramer acetate, interferons, daclizumab and estradiol for treatment of MS. Laboratory and clinical investigations of MS and neuroimmunologic diseases are the subjects of ongoing research funded by the VA.

John E. Greenlee, MD, professor of neurology, has advanced the field of paraneoplastic diseases with his investigations of antibody mechanisms of action. Noel G. Carlson, PhD, research professor of neurobiology and anatomy, has lead the way in the understanding of oligodendrocyte survival and death in MS and model systems. John Rose, MD, professor of neurology, and Eun-Kee Jeong, PhD, professor of radiology research, have pioneered new imaging technology and protocols to better understand the types of damage in the cervical spinal cord for both demyelinating disease and spinal cord compression.

**KEY PUBLICATIONS AND PRESENTATIONS:**


Greenlee JE et at: Anti-Yo antibody interaction with its intracellular target antigen leads to targeted Purkinje cell death in rat cerebellar slice cultures: a possible mechanism for paraneoplastic cerebellar degeneration in humans with gynecological or breast cancers. PLOSone (2015).


**GRANTS:**

Advanced Quantitative MRI of the Cervical Spinal Cord in Demyelinating Disease, U.S. Department of Veterans Affairs Merit Review Award, PI: John W. Rose.

Antineuronal antibodies in autoimmune neurological disease, U.S. Department of Veterans Affairs Merit Review Award, PI: John E. Greenlee.

Roles of microglia and prostaglandin receptors in neuroprotection, U.S. Department of Veterans Affairs Merit Review Award, PI: Noel G. Carlson.
Type 2 diabetes affects >8% of Americans; half develop peripheral neuropathy (DPN). DPN is a major cause for disability due to numbness, pain, falls, foot ulcers and amputations, and there are currently no effective treatments. Even aggressively controlling blood sugar is only marginally effective. The Utah Diabetic Neuropathy Study (UDNS) found that early DPN is characterized by progressive loss of the smallest nerve fibers, which are responsible for pain perception. These nerve fibers can be evaluated using a skin biopsy to estimate intraepidermal nerve fiber density (IENFD). The UDNS found that intensive exercise prevented early decline in IENFD. These results add to other data from our group indicating that successful exercise improves the ability of nerves to regenerate following injury. Unfortunately, intensive exercise is of limited long-term benefit because patients frequently increase caloric intake and reduce non-exercise activity.

We hypothesize that an intervention integrating moderate supervised exercise with actigraphy based strategies to reduce sedentary (sitting) behavior will result in sustainable metabolic improvement, slow the rate of DPN progression, and improve quality of life. The Activity for Diabetic Polyneuropathy (ADAPT) study is randomizing 140 patients to standard of care or an integrated program of moderate supervised exercise and actigraphy-based anti-sedentariness counseling. IENFD and the Norfolk Quality of Life – Diabetic Neuropathy are co-primary endpoint measures. The goal is to determine if this novel approach to increasing home activity and reduced sedentary time is an effective therapy. A second objective is to better evaluate the clinical meaning of change in IENFD. Skin biopsies are being used to explore the intervention’s impact on nerve regeneration and inflammation. The results of the ADAPT study will be of immediate significance, and if the intervention is successful, a greater clinical focus on strategies to reduced sedentary behavior at home will be justifiable. Demonstration of a minimally clinically meaningful change in IENFD will greatly facilitate early phase proof of concept trials for DPN, thus supporting therapeutic development for this common and disabling diabetic complication.

Above: Skin biopsy from a normal control shows regenerating axons in the epidermis.
Diabetes affects over 25 million Americans; 50% have peripheral neuropathy (DPN). DPN is a leading cause of disability for which there is no treatment. Skin biopsies with measurement of intraepidermal nerve fiber density (IENFD) is a reproducible tool to assess small nerve fibers lost in early DPN. IENFD declines prior to DPN, suggesting it is a sensitive diagnostic measure that could be used to evaluate treatment efficacy; however, IENFD is invasive, technically demanding, expensive and inconvenient. Corneal confocal microscopy (CCM) noninvasively and directly visualizes small nerves on the surface of the eye, making it rapid and well tolerated.

Because reversible metabolic injury segues into irreversible nerve loss, there is consensus that therapy should be initiated early. An ideal strategy is to screen diabetic patients to identify those at high DPN risk in order to facilitate prevention or early intervention.

Annual screening for diabetic retinopathy has reduced the risk of blindness and serves as a model. Availability of a similar screening method for DPN would enhance patient care and the ability to evaluate novel treatments.

This study is evaluating CCM as a diagnostic and screening tool and a surrogate progression measure. There are a number of critical issues that must be resolved before CCM can be routinely used as a diagnostic test or surrogate measure, including demonstration of its clinical meaning and responsiveness to change. Because DPN affects the longest nerves, the observation of abnormal corneal innervation is unexpected. Rigorous prospective evaluation is therefore necessary to establish utility. Preliminary data indicates CCM estimation of nerve fiber length (NFL) is highly reproducible, well tolerated and efficient, and that NFL and other measures are reduced in diabetic patients, more so in those with DPN. Specific aims of this study include development of normal data, determination of CCM’s diagnostic utility and its responsiveness to DPN progression.

The clinical meaning of CCM is being assessed by correlation with validated patient-reported outcomes and functional measures of mobility and balance. A major goal is to determine if CCM can be used as an effective screening strategy linked in time and location to yearly retinal screening. Participants are being recruited from those being seen for annual retinopathy screening. Early identification of patients with DPN will allow clinicians to begin treatment while DPN is potentially reversible. Development of simple predictive tools for DPN risk will facilitate practically achievable prevention studies, something impossible using current methodologies.

“Screening for diabetic retinopathy has dramatically reduced the prevalence of blindness. We hope to develop a similarly successful strategy for diabetic neuropathy.”

- A. Gordon Smith, MD
Myotonic dystrophy is caused by a CTG repeat at the end of the DMPK gene. In adults with the disease, it is known that this repeat sequesters importing splicing machinery and causes a global dysregulation of RNA splicing throughout the body. This knowledge has led to the development of a therapy for the disease, an antisense oligonucleotide that binds to the repeat and degrades it. The University of Utah is participating in a phase I study of this treatment, and in an effort to begin to prepare children with congenital myotonic dystrophy for therapeutic trials, we have developed a preliminary disease-specific outcome. A similar outcome had been developed in adults with myotonic dystrophy and is currently being used in therapeutic trials. This step is only the beginning in understanding the course of myotonic dystrophy throughout childhood.

Unfortunately, there is little information about how myotonic dystrophy progresses throughout childhood, which is important information for designing a treatment trial in children.

It is not known if the same splicing dysregulation occurs in childhood.

Currently, Nicholas Johnson, MD, assistant professor of neurology, is conducting a research study called Health Endpoints and Longitudinal Progression in Congenital Myotonic Dystrophy (HELP-CDM). This research program involves a natural history study to measure the change in disease progression in childhood myotonic dystrophy. In addition, the study validates a disease-specific patient-reported outcome in congenital myotonic dystrophy. Changes in RNA splicing are also investigated in the blood and muscle through this study. Already in its first year of the program, there is emerging evidence that splicing changes will be different in childhood and that clinical endpoints such as oral facial weakness represent potential outcomes in a clinical trial. Overall, these efforts represent the first and most complete effort to understand the course of congenital myotonic dystrophy throughout childhood and prepare this population for future therapeutic studies.

"Children with myotonic dystrophy lack the necessary research to allow them to participate in exciting clinical trials. This research should accomplish this."

- Nicholas Johnson, MD

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Chemotherapy induced peripheral neuropathy (CIPN) is the most common dose-limiting side effect of many commonly used chemotherapies, often requiring discontinuation of the most effective agent. CIPN is also a major contributor to decreased quality of life in cancer survivors due to numbness, pain, and difficulty walking. Unfortunately, there are no known preventative or treatment strategies.

The objectives of this project are to define metabolic and molecular risk factors for CIPN in order to design personalized therapy for cancer patients and to better understand CIPN outcomes in order to improve patient therapy. The Utah Cancer Registry and electronic data warehouse have been used to design a complex algorithm to identify CIPN patients in the medical record in order to explore potential metabolic risk factors including diabetes, obesity, dyslipidemia and alcohol use. Simultaneously, patients receiving potentially neurotoxic chemotherapy are being followed prospectively to better understand the clinical spectrum of CIPN and how to best assess disease progression. Ultimately, data from these sources will be used to explore genetic risk factors for CIPN.

**“CIPN is a major cause for disability in cancer survivors. Our aim is to develop the tools to predict who is at highest risk, so we can prevent this complication.”**

- Noah Kolb, MD

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**GRANTS:**

A Longitudinal Study of Disease Progression in Congenital Myotonic Dystrophy, Muscular Dystrophy Association, PI: Nick Johnson.

Development of a Personalized Medicine Approach to Chemotherapy Induced Peripheral Neuropathy, 1KL2TR001065, PI: Noah Kolb.

Health Endpoints and Longitudinal Progression in Congenital Myotonic Dystrophy (HELP-CDM), 1K23NS091511-01, PI: Nick Johnson.

Sudoscan as a Biomarker for Chemotherapy Induced Peripheral Neuropathy, Impeto SAS, PI: Gordon Smith.

The Activity for Diabetic Neuropathy – ADAPT, Study, R01DK064814, Co-PI: Rob Singleton, Gordon Smith.

The Clinical Relevance of Corneal Confocal Microscopy as a Biomarker of Diabetic Neuropathy and its Application in a Novel Screening Paradigm, DP3DK104394, Co-PI: Gordon Smith, Rob Singleton.

The effect of bariatric surgery on peripheral nerve and axonal regeneration, American Diabetes Association, PI: Gordon Smith.
Top (from left to right): Stefan M. Pulst, MD, Dr. med; Summer Gibson, MD; Mark B. Bromberg, MD
Bottom left: K. Patricia Figueroa, MS
Bottom right: Daniel R. Scoles, PhD
The impact on quality of life and health care costs of neurodegenerative diseases are rapidly surpassing the combined disease burden of vascular disease and cancer. As age is the major risk factor, this effect will be particularly strong.

In 2012, the Department of Neurology at the University of Utah established a process to bank biological samples from patients. Under direction of Pattie Figueroa, MS, the biobanking core consents patients, obtains blood samples, and isolates DNA and RNA. An early user of the biobanking core was the ALS center, co-directed by Mark Bromberg, MD, PhD, and Summer Gibson, MD, in the Department of Neurology. As part of a large international collaboration, Drs. Gibson and Stefan Pulst, MD, Dr med, have been hunting for new ALS genes using this core and the unique resources of the Utah Population Database (UPDB), and they have recently identified a new ALS gene.

Half a mile east of the ALS clinic in the new Neuroscience Building, Dan Scoles, PhD and Pulst lead a large team of neuroscientists and have built a translational preclinical laboratory that develops novel approaches to treating neurodegeneration. The stem cell group uses a novel, recently patented approach to make human nerve cells from the skin cells of patients working toward creating the “disease in a dish.”

Another group uses DNA molecules targeted to disease genes to treat neurodegenerative diseases. They study late-onset genetic cerebellar ataxias, diseases that cause progressive imbalance, slurred speech and inability to perform fine-motor tasks, and that are fatal in later adult life. They have focused on a particular type of ataxia, for which the Pult group identified the causative mutation in 1996 called spinocerebellar ataxia type 2 (SCA2). They then engineered mice to develop a human-like disease and use these mouse models to test novel treatments.

Coming full circle, the mutations in the SCA2 gene not only cause unsteadiness and loss of nerve cells in the cerebellum, but they can also present as ALS with loss of motor neurons in the spinal cord, or Parkinson’s disease with loss of nerve cells in the substantia nigra. Several neurologists in the department have teamed up with epidemiologist Lisa Cannon-Albright, PhD, to unravel the intricate connections between different neurodegenerative diseases as well as between these diseases and specific cancers. In these studies they make use of a unique resource, the UPDB. UPDB contains the medical records of millions of Utahns and links individuals by their genetic ancestry. One of the studies uncovered a link between Parkinson’s disease and specific cancers not only in the respective patient, but also in close and distant relatives without Parkinson’s disease that had an increased risk of melanoma and prostate cancer.

**KEY PUBLICATIONS AND PRESENTATIONS:**


**GRANTS:**

- Antisense oligonucleotides for the treatment of spinocerebellar ataxia type 2, R21NS081182, Co-PI: Dan Scoles, Stefan Pulst.
- ATXN2 and ALS, Target ALS, PI: Stefan Pulst.
someone in the United States develops Alzheimer’s disease every 67 seconds, with the prevalence likely to double by 2050. Without methods of delaying or preventing onset, the financial and societal tolls could be catastrophic. Faculty in the Center for Alzheimer’s Care, Imaging, & Research (CACIR) are working to make these advances. In 1965, no treatments for Alzheimer’s disease and related dementing illnesses existed. It would be nearly 30 years before the FDA approved the first medication to treat Alzheimer’s disease (tacrine). Despite its lackluster beginning, we have come a very long way since that time, with multiple FDA-approved medications that work on different mechanisms of action.

In 2006, CACIR was founded with a mission to conduct translational, patient-oriented, multidisciplinary clinical research that brings advances in fundamental and social sciences to the routine practice of dementia care. An extension of this mission has been the development and investigation of a variety of interventions for Alzheimer’s disease and similar neurodegenerative conditions in later life.

In a CACIR office in Research Park, Kevin Duff, PhD, associate professor of neurology, received funding from NIH in 2014 to examine the short- and long-term benefits of a computerized cognitive training program in patients with mild cognitive impairment, a group at higher risk of developing Alzheimer’s disease. If this noninvasive intervention can delay the onset of Alzheimer’s disease, intervention could have dramatic effects on the $226 billion spent on healthcare expenditures in 2015. This project will also determine if short-term practice effects on cognitive testing can predict responsiveness to the intervention. It is hypothesized that individuals with lower-than-expected practice effects will show less benefit of the intervention, which could lead to more personalized medicine. Dr. Duff has already shown that practice effects provide valuable information about diagnosis, prognosis,
and likelihood of Alzheimer’s disease-related biomarkers in these older patients.

In the next office, Gordon Chelune, PhD, professor of neurology, reviews patient files from the SPRINT-MIND trial, on which he is an investigator. The parent study, Systolic Blood Pressure Intervention Trial, collected data on over 9,000 individuals over the age of 50 with at least one cardiovascular risk factor and attempted to carefully adjust their blood pressure medication to achieve a target systolic pressure of 120 millimeters of mercury. Doing so reduced rates of heart attacks and strokes by almost 33% and reduced risk of death by almost 25%. In the SPRINT-MIND extension, the effect of this target blood pressure is being examined for all-cause dementia and cognitive decline.

Down the hall, Norman Foster, MD, professor of neurology, improves practice models that empower dementia patients and their families with a unified plan tailored to the specific needs of the patient to maximize quality of life. His Proactive Dementia Care (PDC) model is multidisciplinary and seeks to identify and intervene with cognitive disorders as early as possible. Dr. Foster is incorporating the tenets of PDC into a group of mobile software applications called Memory Care Partner, which will allow patients, families, and providers to employ these evidence-based practices anywhere. As a joint venture with the University of Utah Research Foundation and funding from NIH and a private foundation, Memory Care Partner is poised to fill a unique niche in this growing market.

A 10-minute walk from these offices is CACIR’s clinical trials team, which has partnered with multiple pharmaceutical companies (e.g., AstraZeneca, Eli Lilly, Roche, and Merck) to offer its patients cutting-edge intervention options involving multiple mechanisms of action (e.g., acetylcholinesterase inhibitors, monoclonal antibodies, nicotinic acetylcholine agonists, amyloid precursor protein cleaving enzyme inhibitors) and multiple modes of administration (e.g., oral medication, subcutaneous injection, infusion, surgery). Clinical trials are currently available for patients across the disease severity spectrum (e.g., cognitively intact, mild cognitive Impairment, mild to moderate Alzheimer’s disease).

KEY PUBLICATIONS AND PRESENTATIONS:


GRANTS:

Cognitive training and practice effects in MCI, 5R01AG045163, PI: Kevin Duff.

Systolic Blood Pressure Intervention Trial - Memory and Cognition IN Decreased Hypertension (SPRINT-MIND), HHSN268200900046C, PI UofU CCN MIND substudy: Gordon Chelune.

The Memory Care Navigator: A Proactive Guide, 1R41AG044147, PI: Norman Foster.
A “quad” of young physician-scientists is bringing new hope to children afflicted by neurological disorders. Josh Bonkowsky, MD, PhD, Russell Butterfield, MD, PhD, Jeffrey Ekstrand, MD, PhD, and Brandon Zielinski, MD, PhD, (Departments of Neurology and Pediatrics) are making discoveries in the lab and testing new treatments for children. Their work is supported by local donors and by national organizations including the National Institutes of Health, the March of Dimes, and Adrenoleukodystrophy Connect.

Dr. Bonkowsky’s group is finding new cures for adrenoleukodystrophy, a devastating disease that afflicts school-aged children. To identify new drugs to stop the disease, his lab team is screening thousands of compounds using the small animal model called zebrafish. Zebrafish are small and inexpensive, and they develop quickly, making them ideal for this work. New drugs discovered by Dr. Bonkowsky’s group are then integrated into a pipeline made up of a national clinical organization with other adrenoleukodystrophy researchers and patients.

Once a promising treatment reaches an investigational stage, a tremendous amount of work is needed to test if it is effective. Dr. Butterfield and his team, supported by the Muscular Dystrophy Association, are helping patients at the University of Utah by testing these newest options for children affected by muscular dystrophies. Muscular dystrophies can affect children from birth, making even the simplest tasks such as walking or sitting difficult.

Before treatments can be identified, it is critical to understand how a disease affects the brain. Dr. Ekstrand’s lab is searching for the molecular changes caused by a severe form of seizures called status epilepticus.

Status epilepticus is a kind of seizure that does not stop, and like a runaway freight train, the key is to find a brake. Dr. Ekstrand’s group has identified a new molecular target called NS-398, which could be a key brake for status epilepticus.

To start treatment it is important to identify affected children as early as possible. Dr. Zielinski is a pioneer in developing an advanced form of brain imaging that can identify children with autism in the first year of their life.

This advanced imaging, called brain MRI functional connectivity, can recognize the very earliest changes in autism. This early identification brings new hope to families of starting treatment immediately.

This quad of researchers and their teams are nationally sought out and have published in internationally respected journals over the past several years, including Neurology, Brain, the Journal of Neurophysiology, and the Journal of Child Neurology.

Left: Confocal microscopy of the zebrafish telencephalon showing projections of the serotonin neurons (in blue) onto foxP2 axons (red).

Bottom right: MRI map of structural differences in autism (yellow) compared to typically developing controls (blue).

Top (from left to right): Brandon A. Zielinski, MD, PhD; Francis M. Filloux, MD; Joshua L. Bonkowsky, MD, PhD
KEY PUBLICATIONS AND PRESENTATIONS:


GRANTS:

Brain Network Development in Normal and Autistic Children, K08MH100609, PI: Brandon Zielinski.

Characterization of Genetic Pathways Regulating Connectivity Disruption in Hypoxic Injury, March of Dimes Foundation, PI: Josh Bonkowsky.


Seizure-induced Neuronal Loss and Epileptogenesis in the Immature Brain, K08NS070957, PI: Jeffrey Ekstrand.

Trans-cellular Activation of Transcription to Analyze Dopaminergic Axon Reorganization, 1DP2MH100008, PI: Josh Bonkowsky.
"We are applying the most advanced imaging techniques to enable fundamental changes in our understanding of how the human brain is wired in health and disease."

- Julie Korenberg, PhD, MD

Below: Diffusion tensor imaging shows how three parts of the brain work together to regulate emotion, reason and behavior forming part of the limbic lobe. The cingulum bundle (black) communicates with the corpus callosum (fuchsia) and a related tract (lilac). The images are from a normal young woman. This new technology provides unprecedented details of brain circuitry related to neurologic and psychiatric diseases, an exciting step to accelerating new treatments.
by Julie R. Korenberg, PhD, MD

Intellectual disabilities and mental illnesses throughout life, from autism and anxiety to Alzheimer’s disease, affect more than 60 million individuals in the U.S. These brain diseases are at the crossroad with genes. The solutions for new therapeutics lie at the center of multiple experts and creative teams who can drill down from the patient and up to the brain wiring and genes that cause disease. A significant number of these patients carry large-scale changes in their genomes, ranging from extra copies of an entire chromosome in the case of Down syndrome or absence of several hundred thousand base pairs in William syndrome. Few know that Utah has the highest prevalence of Down syndrome in the U.S. and that almost 60% of people with DS get Alzheimer’s disease. From the DNA sequencing combined with brain circuitry gone awry, the genes are now being linked to brain function and its cellular origins, to show the fundamental neuroscience systems that hold the keys to providing today, what is needed to treat or prevent our mental illnesses.

Julie Korenberg, PhD, MD, has devoted her life to understanding and forging new therapeutics for mental illnesses, Down and Williams syndrome at the level of genes and their effect on brain structure and function. She moved to Utah as part of the USTAR initiative in 2008 and immediately began to reach out to engineers, computer scientists and neural imagers to develop novel approaches to these common disorders. Now this USTAR cluster is supported by three large NIH grants that bring together investigators from seven departments across the medical and main campus. Working with Sarang Joshi, PhD, Jeff Anderson, MD, PhD, and many others, she has generated a connection and wiring map of the brain at unprecedented resolution. Funded by President Obama’s BRAINOME Initiative, this map is emerging as a Genetic Connectome from Down syndrome to William syndrome and is pointing to entirely new therapeutics for the emerging abnormal nerve networks in patients with intellectual disabilities and autism or anxiety, and others with Alzheimer’s disease.

KEY PUBLICATIONS AND PRESENTATIONS:


GRANTS:

Down syndrome: Bridging Genes, Brain and Cognition, R01HD067731, PI: Julie Korenberg.

Multiscale Genetic Connectivity of Primate Social Circuits, R01MH100635, PI: Julie Korenberg.

**LEVERAGING TECHNOLOGY TO MEET THE CHANGING HEALTHCARE LANDSCAPE**

Two Federal Grants Support Innovation to Expand Access and Codify DBS Programming Expertise at the Busiest DBS Center in the Intermountain West

by Lauren Schrock, MD

Deep Brain Stimulation (DBS) is now a well-established therapy for several movement disorders, with FDA approval for treatment of tremor (1997), Parkinson’s disease (2001) and dystonia (2003). However, high quality and cost effective outcomes require the expertise of interdisciplinary DBS teams that include functional and stereotactic neurosurgery, movement disorders neurology, neuropsychology, physical therapy, and psychiatry. One limitation to this therapy is the fact that in most cases these specialized DBS teams are only found at high volume academic medical centers such as University of Utah Health Care (UUHC).

Paul House, MD, the surgical director of UUHC Movement Disorders Surgery Program, says that DBS does not cure these conditions, but gives patients more hours, days and years of functionality. With an integrated multidisciplinary team of specialists, the UUHC DBS team screens for patients who will benefit from the therapy using evidence-based criteria that predict a good response to DBS without undue surgical risk. Those with significant cognitive decline, for example, generally do not do well with surgery. “We have good outcomes because of how we go about pre-operative evaluation, perform the surgery, and how we do the follow-up,” House explains.

DBS surgeries have been performed at UUHC since initial FDA approval in 1997, and since that time the program has grown into the predominant DBS Center in the Intermountain West—in fact, UUHC is the only center performing DBS in the Intermountain West with a dedicated interdisciplinary DBS team that includes a fellowship trained stereotactic and functional neurosurgeon and movement disorders neurologists.

This highlights an unfortunate but important reality for complex neuromodulation therapies such as DBS: many patients in rural areas who may be candidates for this therapy do not have access to it, and others may have access, but only at low-volume surgical centers that do not have significant experience or expertise in managing DBS patients. With an over 400 mile radius catchment area, “We witness the burden placed on patients and their families by long distance travel required for standard post-operative follow-up for optimization of DBS settings and medications,” which may require multiple visits over the first six months and one-to-four visits annually thereafter depending on the underlying disorder, explains Lauren.
E. Schrock, MD, a Movement Disorders Neurologist and the Medical Director of the Movement Disorders Surgery Program. “I am constantly amazed by the commitment our patients have, not only to their own care, but to participation in research. We try to offer all of our patients the opportunity to get involved in research, whether it be through a simple blood draw as part of our biorepository study, or a clinical trial of a novel neuromodulation device.” Schrock is a critical part of the interdisciplinary team that has put UUHC’s Movement Disorders Surgery Program on the national map. She is the site Primary Investigator for the INTREPID multi-center clinical trial of a new Boston Scientific rechargeable DBS device for treatment of Parkinson’s disease, and UUHC has been the top enrolling site since the study opened.

With the recruitment of bioengineer Chris Butson, PhD, an internationally renowned investigator in the field, as Director of Neuromodulation Research, attention has now turned to development of technological solutions to address the issue of patient access to DBS. He has initiated two clinical studies with the UUHC DBS Program, funded by the National Institutes of Health (NIH) and the National Science Foundation (NSF), that leverage technology to improve access to DBS expertise and reduce patient burden.

The NIH grant supports a clinical study testing a Mobile Decision Support Tool developed by Butson that utilizes patient-specific computational modeling of brain tissue activated by DBS to guide post-operative programming of patients with Parkinson’s disease. For this study DBS nurses at the University of Utah and the University of Florida use an iPad-based tool, which was developed with the goal to make non-expert DBS programmers behave like experts, to guide programming.

The second project, Remote Management of DBS Patients Using the Utah Telehealth Network (UTN), funded by the NSF US Ignite initiative, takes things one step further by harnessing the power of the high bandwidth UTN to make expert DBS care more accessible to patients who don’t live near an academic medical center. By connecting the computational modeling-guided DBS programming tool “to the high bandwidth of the UTN, we can generate on-demand calculations in near real time, hopefully within a couple of seconds,” Butson explains. “This will make the system far more flexible and powerful.”

By reducing the amount of trial and error involved in standard DBS programming, using patient-specific computationally powered neuroanatomical models, these tools are likely to dramatically reduce the time required to optimize programming, and therefore the burden to patients and providers. Schrock emphasizes that “given the trend toward more intricate DBS lead designs, including directional current capabilities and the number of electrode options increasing by a magnitude of 2-10, these tools will be particularly important for us to take advantage of this next generation technology and handle the increasing complexity of post-DBS implantation programming.”
LEARNING TO ADAPT
Using the Past to Help Shape the Future of Partial Tibialis Nerve Transfer

by Lisa Browdy

The bridegroom-to-be had a problem: a softball injury that left him with a "foot drop." Simply trying to throw a runner out at first base in a recreational game led to a tear of his knee ligaments and the crucial nerve that lifts the foot up. The young man's stretched peroneal nerve made it impossible for him to lift his ankle, extend his toes, or turn his foot outward. As a result, he walked with a noticeable limp and hated the idea of limping during the recessional up the aisle with his bride.

If he hadn't consulted with Mark Mahan, MD, he would have had few options, all coming with a steep price. Re-routing the posterior tibialis muscle to the front of the foot, as was done for victims of polio decades ago, would likely leave him with an unstable ankle. A nerve graft from another part of his body would likely leave him with muscle weakness and/or numbness.

Brave enough to try a new procedure, and with approximately nine months before the wedding, Dr. Mahan's patient agreed to be the first to receive a partial tibialis nerve transfer. "I told him, that no one has done this, but I think this procedure will give you the best results," Mahan recalls. There would be long scars – up to 12 cm in the back of the knee and 3 cm in the front – but if all went well, the patient would walk normally again.

A leader in the field of surgical neuro-rehabilitation, Mahan came to University of Utah Health Care (UUHC) in 2014. He says he got the idea for the procedure from some of the newer science that shows nerves helping to regenerate other nerves.

"(Nerve repair) used to be thought of like putting in new plumbing," he explains. "We cut out the old segment and then put in a nerve from somewhere else – like fresh, unscarred piping. The problem with that is that nerves live in a biological world: nerves like to grow alongside other nerves."

Newer techniques resemble grafting plants rather than re-routing pipes, with a new nerve "plugged in" to the side of an injured one, rejuvenating it with new life. The original concept came out of wartime experiences about 100 years ago and was later abandoned without bayonets and hand-to-hand combat to produce similar injuries. A plastic surgeon named Julia Terzis, MD, recently introduced a new strategy of nerve repair, which she called a "babysitter technique" to help patients with facial paralysis.

Mahan's adaptation for peroneal neuropathy borrows a redundant nerve from the double-branched gastrocnemius and moves it alongside the damaged peroneal nerve. The remaining lateral gastroc nerve grows to take its partner's place, keeping full functionality in that part of the leg.

Because nerves grow so slowly, it can be an agonizing six-month wait for doctor and patient to see if the operation "takes." In the meantime, the patient must wear a brace on the leg for many hours of the day so that the Achilles' tendon doesn't shorten.

As of late 2015, Dr. Mahan has performed the operation twice. The second patient is still in the phase of nerve regeneration. But our bridegroom, motivated by all the eyes on him as he walked his bride up the aisle, had a successful procedure. His operation was in December of 2014, he was out of his brace in late May of 2015, and his wedding was the following August.
“I told him that no one has done this, but I think this procedure will give you the best results.”

- Mark Mahan, MD
Due to the high incidence of melanoma in the Intermountain West, metastatic melanoma accounts for the majority of patients treated with stereotactic radiosurgery at Huntsman Cancer Institute and the Clinical Neurosciences Center at University of Utah Health Care (UUHC).

Melanoma has a high rate of brain metastases and mutations in BRAF, a gene involved in cell proliferation and survival, and can be found in 48% of metastatic biopsy specimens. With the use of BRAF inhibitors becoming more common in melanoma treatment, researchers at UUHC needed to know if the BRAF mutation and treatment with BRAF inhibitors had any effect on the outcomes of patients that had been treated with radiosurgery.

“As BRAF mutations become a bigger part of melanoma care, we need to think about, when they [patients] develop brain metastasis, how we’re going to integrate that BRAF treatment into their treatment plan where in the past we haven’t thought about that and just treated it,” states Randy L. Jensen, MD, PhD, professor of neurosurgery. “Now we have to work around that.”

Jensen, in collaboration with Dennis Shrieve, MD, PhD, and David Ly, MD, from the Department of Radiation Oncology, reviewed the cases of patients that had received BRAF mutation testing and were treated with radiosurgery from 2009-2012. They found that patients with metastatic melanoma who had radiosurgery and BRAF inhibitor therapy had improved 1-year local control with no growth at the primary tumor site.
Interestingly, they also found that the 1-year local control rate for all the brain lesions was 69.2% and the overall survival rate was 48.0%.

“One of the exciting things about this project is that patients with melanoma traditionally have been thought of as not doing that well if they had metastasis to the brain,” Jensen states. “We actually show pretty reasonable control of tumors in the brain and we’re finding out some specific markers that tell us why some patients do better than other patients.”

The physicians also uncovered information related to the risk of brain hemorrhage that had an immediate impact on patient care at UUHC. “One of the complicating factors for metastatic melanoma to the brain is that it has a high chance of spontaneously hemorrhaging,” explains Jensen. “It turns out that if you are treated with a BRAF inhibitor you have more hemorrhages, so now we stop the BRAF inhibitor during our radiosurgery treatment.”

This project is ongoing as physicians continue to add patients to a prospective database and enroll patients in a clinical trial on increasing the radiosurgery dose for metastasis to achieve better local control. As Jensen says, “Radiosurgery has become a big part of neurosurgery...so anything that we can do to make that treatment better is an improvement. We need to be constantly looking at what we’re doing and looking at those outcomes and measuring and making sure that we’re refining our technique.”

“Radiosurgery has become a big part of neurosurgery...so anything that we can do to make that treatment better is an improvement.”

- Randy L. Jensen, MD, PhD

Photo: Randy L. Jensen, MD, PhD


Glioblastoma (GBM) is the most common malignant tumor and accounts for 15.4% of all primary brain tumors. With only a 5% 5-year survival rate, there is a clinical need for better ways to characterize tumor aggressiveness in order to personalize patient treatment and increase the survival rate.

While little is known about how this tumor type becomes so aggressive, GBM exhibits certain characteristics, such as intratumoral necrosis and vascular endothelial proliferation, which could potentially be used to characterize a patient’s tumor. Randy L. Jensen, MD, PhD, a neurosurgeon in the Department of Neurosurgery, studies how tumor cells respond to hypoxia, a lack of oxygen in the necrotic areas of the tumor. His laboratory has identified several genes produced in response to hypoxia in GBM, including hypoxia-inducible transcription factor (HIF-1) and vascular endothelial growth factor (VEGF), which can be used as tumor biomarkers.

“We predicted that there would be different areas within the tumor that would have different levels of hypoxia and the molecules that are triggered by hypoxia,” Jensen explains. “Testing our hypothesis and sampling the areas in question led us to a completely new thought. What if you could somehow image that beforehand so you wouldn’t have to do biopsies?”

In a collaboration with the Division of Neuroradiology, Jensen and Karen L. Salzman, MD conducted a pilot study to determine if these hypoxia-induced biomarkers were expressed in specific areas of the tumor and if expression of these biomarkers was associated with patient outcome. They also looked to see if there was an association between the biomarkers, patient outcome, and pre-operative imaging of the tumor using dynamic contrast enhanced MRI (DCE-MRI), also known as perfusion MRI. Perfusion MRI is a non-invasive imaging technique that tracks and quantifies tumor blood flow and, at the time of the study, was considered an experimental technique.

Results from this study showed that certain areas of the tumor could provide more predictive information than others in terms of patient outcome. When researchers looked at the levels of the tumor biomarkers, expression of VEGF and HIF-1 in the active...
tumor area was predictive of overall survival. Progression-free survival was predicted by VEGF expression in areas of peritumoral edema and HIF-1 expression in the active tumor.

Perfusion MRI imaging showed that there was a correlation between interstitial volume in areas of peritumoral edema and capillary heterogeneity in the active tumor with overall patient survival. In addition, capillary transit time, blood volume and capillary heterogeneity were correlated with increased progression-free survival. Several of these imaging parameters also correlated with HIF-1 and VEGF tumor expression.

“This study demonstrates that as we improve our pre-operative imaging, we’ll be able to gather more information about a patient before we have actual tissue sampling. When we couple that with the biomarkers in the tissue itself, we can learn a lot more about a patient’s tumor and that particular patient’s expected outcome,” Jensen says.

Jensen concludes, “I was surprised that the imaging could be done without a lot of effort on the patient or on the clinician’s part but yet gain some very useful information and, hopefully, some day lead to a situation where a biopsy isn’t necessary in some situations.”

Until the day comes when biopsies are no longer essential, the additional information provided by biomarker expression and pre-operative imaging can help guide surgeons in gathering the most informative section of the tumor, leading to the most effective treatment for each patient.
Front or back? That’s the big question being asked by University of Utah Health care neurosurgeon Erica Bisson, MD, MPH, and her fellow spine experts leading a Patient-Centered Outcomes Research Institute (PCORI) study about cervical spondylotic myelopathy (CSM).

CSM can be devastating. Neck arthritis — and the accompanying disc bulges and bone spurs — lead to a narrowing of the spinal canal, which pushes against the spinal cord itself and can cause trouble with walking and motor control, numbness in the upper extremities, and bladder and bowel dysfunction.

“Most people tell me they notice that they’re dropping things — that their hands feel weak or aren’t doing what their brain is telling them to do,” Bisson says. “They start to have balance difficulties so when they walk they feel like they’re wobbly or off-balance.”

Degenerative spine diseases like CSM are one of the most common reasons for spinal surgery in the U.S., with about 112,400 operations annually. The problem is, there’s no consensus among experts like Bisson about the best way to perform the surgery. Simplified, will patients fare better if the surgeon goes in ventrally or dorsally — through the front of the neck or through the back?

Bisson is eager to see the results of the 3-year study, which seeks to track 159 randomized patients’ overall health-related quality of life, complication rates, re-operation rates and out-of-pocket expenses for at least two years following surgery.

“There are regional and national variations in how we approach the same disease process, so we as both orthopedic and neurosurgery spine surgeons are working toward figuring out how best to treat our patients,” says Bisson, one of 15 spine experts at 10 sites engaged in the research.

After poring over each patient’s medical history, examination findings and radiographic imaging, the surgeons first vote on whether a patient is a good fit for randomization. In other words, do the surgeons believe that the patient would receive the best care possible with either technique? If the answer is yes, the physicians then vote on how they would perform the surgery if the individual were in their clinic. If no consensus is reached (less than 80% agreement), the patient is enrolled in the randomized arm of the study. Enrollment began in April 2014, and University of Utah Health Care is among the most productive sites in the nation — tied for most enrollments.

So far, Bisson has yet to see a vote in which every doctor agreed on the approach.

“I absolutely think the results will change my practice,” Bisson says. “We’re engaging in this type of research truly to hone our surgical armamentarium. If we find that one approach is much more dominant, then I would move toward that approach. The findings will also enable us to educate our patients more about why to do which surgery, so the whole goal is really to be able to improve patients’ outcomes and limit the personal cost to them.”

Bisson expects to see preliminary findings by fall 2016.

“I absolutely think the results will change my practice.”

- Erica Bisson, MD, MPH
Like many teens who have yet to earn a driver’s license, 15-year-old Jakob Buhler didn’t have any ID on him as he rode his longboard home from school and suffered a life-threatening traumatic brain injury (TBI) after colliding with a car at a busy intersection.

Because he was such a tall kid for his age, the EMTs who came to his rescue in the Sugarhouse neighborhood of Salt Lake City estimated his age at 30 years old and raced him to University of Utah Hospital rather than a specialized children’s hospital. While some might consider this an error, it ended up being a life-saving decision because it brought him in contact with Gregory Hawryluk, MD, PhD, in the Neurosurgery Critical Care Unit that April afternoon.

Perhaps surprisingly, not many neurosurgeons choose a specialty in treating traumatic brain injuries, but Hawryluk is one of the handful who specialize in cases like Jake’s. According to Jake’s mom, Emily, when the doctor met the family, he told them, “I’m glad your boy and I found each other.” A native of Canada, Hawryluk had completed his neurotrauma subspecialty training in San Francisco before arriving in Utah only a year earlier.

Jake’s prognosis was grim when he was admitted on April 14, 2015. Blood clots on both sides of his brain caused shifting, swelling and pressure, so in separate surgeries Hawryluk removed first the right, then the left sides of Jake’s skull, saving them in a freezer for re-attaching later. Jake remained in a coma for two weeks.

“I made a judgment to leave both of the skull flaps off,” Hawryluk recalls. “It’s very rare to do that procedure on both sides; I’ve only seen that once before.”

Jake’s Glasgow Coma Scale scores showed encouraging signs, so Hawryluk was hopeful when he spoke with Jake’s mother, Emily, and the rest of the family before proceeding with...
treatment. There was concern that Jake might be left without the ability to walk or talk due to severe bruising in his language center and a stroke in the region of his brain that controls his left leg. One factor in Jake's favor was that younger people have a greater ability to heal, so his doctors decided to take the most aggressive approach.

Another factor helping Jake was the Ceretom portable CT scanner that had been serving as "a million-dollar paperweight," under-utilized in the ICU. Though its images aren't quite as clear as the stand-alone model, Hawryluk brought it to the operating room for the first time to use for Jake's case.

"The portable CT saved hours," he explains. "If we had to take him out of the OR for a CT scan, the second surgery would have been delayed and those one or two hours of pressure on the opposite side of his brain would have made his recovery harder."

Another piece of technology that helped was the pupillometer — a handheld device that can measure pupil reactivity to 1/100 mm, decidedly more precisely than the human eye. "This is new technology which can give early warning of increased pressure on the brain," Hawryluk says. In Jake's case, it was able to catch a problem with Jake's cerebrospinal fluid flow (a common complication when a skull flap is removed) and get him into the OR to drain a dangerous build-up of fluid. The NCCU has eight pupillometers, which Hawryluk says gives them a head start on fixing problems before they get serious.

Jake's recovery progressed gradually and after several weeks in the hospital, he had both his skull flaps replaced. He was then ready to focus on physical therapy and was transferred to Primary Children's Hospital, located immediately next to University of Utah Hospital. A few months after the accident, Jake was walking (with a walker), talking, and getting ready to enter 10th grade on a modified schedule.

Jake's mom, Emily, reports that he is the same positive, happy and upbeat kid he was before the accident, not to mention the fact that he's even more polite than he was before. "A loving, supportive family is key to recovery," Hawryluk says. "In Jake's case I think everything came together perfectly to get him the best possible outcome."
Reflecting back on a case where he performed a revolutionary brain aneurysm procedure called Pipeline, Phil Taussky, MD, enthusiastically sits at his desk reviewing a patient’s images and results. “It’s absolutely incredible and always amazes me,” he says. “There is no sign of an aneurysm whatsoever. It has completely disappeared.”

In general, to have a brain aneurysm completely disappear is new and, in many physicians’ eyes, still unheard of. However, with the introduction of Pipeline at University of Utah Health Care (UUHC), it is now a common occurrence.

Since Taussky’s arrival three years ago, he has focused his energy on establishing and expanding the endovascular program at UUHC. With Pipeline serving as the program’s flagship procedure, accounting for approximately 70–80% of UUHC’s brain aneurysm practice, it is now just one of several endovascular techniques being used and has helped UUHC emerge as one of the nation’s premier centers in the country for endovascular research, trials and treatment.

“The introduction of Pipeline significantly changed the way UUHC, and we as surgeons, look at and treat complex vascular diseases and conditions like brain aneurysms,” says Taussky. “We’re the only facility in the region certified to perform Pipeline and we’ve had a great deal of success with it over the past three years.” This “headstart” has changed the lives of dozens of patients and has allowed us to focus on expanding our capabilities – exploring new ways to utilize endovascular technology as a solution for other patient needs.
A significant component of that expansion came in 2014, with the arrival of a second endovascular neurosurgeon, Min Park, MD. Together, Park and Taussky not only represent the only neurosurgeons in the Intermountain West certified to perform the Pipeline procedure, but also signify UUHC’s commitment to researching, testing and implementing new endovascular techniques for improved patient care in the future.

Combine that commitment with the fact that UUHC has its own Clinical Trials Office and the Department of Neurosurgery has its own research coordinator, Salman Yakub, and Taussky and Park feel they have all the right pieces in place to continue as one of the nation’s leaders in complete endovascular care.

“We are working on educating the providers within the region about these minimally-invasive, endovascular techniques for treating neurosurgical diseases,” says Park. “Take a giant aneurysm, for example. These can now be treated with a catheter placed through a small incision in the leg, which was not possible before. The patients oftentimes are able to go home the following day. This also makes it a very exciting time at UUHC because we are on the leading edge of endovascular care – exploring and implementing tools and techniques that are really changing the lives of patients. Conveying these results and showcasing the potential of these procedures to other physicians is a major priority.”

For Taussky and Park, a major portion of their careers is dedicated to completely immersing themselves in what’s new in endovascular neurosurgery. This approach is common in several industries, but, according to Taussky, unless you fully commit yourself to practicing endovascular neurosurgery, you can easily be left behind.

“Endovascular neurosurgery is evolving so rapidly that unless you completely commit yourself and your practice to be in the trenches, understanding what’s possible, then it’s difficult to stay on top of,” says Taussky. “We’ve really stepped up our game and commitment over the last three years and have been fortunate to experience early involvement with new endovascular techniques. This has led to additional expansion, trials and studies, which will be crucial as more and more endovascular possibilities emerge.”

Looking back, Taussky and Park are amazed at the progress UUHC has made from an endovascular standpoint. Looking ahead at the possibilities over the next several years, their excitement is unmistakable. While it may sound cliché, Taussky and Park believe what the medical community is seeing with endovascular care is only the tip of the iceberg.

“We’re already proving there’s an easier and safer way for patients to receive treatment for complex brain conditions like an aneurysm, and the outcomes show that we’re successful,” says Park. “The progress in endovascular neurosurgery has been incredible. We’re thrilled to be part of it and are looking forward to see how patient care will improve in the next five, 10, or 20 years because of it.”
“Our first goal is to be able to define these biomarkers… It’s fine for one institution to do it, but what really will make a more global impact is if you can reproduce the result consistently across different institutions.”

- Lubdha Shah, MD
A spine expert, Lubdha Shah, MD, knows that all those hours staring at your computer screen and cell phone greatly contribute to the pain in your neck. But that standard MRI doesn’t tell your doctor much. And by the time an abnormality shows up on a scan, it may be too late to have a meaningful impact on the outcome.

Shah, the director of spine imaging at University of Utah Health Care (UUHC), wants that to change. “This is such a prevalent disease and can result in profound functional disability if it’s not detected early enough,” she says.

Degenerative cervical spine disease can impact up to 2/3 of the population, but standard imaging techniques often only show doctors the big picture. UUHC researchers have begun using advanced MRI techniques to try and look at the anatomy on the microscopic level using advanced imaging biomarkers.

“We’re trying to see the tissue and its microscopic components rather than the whole cord itself,” Shah says.

Degenerative cervical spine disease can impact up to 2/3 of the population, but standard imaging techniques often only show doctors the big picture. UUHC researchers have begun using advanced MRI techniques to try and look at the anatomy on the microscopic level using advanced imaging biomarkers.

“We’re trying to see the tissue and its microscopic components rather than the whole cord itself,” Shah says.

Now UUHC plans to collaborate with Washington University in St. Louis and the Medical College of Wisconsin in Milwaukee in order to study a larger pool of patients and to show that the MRI sequences are feasible across different MRI platforms.

“Our first goal is to be able to define these biomarkers,” Shah says. “It’s fine for one institution to do it, but what really will make a more global impact is if you can reproduce the result consistently across different institutions.”

By creating repeatable and consistent imaging biomarkers, doctors will be able to generalize the results to a broader population.

Doctors hope the collaboration will ultimately benefit patients with cervical spinal cord myelopathy as well as other pathologies affecting the spinal cord, such as multiple sclerosis. Cervical spondylotic myelopathy can result in substantial physical disability with psychosocial and financial burdens. Some individuals may be in so much pain they are unable to work and may need to pay for assistance if they are significantly incapacitated.

The disease significantly impacts the aging population, so doctors say there is an urgent need to improve the diagnostic and treatment paradigms.

“If we can better understand the underlying processes that create the disability in these patients and identify these processes earlier, we have an opportunity to intervene to improve their neurological recovery,” says Erica Bisson, MD, MPH, associate professor of neurosurgery. “We want to return them to a better functional status, engaging in their life and activities as productive members of their family and society.”

A clinical trial is expected to begin in the next few years. The group is in the first phase of determining which biomarkers correlate with which symptoms, Shah says. Eventually, doctors hope to be better able to determine whether surgery is the best choice for the individual.

Another benefit of the collaboration will be building on other institutions’ strengths. Washington University has experience with a large volume of patients and has done research on animals and humans using similar imaging techniques. UUHC has developed advanced software and hardware imaging tools. The Medical College of Wisconsin has both neurosurgeons and scientists who have studied DTI imaging in acute and chronic spinal cord injury.

“You always achieve more when you can get everybody’s talents together,” Shah says.

E.K. Jeong, PhD, professor of radiology at UUHC, explained that novel imaging techniques to measure diffusion of tissue water have been developed for the research. Monte Carlo simulation software has been created to learn about the change in pathology of spinal cord white matter.

Researchers have also crafted three dedicated radio frequency coils with different sizes to increase accuracy by improving the signal-to-noise ratio.

All of this should one day give doctors new tools to heal.

“Conventional imaging does not provide information fast enough for patients with very subtle symptoms,” Shah says. “So it’s very hard to know when to treat these patients surgically or by other means.”
A loved one can’t remember where she left the car keys and can’t recall the name of her neighbor. Are these simply signs of forgetfulness or something worse?

Even though most people aren’t diagnosed with Alzheimer’s disease until they are over age 65, the condition starts years, and perhaps decades, earlier. Catching the disease at its earliest stages could open doors for new treatments that, one day, might slow or even stop mental decline before it has the chance to begin.

The trouble is, the most accurate way to diagnose Alzheimer’s today is to physically examine the brain after death. “The only way we’ll ever be able to improve Alzheimer’s treatment is if we can keep a watchful eye on it as it develops in patients,” says Satoshi Minoshima, MD, PhD, who joined University of Utah Health Care (UUHC) last year as professor and chair of the Department of Radiology. He is an expert in noninvasive neuroimaging, a virtual window into the living brain that is showing great promise as a means for detecting and improving our understanding of Alzheimer’s and other forms of dementia.

Minoshima was drawn to UUHC for its storied success in devising imaging solutions to medical problems. Here, he has found a comrade-in-arms in John M. Hoffman, MD, director of nuclear medicine, professor in the Department of Radiology, and professor in the Department of Neurology, who shares Minoshima’s passion for neuroimaging and Alzheimer’s research. Yet the two approach the work from different angles.

Minoshima is a clinician and researcher who uncovered one of the earliest signs of Alzheimer’s, abnormalities in a region of the brain called the posterior cingulate cortex. The discovery was made with a technology that he developed, 3D-SSP/NEUROSTAT, now used in 40 countries across the world to interpret positron emission tomography (PET) scans that measure brain metabolism. Hoffman provides scientists like Minoshima with radiopharmaceuticals that can be used to detect sites of dysfunction, making
“The only way we’ll ever be able to improve Alzheimer’s treatment is if we can keep a watchful eye on it as it develops in patients.”

- Satoshi Minoshima, MD, PhD

such research possible. As director of the largest cyclotron facility in the region, Hoffman has become a sought-after national expert on imaging in medicine.

“We’re lucky enough to be able to work closely with the Center for Alzheimer’s Care, Imaging, and Research (CACIR), which brings the latest technologies and therapeutic approaches directly to doctors and patients,” says Hoffman. “There aren’t many places that have the combined Alzheimer’s expertise that we now have here in Utah.”

Complementary strengths in research and clinical care are positioning UUHC to uniquely confront an emerging trend that is highlighting the need for new approaches to Alzheimer’s care. As lifetime expectancy continues to lengthen, the number of dementia sufferers worldwide is predicted to increase from 47.5 to 75.6 million by 2030. Most of these people are expected to have Alzheimer’s, the most common form of dementia.

That’s why one focus of Minoshima and Hoffman’s research will be to investigate the plaques and tangles — abnormal clusters of amyloid and tau molecules — that riddle the brains of Alzheimer’s patients. Though practically synonymous with the condition, surprisingly little is known about the relationship of these molecules to memory loss. Nor is it understood how these insidious invaders contribute differently to Alzheimer’s as compared to other forms of dementia.

Hoffman’s radiopharmaceuticals act as beacons that, in rainbow colors, reveal the locations, and relative quantities, of these tiny telltale signs of disease. And Minoshima’s algorithms are enabling them to be scrutinized in exquisite detail.

“Do the plaques and tangles cause Alzheimer’s, or are they by-products? Why do they arise, and which comes first?” asks Minoshima. “By answering questions like these, we hope to move beyond the end of the disease, to understand its beginnings.”
by Julia Lyon

When Christopher Schlemer couldn’t pour the milk one morning, he knew something was wrong. He began to have trouble walking and his speech slowed. Once he got to the emergency room, a neurologist quickly deduced that he’d had a stroke. The question was, what could have caused it?

An innovative MRI protocol tailored to image the small vessels of the brain helped doctors pinpoint the source: the vessel wall of his basilar artery showed signs of bleeding and inflammation. This was a key indicator that the cause of the stroke was the inflamed artery wall, which was difficult to see since there was no significant narrowing.

The neurology team tailored his treatment accordingly and today, Schlemer, a 38-year-old brand manager for a bowling ball company, is hitting the lanes twice a week.

“It’s definitely a relief and reassuring that someone was able to figure it out,” says the Ogden resident, who compared the medical detective work to an episode of the TV show House.

One of the few institutions in the country to study vessel wall imaging by MRI, University of Utah Health Care hopes soon to enroll patients like Schlemer in studies that could one day help decrease the risk of stroke recurrence. A new focus is intracranial atherosclerosis — one of the most

“The last 30 years of medicine has been focused on vessel narrowing...We are beginning to turn that on its head.”

Scott McNally, MD, PhD
dangerous kinds of stroke because of its high rate of recurrence. The average yearly recurrence for any stroke is 5%, but for intracranial atherosclerosis it’s 10 to 20% per year.

The researchers want to focus their work on patients at highest risk of having a future stroke.

“The last 30 years of medicine have been focused on vessel narrowing. All of our stroke risk models and treatment recommendations are based on that. We are beginning to turn that on its head,” says Scott McNally, MD, PhD, assistant professor of radiology. With the MR physicists of the Utah Center for Advanced Imaging Research (UCAIR), McNally has been studying vessel wall inflammation over the last five years. “We are discovering many hidden stroke sources with these MRIs. These scans also confirm the treatment regimen is on the right track — that the vessel inflammation is going down — without having to wait months or years to see if you’ve prevented another stroke.”

In 2015, the team used the MRI sequence on a hiker after she had a stroke, which was initially assumed to be from a clot in the heart. But the imaging unquestionably showed inflammation in an artery of the brain as the cause.

“The case was dramatic. When these scans are positive like this one, it is like someone shooting off fireworks. It is clear what is causing these strokes, and it is not always vessel narrowing,” McNally recalls. “But we still have a lot to learn.”

One study has already begun. The plan is to complement MRI scans with other testing to help inform the research. Doctors want to check blood for markers of inflammation, including C-reactive protein and oxidative stress. In addition, bacteria in the gut will be examined to check overall body inflammation levels.

“We’re thinking that people who have alterations in serum markers of inflammation and the gut metagenome that favor inflammation will have more inflammation of blood vessels of the brain — in particular areas of atherosclerosis,” says Adam de Havenon, MD, an assistant professor of neurology.

Researchers will also use transcranial doppler ultrasound to identify microembolic signals from brain arteries, which are associated with future stroke.

“In the past, we knew that vessel wall inflammation was important, but the only chance we had to detect it was using pathology after a patient died,” McNally explains. “Now vessel wall MRI allows us to detect the problem and monitor treatment effects like never before.”

“It’s revolutionary,” McNally says.
If a picture is worth a thousand words, a 3-D model may be worth more, if it helps a patient understand the cause of disease or helps medical students to learn procedures or understand complex conditions.

“It can be easier to teach and visualize complex anatomy if you can actually see and interact with it,” says neuroradiologist Edward P. Quigley, MD, PhD. He and colleagues Lubdha Shah, MD, and Justin Cramer, MD, are printing 3-D models of spines to teach residents and fellows how to do spine procedures and approach complicated cases. An additional benefit of 3-D printing patient-specific spine models will be to show patients how degenerative changes cause spinal canal or foraminal narrowing. “It allows patients to see a model of their own spine rather than a doctor just describing it,” says Quigley.

An associate professor of radiology, Quigley is a member of a group of University of Utah Health Care (UUHC) neuroradiologist physicians and researchers, the 3-D Printing and Advanced Visualization Group, studying and using additive manufacturing methods to make models of anatomy, bones, soft tissues and medical devices to help educate patients and trainees and advance research. The creation of anatomic models used to rely on artists, designers, industrial methods, machine shops or even individual craftsmen, but today computer workstations and desktop 3-D printers can streamline the process.

UUHC is striving to help advance this burgeoning medical field. Radiology physicians like Quigley, Shah, Cramer, Ryan O’Harra, MD, and research colleagues are working to stay near the front of the pack among tertiary medical centers. “We are just at the start of what 3-D printing can do,” Quigley says. For example, in collaboration with prosthetics colleague Paul Tanner, of Hunstman Cancer Institute, patient-centered models can be printed to expedite prosthetic development. In the near future, we may be printing biocompatible implantable devices to aid our reconstructive surgeons, saving intraoperative time.

The idea behind 3-D printing is straightforward: take a computer-based, 3-D representation of an object, such as a patient CT scan, process it on a computer workstation, and using custom printers that work with different substances, “print” the desired 3-D object one layer at a time.

Quigley’s interest in advanced visualization technology arose when he was earning his neuroscience doctorate at the Loyola University Medical Center in Chicago. He started by...
building and simulating ion channels, small proteins that control the flow of ions in cells. His training as a neuroradiologist exposed him to 3-D imaging of the nervous system. As 3-D printing became more viable, the 3-D lab was created to help transform medical images into 3-D objects, everything from bones and prosthetics to models of spines to medical devices.

3-D printing requires collaboration among many disciplines — something the University excels at — with physicians, scientists, researchers and engineers from many areas working together to help patients. Clinical radiologists and physicians work closely with researchers at the Utah Center for Advanced Imaging Research at the University. 3-D printing is a natural fit for radiologists.

“Since we spend so much of our time with 3-D imaging, it’s natural that radiologists and radiology researchers can help people visualize things in tactile ways,” Quigley says.

As an educational aide, printed 3-D models of bones and the nervous system can be used to teach procedures or anatomy to students. Shah, Cramer, and Quigley have received a grant from the Radiological Society of North America to teach spine anatomy and spine interventional procedures and techniques using 3-D models.

O’Hara, an interventional radiologist and assistant professor of radiology, won the University Bench to Bedside competition and is looking at printing prototypes of medical devices for interventional procedures. Eugene Huo, MD, adjunct assistant professor of radiology, is printing models of blood vessels. Quigley anticipates rapid prototyping of brain aneurysms could be printed for neurosurgeons and neurointerventionalists to study and manipulate before neurointerventional treatment.
Data throughout this report contain comparisons of the University of Utah Health Care Clinical Neurosciences Center’s performance to the “UHC National Compare Group,” which consists of all hospitals in the University HealthSystem Consortium database. This includes 116 academic medical centers across the United States and 260 affiliated hospitals, representing approximately 90 percent of the nation’s non-profit academic medical centers.

For Length of Stay (LOS) and Mortality indexes, a score of less than one indicates better than expected outcomes for the patient population compared to the 376 UHC hospitals.

### Inpatient Outcomes

**Length of Stay**
- **Mean LOS Observed**
  - University of Utah: 4.38 days
  - Comparison: 4.93 days
- **Mean LOS Expected**
  - University of Utah: 5.24 days
  - Comparison: 4.68 days
- **LOS Index (O/E)**
  - University of Utah: 0.83
  - Comparison: 1.05

**Mortality**
- **% of Deaths Observed**
  - University of Utah: 4.56
  - Comparison: 3.21
- **% of Deaths Expected**
  - University of Utah: 5.44
  - Comparison: 3.55
- **Mortality Index (O/E)**
  - University of Utah: 0.84
  - Comparison: 0.91
NEUROLOGY: LENGTH OF STAY INDEX

EFFECTIVE DATES: JULY 2014-JUNE 2015

1.42%

UNIVERSITY OF UTAH

1.64%

UHC COMP

2.57%

UNIVERSITY OF UTAH

2.59%

UHC COMP

3.27%

UNIVERSITY OF UTAH

4.08%

UHC COMP

RELATED READMISSIONS

Excludes: chemotherapy, rehabilitation, dialysis, delivery/birth, and mental diseases/alcohol and drug use encounters
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**Related Readmissions**

EFFECTIVE DATES: JULY 2014-JUNE 2015

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Excludes: chemotherapy, rehabilitation, dialysis, delivery/birth, and mental diseases/alcohol and drug use encounters

**Inpatient Outcomes**

EFFECTIVE DATES: JULY 2014-JUNE 2015

**Length of Stay**

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**Mortality Index (O/E)**

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**Revascularization in Ischemic Stroke**

EFFECTIVE DATES: JAN - OCT 2015

- **Goal:** 90 min
- **Average time from start of endovascular treatment to recanalization:** 53 min
- **Percent of Acute Ischemic Stroke Patients admitted to hospital that received IV tPA:** 22%

**Performance Measures**

YEAR TO DATE: OCT 2014 - SEPT 2015

**Ischemic Only**

- **IV tPA:** 100%
  - Patient arrived by 2 hour, treated by 3 hour

**Ischemic & TIA**

- **Early Antithrombotics hospital day 1-2:** 95.6%
  - 100%
  - Antithrombotics at discharge
  - Statin at discharge, LDL<99 or on statin on admission
  - Anticoag for Afib/Flutter at discharge

**Ischemic & Hemorrhagic**

- **Dysphagia Screen before meds, food, drink PO:** 94.3%
  - VTE Prophylaxis hospital day 1-2, SCDs/SQ Hep/Coumadin
  - Rehab Considered

**Ischemic, Hemorrhagic & TIA**

- **Stroke Education patient discharged to home:** 91.5%
  - Smoking Cessation 96.3%
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### Length of Stay

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### Mortality

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<tbody>
<tr>
<td>% of DeathsObserved</td>
<td>3.23</td>
</tr>
<tr>
<td>University of Utah</td>
<td></td>
</tr>
<tr>
<td>% of DeathsExpected</td>
<td>2.81</td>
</tr>
<tr>
<td>University of Utah</td>
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</tbody>
</table>
### NEUROSURGERY: LENGTH OF STAY INDEX

**EFFECTIVE DATES: JULY 2014-JUNE 2015**

<table>
<thead>
<tr>
<th>%7 DAY READMIT</th>
<th>%14 DAY READMIT</th>
<th>%30 DAY READMIT</th>
</tr>
</thead>
<tbody>
<tr>
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<td><strong>UNIVERSITY OF UTAH</strong></td>
<td><strong>UNIVERSITY OF UTAH</strong></td>
</tr>
<tr>
<td>1.79%</td>
<td>3.10%</td>
<td>6.44%</td>
</tr>
<tr>
<td>1.95% UHC COMP</td>
<td>3.40% UHC COMP</td>
<td>5.50% UHC COMP</td>
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</tbody>
</table>

Excludes: chemotherapy, rehabilitation, dialysis, delivery/birth, and mental diseases/alcohol and drug use encounters

**RELATED READMISSIONS**

**EFFECTIVE DATES: JULY 2014-JUNE 2015**

- %7 DAY READMIT: 1.79%
- %14 DAY READMIT: 3.10%
- %30 DAY READMIT: 6.44%

**RELATED READMISSIONS**

- %7 DAY READMIT: 1.79%
- %14 DAY READMIT: 3.10%
- %30 DAY READMIT: 6.44%

**RELATED READMISSIONS**

- %7 DAY READMIT: 1.79%
- %14 DAY READMIT: 3.10%
- %30 DAY READMIT: 6.44%

**RELATED READMISSIONS**

- %7 DAY READMIT: 1.79%
- %14 DAY READMIT: 3.10%
- %30 DAY READMIT: 6.44%

**RELATED READMISSIONS**

- %7 DAY READMIT: 1.79%
- %14 DAY READMIT: 3.10%
- %30 DAY READMIT: 6.44%
University of Utah Health Care’s spine division is participating in the National Neurosurgery Quality and Outcomes Database (N2QOD). N2QOD serves as a continuous national clinical registry for neurosurgical procedures and practice patterns. Its primary purpose is to track quality of surgical care for the most common neurosurgical procedures, as well as provide practice groups and hospitals with an immediate infrastructure for analyzing and reporting the quality of their neurosurgical care.

### PATIENTS WITH BACK SURGERY

- Lumbar Disc Herniation
- Lumbar Stenosis
- Lumbar Spondylolisthesis

**VAS Back Pain**

<table>
<thead>
<tr>
<th></th>
<th>BEFORE</th>
<th>AFTER</th>
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<tbody>
<tr>
<td>10</td>
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**VAS Leg Pain**

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**ODI**

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**EQ5D**

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**EQVAS**

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<td>40</td>
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</tr>
</tbody>
</table>

### PATIENTS WITH NECK SURGERY

- Cervical Disc Herniation
- Cervical Foraminal Stenosis
- Cervical Central Stenosis

**VAS Neck Pain**

<table>
<thead>
<tr>
<th></th>
<th>BEFORE</th>
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<tbody>
<tr>
<td>10</td>
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**VAS Arm Pain**

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<tr>
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**ODI**

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**EQ5D**

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<td>0.4</td>
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**EQVAS**

<table>
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</table>
### SPINE: LENGTH OF STAY INDEX

<table>
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<tr>
<th>Quarter</th>
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<tbody>
<tr>
<td>2014 Q3</td>
<td>1.00</td>
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<td>2015 Q1</td>
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<tr>
<td>2015 Q2</td>
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<td>1.00</td>
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### ALL CAUSE READMISSIONS

**Effective Dates: July 2014-June 2015**

<table>
<thead>
<tr>
<th>Metric</th>
<th>University of Utah</th>
<th>UHC Comparison</th>
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<tbody>
<tr>
<td>%7 Day Readmit</td>
<td>1.32%</td>
<td>1.91%</td>
</tr>
<tr>
<td>%14 Day Readmit</td>
<td>2.12%</td>
<td>3.10%</td>
</tr>
<tr>
<td>%30 Day Readmit</td>
<td>3.97%</td>
<td>4.73%</td>
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</table>

Excludes: chemotherapy, rehabilitation, dialysis, delivery/birth, and mental diseases/alcohol and drug use encounters.

### INPATIENT OUTCOMES

**Effective Dates: July 2014-June 2015**

<table>
<thead>
<tr>
<th>Metric</th>
<th>University of Utah</th>
<th>Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean LOS Observed</td>
<td>3.30</td>
<td>3.45</td>
</tr>
<tr>
<td>Mean LOS Expected</td>
<td>3.59</td>
<td>3.62</td>
</tr>
<tr>
<td>LOS Index (O/E)</td>
<td>0.92</td>
<td>0.95</td>
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### RELATED READMISSIONS

**Effective Dates: July 2014-June 2015**

<table>
<thead>
<tr>
<th>Metric</th>
<th>University of Utah</th>
<th>UHC Comparison</th>
</tr>
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<tbody>
<tr>
<td>%7 Day Readmit</td>
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<td>0.97%</td>
</tr>
<tr>
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<td>1.06%</td>
<td>1.71%</td>
</tr>
<tr>
<td>%30 Day Readmit</td>
<td>1.59%</td>
<td>2.77%</td>
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</table>

Excludes: chemotherapy, rehabilitation, dialysis, delivery/birth, and mental diseases/alcohol and drug use encounters.
### FY15 ED Turnaround Neuro MRI/CT Exams

<table>
<thead>
<tr>
<th>Month</th>
<th>JULY (N=816)</th>
<th>AUG. (N=860)</th>
<th>SEPT. (N=923)</th>
<th>OCT. (N=835)</th>
<th>NOV. (N=883)</th>
<th>DEC. (N=794)</th>
<th>JAN. (N=799)</th>
<th>FEB. (N=801)</th>
<th>MAR. (N=818)</th>
<th>APR. (N=793)</th>
<th>MAY (N=875)</th>
<th>JUNE (N=812)</th>
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</thead>
<tbody>
<tr>
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<td>0:34</td>
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<td>0:30</td>
<td>0:32</td>
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<td>0:27</td>
<td>0:26</td>
<td>0:29</td>
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</table>

*TAT=Turnaround Times computed for Fiscal Year 2015 through June 2015 (May and June Complete to Preliminary TAT unavailable due to Epic implementation.)

### Summary of Peer Review Data

<table>
<thead>
<tr>
<th></th>
<th>TOTAL</th>
<th>1 Totally Agree</th>
<th>2 Mostly Agree</th>
<th>3 Minor Miss</th>
<th>4 Major Miss</th>
<th>Clinically Significant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plain Films:</td>
<td>1294</td>
<td>75.27%</td>
<td>21.95%</td>
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<tr>
<td>Ultrasound:</td>
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<td>83.06%</td>
<td>14.52%</td>
<td>2.42%</td>
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<td>2.42%</td>
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<tr>
<td>CT Scans:</td>
<td>1193</td>
<td>65.38%</td>
<td>29.17%</td>
<td>3.77%</td>
<td>1.68%</td>
<td>5.45%</td>
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<tr>
<td>MRI Scans:</td>
<td>896</td>
<td>37.28%</td>
<td>60.49%</td>
<td>1.34%</td>
<td>0.89%</td>
<td>2.23%</td>
</tr>
<tr>
<td>Nuclear Medicine:</td>
<td>70</td>
<td>97.14%</td>
<td>2.86%</td>
<td>0.00%</td>
<td>0.00%</td>
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</tr>
<tr>
<td>Interventional:</td>
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<td>75%</td>
<td>25%</td>
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<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>PET:</td>
<td>153</td>
<td>85.62%</td>
<td>14.38%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>TOTAL:</td>
<td>3870</td>
<td>64.73%</td>
<td>31.99%</td>
<td>2.56%</td>
<td>0.72%</td>
<td>3.28%</td>
</tr>
</tbody>
</table>

**Notes:**
- Total number of studies peer reviewed in FY2015=3870
- Scale Definitions: 1=Totally Agree, 2=Mostly Agree, 3=Minor Miss, 4=Major Miss
- Clinically Significant identifies the percentage of the total number of 3’s and 4’s given in relation to the total number of studies reviewed.
STEFAN M. PULST, MD, DR MED
is professor and chair of Neurology. His research focuses on inherited diseases of the nervous system with an emphasis on spinocerebellar ataxias and Parkinson’s disease. In addition to molecular and cellular approaches in the laboratory, he has used the Utah Population Database to examine the genetic epidemiology of neurodegenerative diseases. Dr. Pulst was past editor of the international journal Current Genomics and is on the editorial board of several international journals, including Nature Reviews of Neurology. He serves on the American Academy of Neurology (AAN) Board of Directors and is a former chair of the AAN’s Science Committee. In 2014, he was awarded the George C. Cotzias Prize from the American Academy of Neurology for his achievements in translational neuroscience and a Senator Jacob Javits Award in the Neurosciences from NINDS.

NEUROGENETICS, SPINOCEREBELLAR ATAXIA, PARKINSON’S DISEASE, ION CHANNELS, TRANSLATIONAL NEUROSCIENCE

PEGAH AFRA, MD
focuses her practice on the diagnosis and treatment of seizures and epilepsy. Her specific interests include diagnosis and management of intractable epilepsy, including presurgical evaluation and surgical treatment of intractable medication resistant epilepsies, invasive intracranial electroencephalography (EEG) monitoring, and magnetoencephalography (MEG). She also participates in intraoperative monitoring. Dr. Afra is currently investigating the role of new anti-epileptic drugs in treatment of epilepsy, as well as neurophysiology of intracranial EEG. She has had the honor of receiving the award of Neurologist of the Year from the Epilepsy Association of Utah.

SPECIALTIES: EPILEPSY, CLINICAL NEUROPHYSIOLOGY, EEG, MEG, INTRAOPERATIVE MONITORING

JULIANN W. ALLRED, MD
a Utah native, specializes in general neurology, including the treatment of patients with multiple sclerosis, movement disorders, migraine/headache, stroke and cognitive dysfunction. She also has an interest in neurogenetics and treats adult patients with neurofibromatoses. Dr. Allred enjoys teaching medical students and residents and is dedicated to education.

SPECIALTY: GENERAL NEUROLOGY

SAFDAR A. ANSARI, MD
is the division chief of neurocritical care at the Department of Neurology. His clinical activities include managing critically ill patients in the hospitals state-of-the-art Neurocritical Care Unit, providing consultation services to other intensive care units, and covering the stroke service and TELESTROKE network. He serves as co-chair of the Organ Donor Council and as the site investigator for two large multinational clinical trials for brain hemorrhage in addition to pursuing his own research interests in therapeutic hypothermia. He plays an integral role in education for trainees at all levels in the neurocritical care unit.

SPECIALTY: NEUROCRITICAL CARE

K.C. BRENNAN, MD
is assistant professor and division chief for Translational neuroscience in the Department of Neurology. His research and clinical care both focus on the headache disorders. His laboratory examines the basic mechanisms of migraine and post-traumatic headache. A particular interest is cortical spreading depression, a wave of massive excitation that is also relevant to stroke and traumatic brain injury. He and his colleagues also do focused physiological research on patients with migraine and post-traumatic headache. His clinical work involves seeing patients in the Headache Clinic and in the hospital in the Neurology Consult Service.

SPECIALTY: HEADACHE

JOSHUA L. BONKOWSKY, MD, PHD
is director of pediatric neurology research and the recipient of the 2012 NIH New Innovator Award. His lab studies mechanisms and disease in the developing brain, including the formation of circuitry and its disruption by prematurity, and drug discovery for leukodystrophy treatment. He manages a specialty clinic for adults and children with leukodystrophies and other neurogenetic disorders.

SPECIALTIES: LEUKODYSTROPHIES, NEUROGENETICS

JAMES F. BALE, JR, MD
is professor of neurology and pediatrics. He is the Utah site director for Education in Pediatrics Across the Continuum, an Association of American Medical Colleges sponsored education innovation that uses competency based methods to determine when medical students are ready to enter residency training in pediatrics. Dr. Bale has published extensively regarding medical education, clinical child neurology, cytomegalovirus, and neurological infections. He is the lead author of a pediatric neurology textbook: Pediatric Neurology: A Color Handbook. Dr. Bale served as president of the Child Neurology Society from 2003-2005 and as chair of the Council of Pediatric Subspecialties from 2010-2012.

SPECIALTIES: NEUROLOGY, CONGENITAL INFECTIONS, HEADACHE

MARK B. BROMBERG, MD, PHD
is interested in neuromuscular disorders, with focus on amyotrophic lateral sclerosis, myasthenia gravis and inflammatory neuromyopathies, and electroneurodiagnosis (EMG). He is co-director of the Amyotrophic Lateral Sclerosis/Muscular Dystrophy Association. His research interests...
are in the clinical care of ALS and include understanding the spectrum of patient and caregiver issues. He is also interested in education and directs the medical student neurology clerkship.

**SPECIALTIES**
- ALS, MYASTHENIA GRAVIS,
- ELECTROMYOGRAPHY

**JAMES B. BURNS, MD**

has a longstanding research interest in the possible role of T-cell autoreactivity in multiple sclerosis (MS). He is also a regular participant in a variety of clinical trials for MS treatments.

**SPECIALTY**
- MULTIPLE SCLEROSIS

**RUSSELL J. BUTTERFIELD, MD, PHD**

is assistant professor in the Division of Pediatric Neurology and co-directs the Muscular Dystrophy Association Clinic. Dr. Butterfield sees patients with neurogenetics and neuromuscular disorders with a specific interest in congenital muscular dystrophies and myopathies. His research efforts are in genetic and genomic analysis of inherited neuromuscular disorders.

**SPECIALTY**
- PEDIATRIC NEUROLOGY,
- NEUROMUSCULAR DISORDERS,
- MUSCULAR DYSTROPHY

**GORDON J. CHELUNE, PHD**

is professor of neurology and senior neuropsychologist in the Center for Alzheimer's Care. Imaging and Research (CACIR) in the Division of Cognitive Neurology. Dr. Chelune is board certified in clinical neuropsychology and has over 35 years of experience in his field. His clinical interests include memory disorders, deficits of higher executive function, and trajectories of cognitive change in aging. He has been actively involved in test development and outcomes research throughout his career. He is a Fellow of the American Psychological Association, National Academy of Neuropsychology and Society of Personality Assessment, and currently serves as the executive director of the International Neuropsychological Society.

**SPECIALTIES**
- NEURODEGENERATIVE DISORDERS,
- MEMORY,
- NEUROCOGNITIVE OUTCOMES RESEARCH,
- NEUROPSYCHOLOGICAL ASSESSMENT

**LEE S. CHUNG, MD**

is a vascular neurologist at the University of Utah Stroke Center. He received his A.B. in Psychology from Harvard College. He attended medical school at University of California, San Diego and completed internship and neurology residency at the University of Utah. His current research interests include stroke care delivery systems including telestroke and prehospital management.

**SPECIALTIES**
- VASCULAR NEUROLOGY,
- STROKE,
- GENERAL NEUROLOGY

**STACEY L. CLARDY, MD, PHD**

is both clinical and research faculty in the Division of Neuroimmunology within the Department of Neurology. Prior to joining the University of Utah, Dr. Clardy furthered her training with a fellowship in autoimmune neurology at the Mayo Clinic. Her training and experience focus on the evaluation and management of autoimmune and paraneoplastic disorders of the nervous system. Her main clinical interest is devoted to patients affected by antibody-mediated disorders of the nervous system, as well as demyelinating CNS disease, including neuromyelitis optica (NMO) and multiple sclerosis, and central nervous system complications of rheumatologic disease. She established the Autoimmune Neurology Clinic at the University of Utah, one of the few clinics in the United States devoted to the care of patients with antibody-mediated neurologic disorders and neuro-immune diseases.

**SPECIALTY**
- NEUROIMMUNOLOGY

**ADAM De HAVENON, MD**

is an assistant professor of Neurology at the University of Utah and Neurology Department. He received his medical degree from Brown University School of Medicine in 2001, he received his medical degree from Brown University School of Medicine in 2001, and completed internship and neurology residency at the University of Utah in 2003. He finished a vascular neurology fellowship at University of Washington in 2014 under the mentorship of Dr. David Tirschwell, where he also pursued additional training and certification in carotid and transcranial Doppler (TCD) ultrasound. Dr. de Havenon's independent research is focused on studying the application of advanced imaging modalities to better understand the physiology of large vessel atherosclerosis and pathways of collateral blood flow in stroke patients. He is conducting a prospective clinical trial to evaluate the utility of MRI in choosing stroke patients that may benefit from experimental treatment to maintain blood flow to the area of stroke.

**SPECIALTIES**
- VASCULAR NEUROLOGY,
- STROKE

**MELISSA CORTEZ, DO**

is an assistant professor within the Department of Neurology at University of Utah Health Care. Dr. Cortez is also the director and founder of the Autonomic Physiology Lab. Dr. Cortez is a board-certified physician and completed her neurology residency at the University of Utah School of Medicine. Before returning to University of Utah Health Care in 2014, she served as a Fellow at the Mayo School of Medical Education, receiving specialized training in clinical neurophysiology and the management of multiple sclerosis.

**SPECIALTIES**
- NEUROLOGY,
- MULTIPLE SCLEROSIS,
- AUTOIMMUNE NEUROLOGY

**ADAM De HAVENON, MD**

is an assistant professor of Neurology at the University of Utah School of Medicine. After receiving his BA from Yale University in 2001, he received his medical degree from Brown University School of Medicine in 2009 and completed internship and neurology residency at the University of Utah in 2013. He finished a vascular neurology fellowship at University of Washington in 2014 under the mentorship of Dr. David Tirschwell, where he also pursued additional training and certification in carotid and transcranial Doppler (TCD) ultrasound. Dr. de Havenon's independent research is focused on studying the application of advanced imaging modalities to better understand the physiology of large vessel atherosclerosis and pathways of collateral blood flow in stroke patients. He is conducting a prospective clinical trial to evaluate the utility of MRI in choosing stroke patients that may benefit from experimental treatment to maintain blood flow to the area of stroke.

**SPECIALTIES**
- VASCULAR NEUROLOGY,
- STROKE

**L. DANA DEWITT, MD**

is medical director for inpatient neuro acute care and head of the NeuroHospitalist group. She is board certified in vascular neurology and covers brain attacks and telestrokes and interprets transcranial Doppler ultrasound. She has received awards as Best of Boston Top Docs for Women, Consumer Checkbook top Docs and Best Doctors in America 2005-2014. She is PI for a number of MS studies, including a Neuro-NEXT study for primary progressive and secondary progressive MS, an acute stroke study of Multi-Stem, and a PFO study in stroke. REDUCE: **SPECIALTIES**
- STROKE,
- NEUROIMMUNOLOGY,
- WHITE MATTER DISEASE
KATHLEEN B. DIGRE, MD
directs the Division of Headache and Neuro-Ophthalmology in the Department of Neurology and directs the Neuro-Ophthalmology Fellowship at the Moran Eye Center, along with the Headache Clinic at the Clinical Neurosciences Center. Her clinical research interests include the study of idiopathic intracranial hypertension, neuro-opthalmic disorders in pregnancy, headache, photophobia and optic nerve disorders. Dr. Digre serves as treasurer of the American Headache Society and is past president of the North American Neuro-Ophthalmology Society. She is listed in the Best Doctors in America and recently received the University of Utah's highest honor, the Rosenblatt Award. She has authored over 150 peer-reviewed articles, reviews and abstracts, and was the first Hedi Fritz Guest Professor at the University of Zurich. SPECIALTIES: NEURO-OPTHALMOLOGY, HEADACHE, WOMEN’S HEALTH

KEVIN DUFF, PHD
joined the University of Utah as associate professor of Neurology in 2009 and practices neuropsychology for the Center for Alzheimer’s Care, Imaging and Research (CACIR). Dr. Duff is a board certified neuropsychologist with over 10 years of experience working in dementia and other neuropsychiatric illnesses. His research program examines the earliest cognitive changes in the development of dementia, practice effects as a marker of brain plasticity, and methods for improving cognitive functioning in late life. He frequently lectures in the community about brain fitness. SPECIALTIES: DEMENTIA, ALZHEIMER’S DISEASE, HUNTINGTON’S DISEASE, OTHER NEUROPSYCHIATRIC CONDITIONS

ANGELA D. EASTVOLD, PHD
joined the Department of Neurology in 2011 as assistant professor after having completed her clinical neuropsychology fellowship at the James A. Haley Veterans’ Hospital in Tampa, FL, and her neuropsychology internship at the University of Florida. Dr. Eastvold has extensive experience with all severity levels of brain injury and neurologic/psychiatric differential diagnosis. SPECIALTY: CLINICAL AND FORENSIC NEUROPSYCHOLOGICAL ASSESSMENT, TBI, EPILEPSY

FRANCIS M. FILLOUX, MD
is chief of the Division of Pediatric Neurology at the University of Utah School of Medicine and Primary Children’s Hospital, being responsible for administering the Division of Pediatric Neurology. Dr. Filloux is a general child neurologist who sees children with all forms of neurological disease, having special interest in tic disorders, Tourette’s, and neurobehavioral problems. SPECIALTY: PEDIATRIC NEUROLOGY

NORMAN L. FOSTER, MD
is a board-certified geriatric neurologist who has specialized in brain imaging and dementing and neurodegenerative diseases for over 30 years. He is professor of neurology, chief of the Division of Cognitive Neurology, senior investigator in the Brain Institute, and director of the Center for Alzheimer’s Care, Imaging and Research (CACIR), which he helped establish in 2005. His recent research has focused on pragmatic studies to improve evaluation, diagnosis and treatment of neurodegenerative disorders and the development and application of neuroimaging in clinical care. Dr. Foster is a Fellow of the American Academy of Neurology and the American Neurological Association, a member of the Alpha Omega Alpha Honorary Medical Society and the Amyloid PET Imaging Task Force of the Alzheimer’s Association. He helped develop the Utah State Plan for Alzheimer’s Disease and Related Disorders passed by the Utah State Legislature in January 2012. He has served as an advisory for several international, federal and state agencies. SPECIALTIES: ALZHEIMER’S DISEASE AND RELATED NEURODEGENERATIVE DISORDERS, POSITRON EMISSION TOMOGRAPHY, NEUROIMAGING

SUMMER GIBSON, MD
is a Utah native. She attended Rice University, where she earned her BA in biology. She received her MD from the University of Texas Health Science Center in San Antonio. She returned to Utah for her neurology residency and in her last year was nominated a co-chief. During her residency she developed a strong research and clinical interest in ALS. After completion of her residency she was elected as the first Petajan neuropsychology fellowship recipient. She completed epidemiologic studies on ALS using the Utah Population Database (UPDB), which was published in Neurology. With the mentorship of Dr. Stefan Pulst, she also started an ALS clinic tissue bank repository and received funding through the Utah Genome Project (UGP) in hopes of identifying and further expanding the understanding of ALS genes and explaining findings from her UPDB studies. SPECIALTIES: NEUROMUSCULAR, ELECTROMYOGRAPHY

JOHN E. GREENLEE, MD
is professor and executive vice chair and former interim chair (2002-2007). His areas of specialty are central nervous system (CNS) infections and paraneoplastic and other autoimmune diseases of the CNS, with particular emphasis on antibody-mediated syndromes of neurological injury. Dr. Greenlee is one of the first individuals to recognize that an immune response to neurons can cause CNS injury. SPECIALTIES: CNS INFECTIONS, AUTOIMMUNE NEUROLOGICAL DISEASE, COMPLEX NEUROLOGICAL DIAGNOSIS

DUSTIN B. HAMMERS, PHD, ABPP
joined the University of Utah in 2011 as assistant professor of neurology, after having completed his clinical neuropsychology fellowship at the University of Michigan. He completed board certification in clinical neuropsychology in 2014 and currently practices neuropsychology for the Center for Alzheimer’s Care, Imaging and Research (CACIR). His clinical interests include memory and executive declines in the elderly, and assessment of adult attention deficit/hyperactivity disorder. SPECIALTIES: NEUROPSYCHOLOGICAL ASSESSMENT, NEURODEGENERATIVE DISORDERS, OTHER NEUROPSYCHIATRIC CONDITIONS

John E. Greenlee, MD
is professor and executive vice chair and former interim chair (2002-2007). His areas of specialty are central nervous system (CNS) infections and paraneoplastic and other autoimmune diseases of the CNS, with particular emphasis on antibody-mediated syndromes of neurological injury. Dr. Greenlee is one of the first individuals to recognize that an immune response to neurons can cause CNS injury. SPECIALTIES: CNS INFECTIONS, AUTOIMMUNE NEUROLOGICAL DISEASE, COMPLEX NEUROLOGICAL DIAGNOSIS

Dustin B. Hammers, PhD, ABPP
joined the University of Utah in 2011 as assistant professor of neurology, after having completed his clinical neuropsychology fellowship at the University of Michigan. He completed board certification in clinical neuropsychology in 2014 and currently practices neuropsychology for the Center for Alzheimer’s Care, Imaging and Research (CACIR). His clinical interests include memory and executive declines in the elderly, and assessment of adult attention deficit/hyperactivity disorder. SPECIALTIES: NEUROPSYCHOLOGICAL ASSESSMENT, NEURODEGENERATIVE DISORDERS, OTHER NEUROPSYCHIATRIC CONDITIONS
PETER M. HANNON, MD
is an assistant professor of neurology at the University of Utah in the Division of Vascular Neurology. He received his undergraduate degree in fine arts at Rice University and obtained his medical degree from Baylor College of Medicine. He completed neurology residency and a vascular neurology fellowship at the University of Utah. His areas of focus include medical education, quality improvement (QI), and investigating innovative methods of healthcare delivery. He has co-directed the medical school Brain and Behavior course and is very involved with both resident and medical student clerkship education. Dr. Hannon has been involved in QI projects throughout residency and fellowship and is currently a departmental physician contact for the AAN Axon Registry and the UHC Mortality Review Collaborative. He is very interested in telemedicine and has created two innovative telehealth neurology clinics to increase access to post-stroke and general neurology specialist care in both urban and rural Utah. Recently, he was nominated to become a council member representing education and research for the Utah Telehealth Network (UTN). He is site-PI for an NIH funded NeuroNext trial investigating novel agents in acute stroke care and is working to help utilize existing telehealth technologies to increase enrollment in acute stroke trials at the university.

SPECIALTY: VASCULAR NEUROLOGY

JOHN M. HOFFMAN, MD
is a professor of radiology and neurology and director of nuclear medicine in the Department of Radiology at the University of Utah. He is also director of the Center for Quantitative Cancer Imaging at Huntsman Cancer Institute. He holds the Willard Snow Hansen Presidential Endowed Chair in Cancer Research. His research interests include imaging of brain tumors, dementia and neuroinflammation.

SPECIALITIES: NEUROIMAGING, NUCLEAR MEDICINE, NEUROLOGY

DUONG P. HUYNH, PHD
is currently investigating neurodegenerative diseases such as Alzheimer’s disease, Parkinson’s disease, and spinocerebellar ataxia type 2. Currently, his group is focusing on the influence of environmental toxins on specific genes associated with Parkinson’s disease. Dr. Huynh is a member of the Society for Neuroscience and the American Association for the Advancement of Science. He is also a faculty representative for the Intermountain Chapter of the Society for Neuroscience.

SPECIALTY: RESEARCH

NICHOLAS E. JOHNSON, MD
has joined the Department of Neurology as assistant professor following completion of his residency and fellowship at the University of Rochester. His clinical interests include adult and pediatric inherited myopathies (muscular dystrophies) and acquired myopathies. His research focuses on the disease mechanism and progression of congenital myotonic dystrophy.

SPECIALTIES: ADULT AND PEDIATRIC NEUROMUSCULAR DISORDERS, MUSCULAR DYSTROPHIES

CHRISTOPHER R. JONES, MD, PHD
retired from patient care at the Hospital Sleep-Wake Center in July 2011 to focus on sleep research. Dr. Jones has two NIH subcontracts from UCSF geneticists Ying-Hui Fu and Louis J. Ptacek to find, recruit and phenotype families of short sleepers and of morning people. In 1999 Drs. Ptacek, Jones, and others published a report of familial advanced sleep phase that led directly to the discovery of the first causative autosomal dominant FAS mutation. In 2009, Drs. Fu, Ptacek, Jones and others discovered and published the first autosomal dominant human short sleeper mutation.

SPECIALTY: SLEEP MEDICINE RESEARCH (CLINICAL)

RICHARD D. KING, MD, PHD
is assistant professor of neurology in the Center for Alzheimer’s Care, Imaging and Research (CACIR) and holds adjunct appointments in bioengineering and neuroscience. He directs the Alzheimer’s Image Analysis Laboratory, which uses advanced neuroimaging analysis tools to study morphometric changes in the brain associated with neurodegenerative disease. He is currently funded by the Paul Beeson Career Development Award in Aging Research for his work examining cortical complexity changes in normal aging and Alzheimer’s disease (NIH grant K23 AG03939). SPECIALTIES: ALZHEIMER’S DISEASE AND RELATED NEURODEGENERATIVE DISORDERS, NEUROIMAGING

NOAH KOLB, MD
studied biochemistry at Bowdoin College and attended medical school at the University of Massachusetts. He completed his neurology residency at the University of Virginia, where he served as chief resident during his final year. He completed his fellowship training at the University of Utah, where he currently practices neuromuscular medicine, and teaches at the University of Utah School of Medicine. His research interest is currently focused on chemotherapy-induced neuropathy.

SPECIALTIES: NEUROMUSCULAR, ELECTROMYOGRAPHY

HOLLY K. LEDYARD, MD, MS
completed her emergency medicine residency and neurocritical care/neurovascular emergencies fellowship at the University of Cincinnati. She is an assistant professor of neurology and emergency medicine and splits her time between the Neurocritical Care Unit and the Emergency Department. She is the director of the Neurocritical Care Fellowship program and is a CDI Physician Advisor for the hospital.

SPECIALTY: NEUROCITICAL CARE

JENNIFER J. MAJERSIK, MD, MS, FAHA
is an associate professor of neurology and the medical director of the University of Utah Stroke Center. Her clinical practice includes evaluating and treating patients with acute stroke in the Emergency Department and in community hospitals throughout the region that participate in the TeleStroke Network (telemedicine). Under her leadership, the University of Utah Health Care TeleStroke Network has grown from eight sites to 23 sites in five states. Dr. Majersik also manages patients on the Inpatient General Neurology Service and provides outpatient consultation in the Stroke Clinic, including urgent referrals. She studies the genetic causes of stroke and how systems of care affect stroke outcomes. She is the principal investigator of the
FUMISUKE MATSUO, MD
is a long-time faculty member of the Department of Neurology. Surgical treatment of medically refractory epilepsy has been an area of special interest for Dr. Matsuo. His main expertise as a clinical electroencephalographer is in the assessment of episodic neurobehavior symptoms, separating epileptic seizures from non-epileptic events. SPECIALTIES CLINICAL NEUROPHYSIOLOGY, INTRAOPERATIVE MONITORING, EPILEPSY

LIGIA ONOFREI, MD
obtained her medical degree from the University of Colorado at Denver School of Medicine. She then completed her neurology residency and her neuromuscular fellowship at the University of Utah. Dr. Onofrei currently focuses her practice on the evaluation of patients with neuromuscular disorders, with a special emphasis on the evaluation of patients with degenerative spine disorders. Dr. Onofrei has a particular interest in teaching and is involved in various educational activities. SPECIALTIES GENERAL NEUROLOGY

ANGELA PETERS, MD
joined the Epilepsy Division as faculty in 2015. She currently holds a position as an assistant professor of neurology and is a diplomate of the American Academy of Neurology. She specializes in epilepsy and neurophysiology. She currently sees patients at the University of Utah with medically intractable epilepsy who might be surgical candidates, and performs programming for responsive neurostimulation. She is a member of the American Epilepsy Society, American Clinical Neurophysiology Society, and American Medical Association. She did her medical training at Baylor College of Medicine and her neurology residency and neurophysiology fellowship at the University of Utah. She did an observership in surgical epilepsy at Cleveland Clinic and a predoctoral fellowship in retinal neurophysiology at the Retina Foundation of the Southwest. She has a research interest in autoimmune mediated epilepsies and a special interest in medical ethics, especially as it relates to neurostimulation. SPECIALTIES EPILEPSY

DAVID R. RENNER, MD
is formerly the director of the University of Utah Neurology Residency Program. Under his leadership the program grew from four to six residents per year. He started the University of Utah’s first HIV-Neurology Clinic, as well as the Department of Neurology’s first outreach clinic in Jackson Hole, WY. He has been actively involved in practicing infectious and tropical neurology in the countries of Kenya and Ghana, where he also teaches residents (registrars) and medical students about the neurosciences. SPECIALTIES HIV-NEUROLOGY, INFECTIOUS AND TROPICAL NEUROLOGY, NEUROMUSCULAR ELECTROMYOGRAPHY, VASCULAR, GENERAL NEUROLOGY

ISHWARA R. SANKARA, MPH, MBBS
is an assistant professor within the Department of Neurology at University of Utah Health Care. His research interests include quality improvement/practice management in the Neurocritical Care Unit, sepsis, and thromboelastometry in the Neurocritical Care Unit. Before arriving at University of Utah Health Care, Dr. Sankara attended medical school at Osmania Medical College in India and completed his residency at University of Alabama Health Center Montgomery. SPECIALTIES NEUROIMMUNOLOGY, MULTIPLE SCLEROSIS

JOHN W. ROSE, MD
is professor of neurology at the University of Utah and is chief of neurology at the Salt Lake City Veterans Administration Hospital. Dr. Rose and his colleagues investigate diverse aspects of multiple sclerosis (MS), including the immunopathology of MS and related models, the development of new treatments for MS, early disease detection with advanced magnetic resonance imaging (MRI), and the detection of susceptibility genes for MS. SPECIALTIES NEUROIMMUNOLOGY, MULTIPLE SCLEROSIS

LAUREN E. SCHROCK, MD
is the medical director of the Movement Disorders Surgery Program (e.g., Deep Brain Stimulation). During her tenure at University of Utah Health Care, the DBS Program has become a model multidisciplinary program at the institution and is now consistently one of the top 15 busiest DBS programs in the country. Dr. Schrock conducts interventional clinical trials of novel DBS devices and will be the site principal investigator for an upcoming multi-center NIH-CTSA funded study of DBS in early-stage Parkinson’s disease. Her clinical expertise is in movement disorders, with a particular focus on DBS treatment of Parkinson’s disease, tremors, and dystonia, intraoperative neuropsychological guidance for placement of DBS electrodes, and botulinum toxin injections for treatment of complex dystonias and hemifacial spasm. SPECIALTIES MOVEMENT DISORDERS, DEEP BRAIN STIMULATION, INTRAOPERATIVE NEUROPHYSIOLOGY, BOTULINUM TOXIN FOR DYSTONIAS

THOMAS SCHENKENBERG, PHD
conducts neuropsychological and psychological evaluations for patients with a variety of conditions. His research interests include dementia, head injury, various neuropsychological syndromes, and clinical ethics. He has been involved in the screening process for deep brain stimulation (DBS) for several years and consults regularly with the DBS team. SPECIALTIES CLINICAL NEUROPSYCHOLOGY, CLINICAL PSYCHOLOGY

LAUREN E. SCHROCK, MD
DANIEL R. SCOLES, PHD
is associate professor of neurology. His scientific training includes biochemistry, genetics of natural populations, and neurology with emphasis on brain tumor research. Dr. Scoles’s research objectives are centered on the identification of drugs for the treatment of spinocerebellar ataxia type 2 (SCA2) and Parkinson’s disease. Drug discovery methodologies used by Dr. Scoles include quantitative high throughput screening (qHTS) and antisense oligonucleotide screening. His research is promoted by collaborative partnerships with industry and the National Institutes of Health. Dr. Scoles also investigates molecular mechanisms of disease gene expression control aimed at identifying new therapeutic targets and understanding drug action. Dr. Scoles is currently supported by grants from the NINDS. SPECIALTIES: DRUG DISCOVERY, MOLECULAR, CELLULAR AND ORGANISMAL BIOLOGY.

RUGGERO SERAFINI, MD, PHD
is assistant professor of neurology, specializing in electroencephalography and epilepsy. Dr. Serafini recently came to University of Utah Health Care from Wayne State University in Detroit, MI, where he was affiliated with Detroit Receiving Hospital and Harper University Hospital. He received his medical degree from the Catholic University School of Medicine in Rome, Italy, and has a longstanding career as a researcher in neurophysiology and in the basic mechanisms of epilepsy on which he has published several papers. A board-certified epileptologist, Dr. Serafini is a regular presenter to physician groups on a variety of epilepsy-related topics. He currently spends most of his clinical time caring for patients at the Neurology Clinic of the University of Utah and at the Epilepsy Clinic of the VA Hospital, located on the University of Utah campus. SPECIALTIES: EPILEPSY, ELECTROENCEPHALOGRAPHY.

J. ROBINSON SINGLETON, MD
is Director of the Neurophysiology Laboratory at the Salt Lake City Veterans Administration Hospital. He teaches neuromuscular disease diagnosis and electrodiagnostic techniques to neurology, physical medicine, and rehabilitation residents and has helped train many neuromuscular fellows. Dr. Singleton also serves on the Centers for Translational and Clinical Science Advisory Board and is a grant review panelist for the National Institute of Neurological Disorders and Stroke and the American Diabetes Association. SPECIALTIES: NEUROMUSCULAR, ELECTROMYOGRAPHY, DIABETIC NEUROPATHY.

A. GORDON SMITH, MD
is Professor and Vice Chair for Research, Chief of the Division of Neuromuscular Medicine, and Director of the Jack H. Petajan EMG Laboratory at the University of Utah. He also directs the Peripheral Nerve Study Group and the Cutaneous Nerve Laboratory. Dr. Smith’s research focuses on the relationship between peripheral neuropathy and obesity, metabolic syndrome and early diabetes, and biomarker development and novel clinical trial design for peripheral nerve disorders. He is the Principal Investigator for the Utah Regional site in the NIH funded Network for Excellence in Neuroscience Clinical Trials (NeuroNEXT). His clinical expertise is in neuromuscular disorders, clinical neurophysiology, and the therapeutic application of botulinum toxins. Dr. Smith serves on the Board of Directors of the American Academy of Neurology (AAN) and is chair of the Education Committee. He is also a member of the board of trustees of the American Brain Foundation. SPECIALTIES: NEUROMUSCULAR, PERIPHERAL NEUROPATHY, ELECTROMYOGRAPHY, BOTULINUM TOXIN.

M. MATEO PAZ SOLDÁN, MD, PHD
is an assistant professor within the Department of Neurology at University of Utah Health Care, where his primary focus is Neuroimmunology. Before arriving at University of Utah Health Care, Dr. Paz Soldán attended medical school at the Mayo Medical School and completed a residency and fellowship at the Mayo School of Graduate Medical Education. SPECIALTY: NEUROIMMUNOLOGY.

JOHN D. STEFFENS, MD
is director of the Division of Diagnostic and Clinical Neurology. He is currently reducing his outpatient practice in order to focus on clinical resident education and acute neurology as a neurohospitalist. In addition, Dr. Steffens maintains a part-time private practice in Twin Falls, ID. SPECIALTIES: NEUROHOSPITALIST, NEUROMUSCULAR, GENERAL, NEUROLOGY, ELECTROMYOGRAPHY.

MATTHEW T. SWENEY, MD, MS
is currently an assistant professor with joint appointment in pediatrics and neurology at the University of Utah. His specific clinical interests include pediatric epilepsy and EEG, intraoperative neuromonitoring, and general child neurology. His research interests primarily include ongoing participation in novel anti-epileptic drug trials. He serves as the chair of the Medical Advisory Board for the Alternating Hemiplegia of Childhood Foundation of North America and remains active with national and international collaborations related to this rare disorder. Dr. Sweeney is board certified in general pediatrics and neurology, with special qualification in child and adolescent epilepsy. He holds additional board certification by the American Board of Clinical Neurophysiology with qualification in epilepsy monitoring (EEG) and intraoperative neuromonitoring (IONM). SPECIALTY: PEDIATRIC NEUROLOGY.

PERLA C. THULIN, MD
has special expertise and training in the evaluation and treatment of movement disorders, including Parkinson’s disease, tremor, ataxia, hemifacial spasm, tics, and dystonia, including torticollis and blepharospasm, and she is an expert in the use of Botox and Myobloc. Dr. Thulin also evaluates patients with Parkinson’s disease and essential tremor for deep brain stimulation surgery. SPECIALTY: MOVEMENT DISORDERS.
ALEKSANDER TKACH, MD
is originally from rural Montana. He attended medical school at the University of Colorado School of Medicine and completed a neurology residency at the University of Washington. After being in private practice as a vascular neurohospitalist at Banner University Hospital in Phoenix, AZ, he decided to expand his knowledge with a vascular neurology fellowship at the University of Utah. He then spent a short time in private practice in Seattle, WA before returning to Salt Lake City and the University of Utah in 2015. His current interests are in the field of vascular neurology and the delivery of excellent stroke care to rural areas. He is often found providing education and lectures locally and to the surrounding communities as well as working on systems of care to improve delivery for all patients and families with medical providers and community leaders.

SPECIALTY VASCULAR NEUROLOGY

COLIN B. VAN ORMAN, MD
focuses his clinical practice on pediatric epilepsy, which also includes general pediatric neurology. He is involved in the Comprehensive Epilepsy Program at the University of Utah, which includes the use of standard anti-epilepsy medications, vagus nerve stimulation, dietary treatments, and evaluation for potential epilepsy surgery. Dr. Van Orman’s research interests focus on the study of investigational medications, the ketogenic diet, and epilepsy surgery.

SPECIALTY PEDIATRIC EPILEPSY

JUDITH E. A. WARNER, MD
specializes in neuro-ophthalmology, the study of the eye as it relates to the brain. She evaluates complex visual complaints, which can be due to optic nerve or brain disease, and provides treatment for these disorders. Dr. Warner’s interests include diplopia, giant cell arteritis, optic neuropathies, and idiopathic intracranial hypertension.

SPECIALTY NEURO-OPTHALMOLOGY

JANA WOLD, MD
evaluates and treats acute stroke patients in the hospital and through use of the Telestroke Network (telemedicine). Dr. Wold provides outpatient consultation in the Stroke Clinic and in the General Neurology Clinic, and she serves on the NeuroHospitalist Inpatient Service. She is the director of the annual Utah Stroke Symposium, the program director for the Neurology Residency, and the vice-chair of the Utah Stroke Task Force. Her interests lie in inpatient neurology and education.

SPECIALTIES STROKE, VASCULAR NEUROLOGY

BRANDON A. ZIELINSKI, MD, PHD
joined the Division of Pediatric Neurology after completing his subspecialty training at the University of California San Francisco. His focus on acute care fills a “neurohospitalist” role, and his specific clinical interests include pediatric neurocritical care, stroke, and neurovascular disease. He studies large-scale brain networks in children using advanced functional and structural neuroimaging techniques. He is also developing a functional MRI clinical service with the Department of Radiology.

SPECIALTIES PEDIATRIC NEUROLOGY, STROKE, NEUROIMAGING

GEORGE M. ZINKHAN, MD
obtained a medical degree from the University of Texas Southwestern with distinction in research, after which he completed a residency in neurology at the University of Utah in 2011. Dr. Zinkhan treats a variety of neurological conditions in the General Neurology Clinic, including headache, multiple sclerosis, movement disorders, and stroke.

SPECIALTY GENERAL NEUROLOGY

DEPARTMENT OF NEUROSURGERY

WILLIAM T. COULDWELL, MD, PHD
serves as professor and chair of the Department of Neurosurgery at the University of Utah. He also has served as director for the American Board of Neurological Surgery and is the former president of the American Association of Neurological Surgeons. Dr. Couldwell has over 300 peer-reviewed publications and has been the recipient of several federal (NIH) and other research grants. His clinical interests include surgical management of epilepsy, neuro-oncology, pituitary tumors, skull base and cerebrovascular neurosurgery.

SPECIALTIES SKULL BASE SURGERY, NEUROSURGICAL, ONCOLOGY, NEUROVASCULAR SURGERY

RONALD I. APFELBAUM, MD EMERITUS
is professor emeritus in the Department of Neurosurgery. Throughout his tenure with the University of Utah, Dr. Apfelbaum served as Neurosurgery Residency Training Program director, interim chair for the Department of Neurosurgery, and also directed the Neurosurgery Spine Program and the neurosurgery portion of the Spine Fellowship Program. Since he retired in 2009, Dr. Apfelbaum continues to participate in an advisory and teaching role for the Department of Neurosurgery.

SPECIALTIES CERVICAL SPINE SURGERY, CRANIAL NERVE AND SKULL BASE SURGERY, PITUITARY SURGERY

ERICA F. BISSON, MD
specializes in complex spine surgery with a focus on cervical disease (neck pain), spinal cord injury, spine trauma, and degenerative spinal conditions (neck and back pain). Dr. Bisson obtained her medical degree from Tufts University. She also completed her fellowship in spine surgery at the University of Utah in 2008 and is currently an associate professor in the Department of Neurosurgery at the University of Utah. Dr. Bisson’s professional interests include occipitocervical disease, cervical degenerative disorders, advanced spinal fusion techniques, and image-guided surgery.

SPECIALTY COMPLEX SPINE SURGERY

ROBERT J. BOLLO, MD, MS
received his medical degree from Boston University School of Medicine in 2003. He then completed an internship as well as his neurosurgery residency at New York University Medical Center and Bellevue Hospital between 2003-2010. Following his residency he completed a one-year pediatric fellowship at the University of Utah. Following his fellowship, he was appointed...
EDGAR C. GOLDBTON, JR., MD
is actively involved with the development and implementation of the Comprehensive Spine Program at the University of Utah, which incorporates a multidisciplinary approach to spine care. His clinical interests are in interventional spinal medicine and spinal diagnostics, as well as the non-operative management of spinal and musculoskeletal disorders. He has strong interests in spine-related science and research.

SPECIALTIES SPINE, PAIN MEDICINE

GREGORY HAWRYLUK, MD, PHD, FRCSC
is a neurosurgeon-scientist who comes to University of Utah Health Care from the University of California San Francisco, where he recently completed subspecialty training in neurotrauma and complex spinal surgery. Dr. Hawryluk is a general neurosurgeon with a special interest in the management of patients with head and spine injuries. He contributes to the international guidelines that set the standard for how patients with severe brain injuries are managed and will be a crucial member of the Neurocritical Care Team at University of Utah Health Care.

SPECIALTIES NEUROSURGERY, NEUROCITICAL CARE

ROBERT S. HOOD, MD
is the second-ever resident of the Department of Neurosurgery and has since returned as faculty in September 2010. Prior to joining the department, Dr. Hood built a reputable career in minimally invasive spine surgery and overall patient care. Dr. Hood also developed a surgical procedure to treat far lateral lumbar herniated discs in the 1980s.

SPECIALTIES COMPLEX AND MINIMALLY INVASIVE SPINE SURGERY

PAUL A. HOUSE, MD
surgically treats patients who suffer from epilepsy and movement disorders, including tremor, Parkinson’s disease, and dystonia. His research interests include improving the ‘decoding’ of movement information from the brain, understanding epileptic activity across several orders of scale, and designing new devices to provide communication with the brain.

SPECIALTIES EPILEPSY, MOVEMENT DISORDERS

L. ERIC HUANG, MD, PHD
studies mechanisms of tumor progression by the microenvironment. His research focuses on the molecular basis of genetic alterations driven by tumor hypoxia, an area of research pioneered by his team and funded by the National Institutes of Health. Dr. Huang’s interests include molecular mechanisms of tumor progression, brain tumors, and molecular targets.

SPECIALTIES TUMOR HYPOXIA, BRAIN TUMORS
RANDY L. JENSEN, MD, PHD

has a particular emphasis on the treatment of patients with brain tumors. He sees patients with malignant, benign, primary, and metastatic brain tumors. Dr. Jensen’s clinical interests include neuro-oncology, stereotactic radiosurgery, general neurosurgery, intraoperative computer-guided navigation, the use of intraoperative MRI for tumor resection, and cortical mapping of lesions in eloquent brain. He is also a member of the Brain Tumor Research Team at Huntsman Cancer Institute and has a laboratory that examines the role of hypoxia in brain tumor growth and development. He is the director of the Neurosurgery Residency Program. He has served in leadership roles for a number of neurosurgery courses, as well as regional and national neurosurgical societies, and serves on the editorial board of the Journal of Neurosurgery, NeuroOncology and the Journal of Radiosurgery and SRT.

SPECIALTY NEUROSURGICAL ONCOLOGY

JOHN R. KESTLE, MD

is currently professor of neurosurgery and vice chair of clinical research at the University of Utah. He trained at McMaster University in clinical epidemiology and biostatistics. Since the beginning of his career, he has been the principal investigator in a number of multicenter clinical trials in pediatric hydrocephalus and has trained seven pediatric neurosurgery residents in clinical epidemiology and biostatistics (MPH training). In 2006, Dr. Kestle co-founded the Hydrocephalus Clinical Research Network (HCNR). He received NIH funding (RC1NS068943-01) in 2009 and currently has 17 investigators, nine centers and six network protocols running. His role has been development of the network, recruitment of centers and investigators and mentoring of young investigators. Continued development of clinical research in the neurosciences, especially in hydrocephalus, remains his highest academic priority.

SPECIALTIES BRAIN TUMORS, NEUROSURGERY, PEDIATRIC NEUROSURGERY, NEUROCRITICAL CARE

MARK LEHMKUHLE, PHD

received his BS in biomedical engineering at Case Western University in Cleveland, OH in 1999 as well as his PhD degree in 2004 from the University of Utah in the Department of Bioengineering. Dr. Lehmkule went on to complete a postdoctoral training at the University of Michigan, Kresge Hearing Research Institute in Ann Arbor, MI, between 2004-2008. In 2008 he completed his postdoctoral training in the Department of Physiology at the University of Utah.

SPECIALTIES CORTICAL NEURAL PROSTHESIS, EPILEPSY, DEEP BRAIN STIMULATION, NEURAL ENGINEERING

JOEL D. MACDONALD, MD

is associate professor of neurosurgery at the University of Utah, where he specializes in neurosurgery, spine surgery, skull base surgery, head trauma and neurocritical Care. He attended medical school at the University of North Carolina and completed his residency at the University of Utah. Dr. MacDonald completed a fellowship in cerebrovascular and skull base neurosurgery from the University of Florida.

SPECIALTIES NEUROSURGERY, SPINE SURGERY, SKULL BASE SURGERY, HEAD TRAUMA AND NEUROCRITICAL CARE

MARK A. MAHAN, MD

is a neurosurgeon who comes to University of Utah Health Care from the Barrow Neurological Institute in Phoenix, AZ. He completed fellowships in peripheral nerve surgery at the Mayo Clinic and UCSD. Dr. Mahan specializes in spine surgery and will be the only physician in the Intermountain region capable of providing complex peripheral nerve reconstruction and surgical neurorehabilitation.

SPECIALTIES NEUROSURGERY, PERIPHERAL NERVE, SPINAL DISORDERS

JAMES P. (PAT) MCCALLISTER II, PHD

directs a multidisciplinary laboratory that investigates the pathophysiology of hydrocephalus with a particular emphasis on pharmacological treatments to prevent brain damage or promote repair, diagnostic imaging, and novel bioengineering applications to improve cerebrospinal fluid drainage devices. He is the recipient of the Robert H. Pudenz Prize for Excellence in Cerebrospinal Fluid Physiology and Hydrocephalus from the International Society for Pediatric Neurosurgery.

SPECIALTY HYDROCEPHALUS RESEARCH

MIN S. PARK, MD, FAANS

is a neurosurgeon who comes to University of Utah Health Care from the Barrow Neurological Institute in Phoenix, AZ, where he recently completed a fellowship in endovascular neurosurgery. He has active clinical research interests in the endovascular treatment of cerebral aneurysms, focusing on clinical outcomes following endovascular treatment, the use of flow diversion, and the MRI imaging of cerebral aneurysms. With the ability to perform a comprehensive suite of open and endovascular neurosurgical procedures, Dr. Park’s presence will help enable University of Utah Hospital to provide 24/7/365 coverage for patients requiring neurovascular treatment.

SPECIALTIES AVMS, ANEURYSMS, CAVERNOUS ANGIOMAS, MENINGIOMAS, MOYA-MOYA, STROKE, CAROTID DISEASE

JAY K. RIVA-CAMBRIN, MD, MSC

joined the faculty of the University of Utah and Primary Children’s Hospital in 2006. Dr. Riva-Cambrin’s clinical interests in pediatric neurosurgery include the treatment of hydrocephalus and clinical trials. He performs over 250 neurosurgeries per year, with 100 being hydrocephalus related.

SPECIALTIES PEDIATRIC NEUROSURGERY, HYDROCEPHALUS, BRAIN TUMORS, ENDOSCOPIC SURGERY

MEIC H. SCHMIDT, MD, MBA, FACS

serves as vice chair of the Department of Neurosurgery at the University of Utah and chief of the Spinal Oncology Service at Huntsman Cancer Institute. His academic practice specializes in neurosurgical oncology, neurotrauma, minimally invasive and complex spinal surgery. He provides neurosurgery and spine care for patients with metastatic spine disease, traumatic spine injuries, brain and spinal cord tumors, and degenerative spine disease.

SPECIALTIES NEUROSURGERY, SPINE, ONCOLOGY, TRAUMA
RICHARD H. SCHMIDT, MD, PHD
joined the Department of Neurosurgery in 1993 and currently serves as associate professor. Dr. Schmidt has clinical and research interests that include cerebral aneurysms, Chiari malformation, hydrocephalus, trauma and critical care. **SPECIALTIES** CEREBRAL ANEURYSMS, VASCULAR MALFORMATION, CHIARI MALFORMATION, ENDOSCOPIC VENTRICULAR SURGERY

PHIL TAUSSKY, MD
completed a skull base/cerebrovascular fellowship at the University of Utah and an endovascular fellowship at the Mayo Clinic, focusing on minimally invasive techniques to treat stroke, aneurysms, AVMS and other vascular diseases. As a result of his dual training, he has a unique perspective offering his patients both microsurgical and minimally invasive endovascular treatment for vascular disease. His training also included extensive experience in the use of modern flow diverters, such as the Pipeline device. **SPECIALTIES** AVMS, ANEURYSMS, CAVERNOUS ANGIOMAS, MENINGIOMAS, MOYA-MOYA, STROKE, CAROTID DISEASE

MARION L. WALKER, MD
is professor of neurosurgery in the Division of Pediatric Neurosurgery and adjunct professor of pediatrics at the University of Utah and Primary Children’s Hospital. Dr. Walker is former chair of the pediatric section of the American Association of Neurological Surgeons, the section on pediatric neurosurgery of the American Academy of Pediatrics, and the American Society of Pediatric Neurosurgeons. He also served as president of the International Society of Pediatric Neurosurgery and was a past editor for the *Journal of Neurosurgery: Pediatrics*. **SPECIALTY** PEDIATRIC NEURORADIOLOGY

Satoshi Minoshima, MD, PhD
is professor and chair of the Department of Radiology at University of Utah Health Care. Dr. Minoshima is an internationally renowned clinician and scientist in the field of dementia and molecular imaging, and most recently held the position of Wil B. Nelp Endowed Professor in Radiology at University of Washington in Seattle. He is internationally recognized for his research, including the discovery of the posterior cingulate abnormality in Alzheimer’s disease and invention and dissemination of diagnostic statistical mapping technology for brain PET and SPECT scan interpretation. **SPECIALTY** NUCLEAR MEDICINE

Karen L. Salzman, MD
is chief of the Division of Neuroradiology. She has special interest in neuro-oncologic imaging and new imaging techniques, including magnetic resonance (MR) perfusion, MR spectroscopy, and diffusion tensor imaging (DTI). Dr. Salzman’s research interests include brain tumor perfusion imaging and DTI in an effort to help improve accurate pre-operative diagnosis and surgical planning and predict prognosis. Other research interests include stroke imaging, along with head and neck neoplasms. **SPECIALTY** NEURORADIOLOGY

Jeffrey S. Anderson, MD, PhD
directs the fMRI Neurosurgical Mapping Service and is principal investigator for the Utah Functional Neuroimaging Laboratory. Dr. Anderson’s lab studies brain networks using functional imaging techniques such as fMRI, diffusion tensor imaging, and magnetoencephalography. Dr. Anderson also has particular interest in autism, multiple sclerosis, vision research, and dementia. **SPECIALTY** NEURORADIOLOGY

Yoshimi Anzai, MD, MPH
is a professor of radiology at the University of Utah and is an expert in head and neck/neuro imaging, publishing over 150 articles during her 15-year academic career. A graduate from Chiba University Medical School in Japan with subsequent research training at UCLA, Dr. Anzai completed her radiology residency and neuroradiology fellowship at the University of Michigan. Her major area of research interest is focused on head and neck cancer imaging, traumatic brain injury and neurodegenerative disease. **SPECIALTIES** NEURORADIOLOGY, TRAUMATIC BRAIN INJURY, NEURODEGENERATIVE DISEASE

H. Christian Davidson, MD
is a board-certified neuroradiologist with subspecialty interests in imaging of brain ischemia, imaging of the orbit, and imaging of the head and neck. Dr. Davidson has a background in medical informatics, including clinical and educational computer systems. He is also program director for the Radiology Residency Program and has served in various leadership capacities in the University of Utah Medical Group for the past decade. **SPECIALTIES** NEURORADIOLOGY, MEDICAL INFORMATICS

H. Ric Harnsberger, MD
is professor of radiology and R.C. Willey Chair of Neuroradiology at the University of Utah. He is an internationally recognized expert in head and neck imaging, having published over 250 articles and eight books in this area. Dr. Harnsberger is also chair and CEO of AMIRSYS, Inc., a medical electronic decision support company. **SPECIALTY** NEURORADIOLOGY

Troy Hutchins, MD
is a board-certified radiologist currently serving as assistant professor of radiology at the University of Utah. He is licensed to practice medicine in Utah, California, and Louisiana. He attended medical school at the Medical University of South Carolina and completed his residency at Tulane University. He completed neuroradiology fellowships at the University of Utah, and Cedars-Sinai Medical Center. **SPECIALTY** NEURORADIOLOGY
SCOTT MCNALLY, MD, PHD
is an assistant professor of radiology at the University of Utah, where his research interests include carotid MRI, intraplaque hemorrhage, stroke risk stratification, and utilizing high-resolution MRI to measure treatment response. He attended Emory University, where he completed medical school and his doctoral training. He later completed his radiology residency and a neuroradiology fellowship at the University of Utah.

SPECIALTY NEURORADIOLOGY

LUBDHA M. SHAH, MD
has interests that include advanced magnetic resonance imaging (MRI) techniques such as functional MRI, diffusion tensor imaging, and perfusion MR for the brain and spine. In addition to diagnostic radiology, Dr. Shah performs spine interventional procedures such as epidural steroid injections and biopsies. SPECIALTY NEURORADIOLOGY

ANNE G. OSBORN, MD
is distinguished professor of Radiology at the University of Utah. She is recognized internationally for helping establish the field of neuroradiology, which deals with the head, neck, spine, and the central and peripheral nervous system. Dr. Osborn is also the author of numerous medical books and journal articles and is the co-creator of the first comprehensive point-of-care electronic imaging reference system.

SPECIALTY NEURORADIOLOGY

EDWARD P. QUIGLEY III, MD, PHD
centers his research on improving detection, characterization, and the treatment of neurologic diseases through advanced imaging. Disease processes studied by Dr. Quigley include multiple sclerosis, optic neuritis, neoplasm, epilepsy imaging, dementia and aging brain, vascular anomalies and aneurysm.

SPECIALTY NEURORADIOLOGY

ULRICH A. RASSNER, MD
is medical director of magnetic resonance imaging (MRI) and computed tomography (CT) at the University of Utah. Dr. Rassner also has specific research and clinical interest in MRI physics and MRI safety. SPECIALTY NEURORADIOLOGY

EDWIN A. “STEVE” STEVENS, MD
is professor and chair of the Department of Radiology at the University of Utah. Dr. Stevens specializes in neurointerventional surgery, treating neurological diseases by endovascular and minimally invasive techniques guided by imaging. Dr. Stevens has given over 50 presentations, published over 30 articles and book chapters, and is a reviewer for the American Journal of Neuroradiology.

SPECIALTY NEUROINTERVENTIONAL SURGERY

RICHARD H. WIGGINS III, MD, CIIP, FSIIM
is professor of radiology, director of head and neck imaging, and medical administrator for the Picture Archiving Communication System (PACS) at the University of Utah. He is an internationally recognized expert in both head and neck imaging and imaging informatics. In 2008, the Department of Radiology awarded Dr. Wiggins with the Teacher of the Year Award. Dr. Wiggins’ research interests include biomedical informatics, head and neck and brain tumor perfusion imaging, and advanced head and neck imaging. Dr. Wiggins has published over 150 books, book chapters, and peer-reviewed publications and has given over 250 invited presentations.

SPECIALTIES HEAD AND NECK IMAGING, IMAGING INFORMATICS
# RESIDENTS & FELLOWS

## NEUROLOGY

### RESIDENTS

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<tr>
<th>PGY-4</th>
<th>Jennifer Hranilovich, MD</th>
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## NEURORADIOLOGY

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## NEUROSURGERY

### RESIDENTS

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<th>PGY-4</th>
<th>Jian Guan, MD</th>
<th>Bornali Kundu, MD, PHD</th>
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| **PGY-7** | Bornali Kundu, MD, PHD |
| Christian Bowers, MD | Christopher Wilkerson, MD |
OUR MISSION  
The University of Utah Health Sciences Center serves the people of Utah and beyond by continually improving individual and community health and quality of life. This is achieved through excellence in patient care, education, and research; each is vital to our mission and each makes the others stronger.

• We provide compassionate care without compromise.
• We educate scientists and health care professionals for the future.
• We engage in research to advance knowledge and well-being.

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• Innovation
• Responsibility
• Diversity
• Integrity
• Quality
• Trust

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