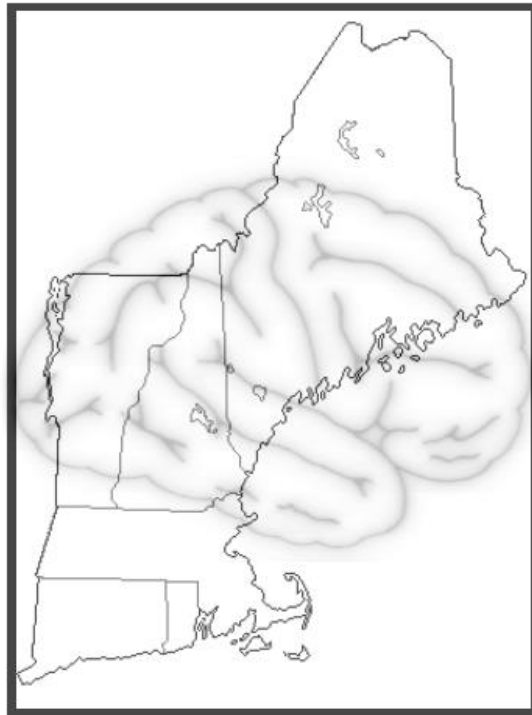


New England Neurosurgical Society Annual Meeting



Ocean Edge Resort
Brewster, MA
June 27-29, 2019



NENS OFFICERS 2019

President: William Curry, MD

Secretary: S. Scott Lollis, MD

Treasurer: Andrew Wakefield, MD

Executive Committee: David Bauer, MD, Robert Whitmore, MD, Dennis Oh, MD, Michael Groff, MD

2019 Planning Committee

Co-Chair: David Bauer, MD

Co-Chair: Robert Whitmore, MD

William Curry, MD

S. Scott Lollis, MD

Andrew Wakefield, MD

Dennis Oh, MD

Michael Groff, MD

ACCREDITATION STATEMENT

This activity has been planned and implemented in accordance with the accreditation requirements and policies of the Accreditation Council for Continuing Medical Education (ACCME) through the joint providership of the AANS and the New England Neurosurgical Society. The AANS is accredited by the ACCME to provide continuing medical education for physicians.

DESIGNATION STATEMENT

The AANS designates this live activity for a maximum of **7.25 AMA PRA Category 1 Credits™**. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

AANS DISCLAIMER STATEMENT

The material presented at the Annual NENS meeting has been made available by the New England Neurosurgical Society and the AANS for educational purposes only. The material is not intended to represent the only, nor necessarily the best, method or procedure appropriate for the medical situations discussed, but rather it is intended to present an approach, view, statement, or opinion of the faculty, which may be helpful to others who face similar situations.

Neither the content (whether written or oral) of any course, seminar or other presentation in the program, nor the use of a specific product in conjunction therewith, nor the exhibition of any materials by any parties coincident with the program, should be construed as indicating endorsement or approval of the views presented, the products used, or the materials exhibited by the New England Neurosurgical Society and jointly provided by the AANS, or its Committees, Commissions, or Affiliates.

Neither the AANS nor the New England Neurosurgical Society makes any statements, representations or warranties (whether written or oral) regarding the Food and Drug Administration (FDA) status of any product used or referred to in conjunction with any course, seminar or other presentation being made available as part of the Annual NENS meeting. Faculty members shall have sole responsibility to inform attendees of the FDA status of each product that is used in conjunction with any course, seminar or presentation and whether such use of the product is in compliance with FDA regulations.

HOW TO CLAIM YOUR CME CREDIT

To claim CME credits you must go to this link:

<https://www.surveymonkey.com/r/2019NENSEVAL> to complete the 2019 Evaluation and CME Attendance Verification Form. There will also be an informational email sent out after the meeting with this link.

Once both these items are complete, your CME Certificate will be emailed to you within one month of the completion of the meeting.

Please Note! In order to expedite your Certificate, please complete this information within 2 weeks of the meeting (by July 12, 2019).

DISCLOSURES

The AANS and the New England Neurosurgical Society control the content and production of this CME activity and attempt to ensure the presentation of balanced, objective information. In accordance with the Standards for Commercial Support established by the Accreditation Council for Continuing Medical Education (ACCME), faculty, abstract reviewers, paper presenters/authors, planning committee members, staff and any others involved in planning the educational content and the significant others of those mentioned must disclose any relationship they or their co-authors have with commercial interests which may be related to their content. The ACCME defines "relevant financial relationships" as financial relationships in any amount occurring within the past 12 months that create a conflict of interest.

Those who have disclosed a relationship* with commercial interests are listed below:

| | |
|-------------------|--|
| Alterman, Ron | Consultant Fee: Medtronic Stock or Shareholder: Helius, Incl Honorarium: Elekta |
| Carter, Bob | Speakers Bureau: NS Employee: MGH Other Financial or Material Support: NIH Grant |
| Danish, Shabbar | Industry Grant Support: Medtronic Consultant Fee: Medtronic |
| Ghogawala, Zohar | Stock or Shareholder: GN2.0-Nidus Fiduciary Position: Cervical Spine Research Society; North American Spine Society; Chair, AANS-CNS Spine Section |
| Groff, Michael | Consultant Fee: Depuy Spine, Biomet Spine, Nuvasive, Spine Art |
| Lu, Yi | University Grants/Research Support: Stepping Strong Foundation Consultant Fee: Depuy/Synthes Stock or Shareholder: AxioMed Speaker's Bureau: Paradigm Spine |
| Maragos, Georgios | Industry Grant: Medtronic |
| Robertson, Faith | University Grants/Research Support: Harvard Medical School Scholars in Medicine Office – Research Funds |
| Whitmore, Robert | Consultant Fee: Intrinsic Therapeutics; Depuy Synthes Spine |

Those who have reported they do not have any relationships with commercial interests:

Ascanio, Luis
Borden, Jonathan
Callahan, Katherine
Curry, William
Dowd, Richard
Grannan, Benjamin
Huang, Kevin
Koch, Matthew
Lai, Pu Man Rosalind
Limoges, Natalie
Mendoza-Elias, Naysa
Oh, Dennis
Pikus, Harold
Sadegh, Cameron
Stoppa, Brittany
Wakefield, Andrew

Bauer, David
Brown, Justin
Cord, Branden
Day, Emily
Elsamadicy, Aladine
Hauser, Blake
Kanter, John
Koffie, Robert
Lak, Asad
Lollis, Scott
Moses, Ziev
Oyelese, Adetokunbo
Riordan, Coleman
Shaffrey, Christopher
Tafel, Ian
Wells, Michael

LEARNING OBJECTIVES

Upon completion of this program, participants should be able to:

Objective 1:

Identify the approach and surgical technique for correction of adult spinal deformity.

Objective 2:

Identify the modern surgical options for treatment of cervical spondylotic myelopathy.

Objective 3:

Identify current advances in cranial and spine surgery.

Objective 4:

Analyze literature and presentations in order to determine best practices in neurosurgery.

INTENDED AUDIENCE

The target audience includes Attending Neurosurgeons in Academic and private practice, Neurosurgical Residents, Interns, Medical Students, Neurosurgical Nurses, Nurse Practitioners, and Physician Assistants.

METHOD OF INSTRUCTION

Live program with interactive discussion and question and answer period with participants using PowerPoint and KeyNote presentations

Speakers/Moderators/Faculty

Ronald Alterman, MD – Beth Israel Deaconess Medical Center, Boston, MA
Luis Ascanio, MD – Research Fellow at Beth Israel Deaconess Medical Center, Boston, MA
David Bauer, MD - Dartmouth-Hitchcock Medical Center, Lebanon, NH
Jonathan Borden, BS – Medical Student at Robert Larner MD College of Medicine at the University of Vermont, Burlington, VT
Justin Brown, MD – Massachusetts General Hospital, Boston, MA
Bob Carter, MD – Massachusetts General Hospital, Boston, MA
Katherine Callahan, BA – Medical Student at Robert Larner MD College of Medicine at the University of Vermont, Burlington, VT
Branden Cord, MD – Resident at Yale University School of Medicine, New Haven, CT
William Curry, MD – Massachusetts General Hospital, Boston, MA
Shabbar Danish, MD – Rutgers Cancer Institute, Rutgers, NJ
Emily Day, BS – Boston Children’s Hospital, Boston, MA
Richard Dowd, MD – Resident at Tufts Medical Center, Boston, MA
Aladine Elsamadicy – Resident at Yale University School of Medicine, New Haven, CT
Zoher Ghogawala, MD – Lahey Clinic and Hospital, Burlington, MA
Benjamin Grannan, MD – Resident at Massachusetts General Hospital, Boston, MA
Michael Groff, MD – Brigham & Women’s Hospital, Boston, MA
Blake Hauser, BS – Medical Student at Harvard Medical School, Boston, MA
Kevin Huang, MD – Resident at Brigham & Women’s Hospital, Boston, MA
Alexander Hulsbergen, BS – Research Intern at Brigham & Women’s Hospital, Boston, MA
John Kanter – Resident at Dartmouth-Hitchcock Medical Center, Lebanon, NH
Matthew Koch, MD – Resident at Massachusetts General Hospital, Boston, MA
Robert Koffie, MD – Resident at Massachusetts General Hospital, Boston, MA
Pu Man Rosalind Lai, MD – Resident at Brigham & Women’s Hospital, Boston, MA
Asad Lak, MD – Research Fellow at Brigham & Women’s Hospital, Boston, MA
Natalie Limoges, MD – Resident at University of Vermont Medical Center, Burlington, VT
S. Scott Lollis, MD – University of Vermont Medical Center, Burlington, VT
Yi Lu, MD, PhD – Brigham & Women’s Hospital, Boston, MA
Georgios Maragkos, MD – Post Doctoral Research Fellow at Beth Israel Deaconess Medical Center, Boston, MA
Nasya Mendoza-Elias, MD – Resident at Lahey Hospital and Medical Center, Burlington, MA
Ziev Moses, MD – Resident at Brigham & Women’s Hospital, Boston, MA
Dennis Oh, MD – Baystate Medical Center, Springfield, MA
Adetokunbo Oyelese, MD – Rhode Island Hospital, Providence, RI
Harold Pikus, MD – Upper Valley Neurology and Neurosurgery, Lebanon, NH
Coleman Riordan, BS - Medical Student at Harvard Medical School, Boston, MA
Faith Robertson – Medical Student at Harvard Medical School, Boston, MA
Cameron Sadegh, MD – Resident at Massachusetts General Hospital, Boston, MA
Christopher Shaffrey – Duke Spine Division, Durham, NC
Brittany Stopa, MPH – Medical Student at Harvard Medical School, Boston, MA
Ian Tafel, MD – Resident at Brigham & Women’s Hospital, Boston, MA
Andrew Wakefield, MD – Hartford Hospital, Hartford, CT
Michael Wells, MD – Brigham & Women’s Hospital, Boston, MA
Robert Whitmore, MD – Lahey Hospital and Medical Center, Burlington, MA

MEMBERS PARTICIPATING

Ronald Alterman – Beth Israel Deaconess Medical Center, Boston, MA
Joshua Aronson – Dartmouth Hitchcock Medical Center, Lebanon, NH
David Bauer – Dartmouth Hitchcock Medical Center, Lebanon, NH
Wenya Linda Bi – Brigham & Women’s Hospital, Boston, MA
Emanuela Binello – Boston Medical Center, Boston, MA
Daniel Cahill – Massachusetts General Hospital, Boston, MA
John Chi – Brigham & Women’s Hospital, Boston, MA
William Curry – Massachusetts General Hospital, Boston, MA
Susan Durham – University of Vermont Medical Center, Burlington, VT
Katie Fehnel – Boston Children’s Hospital, Boston, MA
Jared Fridley – Rhode Island Hospital, Providence, RI
Ziya Gokaslan – Rhode Island Hospital, Providence, RI
Peter Grillo – New England Neurological Associates, Lawrence, MA
Michael Groff – Brigham & Women’s Hospital, Boston, MA
Murat Gunel – Yale University, New Haven, CT
Jennifer Moliterno Gunel – Yale University, New Haven, CT
Kristopher Kahle – Yale University, New Haven, CT
James Kryzanski – Tufts Medical Center, Boston, MA
S. Scott Lollis – University of Vermont Medical Center, Burlington, VT
Yi Lu – Brigham & Women’s Hospital, Boston, MA
Natasha McKay – New England Neurosurgical Associates, Springfield, MA
Gerard Mohr – Jewish General Hospital, Montreal, Quebec, Canada
Dennis Oh – Baystate Medical Center, Springfield, MA
Adetokunbo Oyelese – Rhode Island Hospital, Providence, RI
Nirav Patel – Brigham & Women’s Hospital, Boston, MA
Harold Pikus – Upper Valley Neurology & Neurosurgery, Lebanon, NH
Mark Proctor – Boston Children’s Hospital, Boston, MA
Melvin Prostkoff – Senior Member, Great Bay Neurosurgical, Dover, NH
Timothy Ryken - Dartmouth-Hitchcock Medical Center, Lebanon, NH
Stephen Saris – Neurosurgery Associates, Providence, RI
R. Michael Scott – Senior Member, Boston Children’s Hospital, Boston, MA
Perry Shear – Orthopaedic Specialty Group, Fairfield, CT
John Shin – Massachusetts General Hospital, Boston, MA
Bruce Tranmer – University of Vermont Medical Center, Burlington, VT
Andrew Wakefield – CT Neurosurgery & Spine Associates, Windsor, CT
Robert Whitmore – Lahey Clinic, Burlington, MA

EXHIBITORS

We appreciate the support of our 2019 Annual Meeting and encourage you to visit their websites and meet with representatives who may be able to provide you with additional information to our meeting.

Aesculap

Baxter Biosurgery

Cerapedics

DePuy Synthes Spine

Globus Medical

Integra

Medtronic

Micro Image Technologies

Neuro Alert Monitoring Services

Nuvasive

Olympus

Pacira

Pfizer

RTI Surgical

Spine Wave

Stryker:

CMF/Neuro/Instruments/Spine

Zimmer Biomet

New England Neurosurgical Society

PAST PRESIDENTS

| | |
|---------|----------------------|
| 1951-52 | W.B. Scoville |
| 1952-53 | G.L. Maltby |
| 1953-54 | Hannibal Hamlin |
| 1954-55 | John T.B. Carmody |
| 1955-56 | William H. Sweet |
| 1956-57 | Henry Heyl |
| 1957-58 | H. Thomas Ballantine |
| 1958-59 | R.B. Donaghy |
| 1959-60 | Benjamin B. Whitcomb |
| 1960-61 | Francis H. O'Brien |
| 1961-62 | Bertram Selverstone |
| 1962-63 | Robert Fisher |
| 1963-64 | Joseph Dorsey |
| 1964-65 | Albert Crawford |
| 1965-66 | James C. Walker |
| 1966-67 | Charles A. Fager |
| 1967-68 | Ernest Sachs, Jr. |
| 1968-69 | Rembrandt Dunsmore |
| 1970-71 | Edwin Lang |
| 1971-72 | Walter C. Cotter |
| 1972-73 | David M. Barry |
| 1973-75 | Ronald Birkenfeld |
| 1975-77 | David Cavicke |
| 1977-79 | Harold A. Wilkinson |
| 1979-81 | Richard M. Swengel |
| 1981-83 | Stephen R. Freidberg |
| 1983-85 | Paul T. Welch |
| 1985-87 | Demosthenes D. Dasco |
| 1987-89 | Edward Tarlov |
| 1989-91 | Melvin Roberts |
| 1991-93 | William Shucart |
| 1993-95 | John Shillito |
| 1995-97 | Eugene Leibowitz |
| 1997-99 | Isaac Goodrich |
| 1999-01 | Richard L. Saunders |
| 2001-03 | Robert Harbaugh |
| 2003-05 | Peter Dempsey |
| 2005-07 | Christopher Ogilvy |
| 2007-08 | Gary Bloomgarden |
| 2008-09 | N. Ross Jenkins |
| 2009-10 | Bruce Tranmer |
| 2010-11 | Carl Heilman |

PAST PRESIDENTS continued

| | |
|---------|-----------------|
| 2011-12 | Perry A. Ball |
| 2012-13 | Inam Kureshi |
| 2013-14 | Stephen Johnson |
| 2014-15 | Carlos David |
| 2015-16 | Michael Horgan |
| 2016-17 | Mark R. Proctor |
| 2017-18 | James Kryzanski |

New England Neurosurgical Society

LIFETIME ACHIEVEMENT AWARD WINNERS

| | |
|------|------------------|
| 2017 | David W. Roberts |
| 2018 | R. Michael Scott |

FACULTY LIST

Christopher Shaffrey, MD, FAANS – Duke Spine Division, Durham, NC

Dr. Shaffrey graduated magna cum laude from The Citadel in 1982 with B.S. degree in Biology. He played varsity basketball and was the co-captain his senior year. In 1986, Dr. Shaffrey received his medical degree from the University of Virginia. He completed his general surgical internship at Naval Hospital San Diego in 1987 where he was named the surgical intern of the year. He completed both neurosurgical and orthopaedics residencies at the University of Virginia. A spine fellowship in pediatric and adult reconstructive spine surgery was completed in 1995.

Following completion of his surgical training, he was appointed to the senior staff in the Departments of Neurological Surgery and Orthopaedic Surgery at Henry Ford Hospital where he was actively involved in treating members of Detroit's college and professional athletic teams. In 1999, Dr. Shaffrey was appointed Associate Professor of Neurological Surgery and Adjunct Associate Professor of Orthopaedic Surgery and Sports Medicine at the University of Washington in Seattle. In 2003, he returned to the University of Virginia as Professor of Neurological Surgery and Director of the Neurosurgery Spine Division. In 2008, he was named Harrison Distinguished Teaching Professor of Neurological and Orthopaedic Surgery. On September 1, 2018 Dr. Shaffrey became the Chief of Duke's Spine Division. Dr. Shaffrey is board certified in the fields of Neurological Surgery and Orthopaedic Surgery.

Dr. Shaffrey has an active research interest in spinal surgery, particularly in numerous multicenter outcome research studies of pediatric and adult scoliosis, spinal trauma and tumors involving the spinal column. He has been a funded principal investigator in numerous grants and clinical trials. He serves on the Editorial Boards of Journal of Neurosurgery, Neurosurgery and Journal of Spinal Disorders. Dr. Shaffrey has greater than 100 publications, greater than 500 national and international presentations and served as editor for several textbooks on spinal surgery.

During his career in medicine, Dr. Shaffrey has won numerous awards for clinical medicine. He has won the Counsel of State Neurosurgical Societies Young Neurosurgeons Award. He has been named to Best Doctors and Top Doctors numerous times. He has an active role in organized neurosurgery and spinal surgery. He has been the Chair for the AANS/CNS Joint Section on Disorders of the Spine and Peripheral Nerves. He has served as the Morbidity and Mortality Committee Chair for the Scoliosis Research Society. He has been named to numerous honorary academic societies including the American Orthopaedic Association and the American Academy of Neurological Surgery.

Shabbar Danish, MD – Rutgers Cancer Institute, Rutgers, NJ

Since coming to Rutgers Robert Wood Johnson Medical School in 2008, Dr. Danish has been involved in re-designing the care of patients with brain and spine tumors in this region. He completed his undergraduate training at Rutgers University, and his medical degree at UMDNJ-Robert Wood Johnson Medical School. He obtained his neurosurgical training at the University of Pennsylvania, along with fellowship training in Stereotactic and Functional Neurosurgery as well as GammaKnife Radiosurgery.

Dr. Danish has a strong interest in minimally and noninvasive solutions to treat brain and spine cancer. He has research interests and publications in both fields.

Dr. Danish developed the Laser Ablation Program at Rutgers. Much of what has been learned and developed has been accomplished at this institution. He is also the director for the RWJ GammaKnife Center.

He has authored dozens of peer-reviewed articles and several book chapters as well winning the following awards:

Innovator of the Year Award, *NJ Biz*, 2012: Development of the Center for Brain Tumor Laser Ablation

Innovator of the year Award, *NJ Biz*, 2011: Development of a Multidisciplinary Center for the treatment of Parkinson's disease

AANS Goldenberg Research Award in Stereotactic and Functional Neurosurgery, 2008

Zoher Ghogawala, MD, FAANS – Lahey Clinic & Hospital, Burlington, MA

Dr. Ghogawala serves as the Charles A. Fager Chair of Neurosurgery at Lahey Hospital and Medical Center and is Associate Professor of Neurosurgery at Tufts University School of Medicine. His clinical specialty is the surgical treatment of patients with spine disorders, carotid disease, and pituitary brain tumors.

As Co-Director of the Comparative Effectiveness Research Institute, he is a thought-leader and researcher in the areas of comparative and cost-effectiveness, and neurosurgical outcomes, exploring the value, benefits and sometimes harmful results of different treatment options. He was the principal investigator of the national SLIP study—a randomized clinical trial that compared fusion versus no fusion following spinal decompression.

Dr. Ghogawala has recently received NIH and PCORI funding support to conduct a multi-center prospective randomized control trial that aims to compare ventral versus dorsal surgery options for cervical spondylotic myelopathy.

Dr. Ghogawala recently edited and published a textbook entitled, *The Evidence for Neurosurgery* and he has co-authored the newly updated *Lumbar Fusion Guidelines*. He has served as the Vice-President of the Congress of Neurological Surgeons and is active on the executive committee for AANS/CNS Joint Section on Disorders of the Spine and Peripheral Nerves. He served as the Scientific Program Chair for the 2015 Cervical Spine Research Society Meeting and was also the Annual Program Chair for the 2016 Spine Section Meeting. He is also on the Board of Directors of the North American Spine Society (NASS) and the Cervical Spine Research Society.

Dr. Ghogawala completed his undergraduate degree at Harvard University, and graduated from Harvard Medical School in 1991. He completed his residency training in neurological surgery at the Massachusetts General Hospital.

MEETING AGENDA

Thursday, June 27, 2019

12:00-1:30 pm: NENS Executive Board Meeting
Location: Captain Cook Conference Room

2:00-5:00 pm Case Review Conference
Location: Ballroom C&D

Friday, June 28, 2019

Location: Ballroom

7:00-8:00 Continental Breakfast for meeting participants with Exhibitors in Ballroom A&B
Registration in Ballroom Atrium

8:00-8:05 **Welcome, Will Curry, MD**
President, NENS

8:05-9:15 Scientific Session 1: Oral Abstracts
Moderator: S. Scott Lollis, MD

9:15-9:45 **Invited Lecturer: Dr. Zoher Ghogawala**
“Making Sense of Data and Finding the Truth in Neurosurgery”

9:45-10:15 Coffee Break with Exhibitors

10:15-11:45 Scientific Session 2: Oral Abstracts
Moderator: Andrew Wakefield, MD

11:45-12:15 **Invited Lecture: Dr. Chris Shaffrey**
“How Deformity Concepts Impact the Management of Most Spinal Conditions”

12:15 **ADJOURN**

Saturday, June 29, 2019

Location: Ballroom

7:00-8:00 Continental Breakfast for meeting participants with Exhibitors in Ballroom A&B
Registration in Ballroom Atrium

8:00-8:05 **Welcome, Will Curry, MD**
President, NENS

8:05-9:45 Scientific Session 3: Oral Abstracts
Moderator: David Bauer, MD

9:45-10:05 **ANNUAL BUSINESS MEETING – MEMBERS ONLY**

10:05-10:30 Coffee Break with Exhibitors

10:30-11:40 Scientific Session 4: Oral Abstracts
Moderator: Rob Whitmore, MD

11:40-12:10 **Invited Lecture: Shabbar Danish, MD**
“MRI guided Laser Interstitial Thermal Therapy: Where are we now?”

12:10 pm **ADJOURN**

Social Activities

Thursday, June 27, 2019

5:00 – 9:00 pm Opening Reception with Poster Presentations
Cocktails & Hors d'oeuvres
Location: Ballroom Terrace

Friday, June 28, 2019

1:00 – 5:00 pm Free Time

Other Available Activities: Golf
Tennis

6:30 – 7:30 pm Cocktail Hour
7:30 – 10:00 pm Annual Clambake & Beach Bonfire
Families Invited
Location: Cocktails on the Ballroom Terrace
Clambake at the Bay Pines Pavilion

Case Review Conference

Thursday, June 27, 2019

2:00-2:15 Welcome and first case, Will Curry, MD

2:15-2:30 Scott Lollis, MD

2:30-2:45 Andrew Wakefield, MD

2:45-3:00 David Bauer, MD

3:00-3:15 Robert Whitmore, MD

3:15-3:30 Dennis Oh, MD

3:30-3:45 Michael Groff, MD

3:45-4:00 James Kryzanski, MD

4:00-4:15 Ziya Gokaslan, MD

4:15 Adjourn

Poster Presentations

Thursday, June 27, 2019

The following posters will be presented at the Ballroom Terrace during the Opening Reception beginning at 5:00 pm

Thirty- and 90-Day Readmissions after Decompression and Stabilization Surgery for Spine Metastases: A National Trend Analysis

A. Elsamadicy, A. Koo, M. Lee, A. Kundishora, J. Camara-Quintana, T. Quershi, L. Kolb, M. Laurans, K. Abbed

Single-cellular Representations of Semantic Meaning during Natural Language Perception

B. Grannan, M. Jamali, E. Fedorenko, Z. Williams

Single-level Lumbar Transformational Lumbar Interbody Fusion: A Cohort Study Comparing Percutaneous and Minimally-invasive Approaches

K. Huang, A. Scruton, C. Muggler, A. Hong, J. Driver, M. Abd-El-Barr, J. Chi

Translational Studies of “Defective” MYODURAL BRIDGES – Neurosurgical Implications

P. Klinge, M. Beland, A. McElroy, J. Manfredi, D. Sledge, E. Stopa, A. Rashmir

Pedicled Omental Flaps for Complex Wound Reconstruction for Chordoma of the Mobile Spine and Sacrum

R. Koffie, L. Van Beaver, M. Hadzipasic, J. Wain, J. Mullen, F. Hornicek, J. Schwab, J. Shin

Mechanical Thrombectomy Prediction Score: A Simple Scoring Method that Predicts Outcomes after Endovascular Thrombectomy for Anterior Circulation Large Vessel Occlusions

P. Lai, D. Large, H. Ziajee, R. Du, S. Feske, M. Aziz-Sultan, N. Patel

Virtual Reality Uncovers Functional Heterogeneity of Single Unit Dopamine Neuron Activity in the Midbrain Ventral Tegmental Area

A. Malik, H. Kim, N. Uchida

Factors Affecting the Diagnostic Yield of Frame-Based Stereotactic Intracranial Biopsy

G. Maragos, A. Penumaka, J. Ahrendsen, E. Nelton, M. Salem, A. Filippidis, R. Alterman

Monotherapy Aspirin Use in Traumatic Brain Injury Does Not Worsen Outcome

N. Mendoza-Elias, S. Mackey, L. Jasak, S. Maggee, M. Rosenblatt, R. Whitmore, Z. Ghogawala

Results of Twenty-year or Greater Follow-up in Pediatric Patients with Moyamoya Disease Undergoing Pial Synangiosis

C. Riordan, E. Smith, M. Scott

Presentations and Abstracts

Friday, June 28, 2019

- 8:00-8:05 **Welcome, Will Curry, MD**
- 8:05-8:15 Opioid Use Associated with Worse Post-Operative Lumbar Fusion Outcome at 1-year
N. Mendoza-Elias, M. Dunbar, R. Heller, Z. Ghogawala, **R. Whitmore**
- 8:15-8:25 Management of Mild Traumatic Brain Injury in the Emergency Room Using a Pre-specified Protocol is Safe and Effective
J. Kanter, B. Root, D. Calnan, M. Reyes, H. Gill, P. Lanter
- 8:25-8:35 Choice of Treatment Intervention Does Not Predict 30- or 90-day Unplanned Readmissions after Treatment of Unruptured Aneurysms: A Study of the Nationwide Readmission Database
A. Koo, **A. Elsamadicy**, B. Cord, N. Sujjantararat, S. Sommaruga, C. Santarosa, S. Brown, R. Hebert, F. Bahrassa, A. Malhotra, K. Sheth, G. Falcone, C. Matouk
- 8:35-8:45 Direct vs. Indirect Revascularization in a North American Cohort of Moyamoya Disease
P. Lai, R. Du
- 8:45-8:55 Novel Technique for Atlantoaxial Interlaminar Arthrodesis Utilizing a Modified Sonntag Loop-suture Graft with Posterior C1-2 Fixation
R. Koffie, A. Larsen, B. Grannon, M. Hadzipasic, V. Yanamadala, G. Shankar, L. Van Beaver, J. Shin
- 8:55-9:05 Predictors of Elbow Flexion Outcomes Following Reconstructive Nerve Transfers for Brachial Plexus Injury: An Analysis of 651 Patients
M. Attiah, A. Phatia, **J. Brown**
- 9:05-9:15 Medical Student Perceptions of a Neurosurgical Career and Factors Influencing Career Choice
J. Borden, K. Callahan, S. Durham, R. Jewell
- 9:15-9:45 **Invited Lecture: Dr. Zoher Ghogawala**
“Making Sense of Data and Finding the Truth in Neurosurgery”
- 9:45-10:15 **COFFEE BREAK**

Friday, June 28, 2019 – continued

- 10:15-10:25 Large Single Institution Series of Endoscopically Treated Infants with Craniosynostosis
C. Riordan, D. Zurakowski, P. Meier, G. Alexopoulos, J. Meara, S. Goobie, M. Proctor
- 10:25-10:35 Endoscopic-assisted Mini-craniotomy versus Craniotomy for Management of Subacute Subdural Hematoma: Case-control Study and Technical Report
B. Grannan, M. Zachariah, S. Bick, G. Friedman, P. Codd, P. Agarwalla, J. Coumans
- 10:35-10:45 A Computer Vision Approach to Identifying the Manufacturer and Model of Anterior Cervical Spinal Hardware
K. Huang, M. Silva, A. See, K. Wu, T. Gallerani, H. Zaidi, Y. Lu, J. Chi, M. Groff, O. Arnaout
- 10:45-10:55 Burden of Illness of Aneurysmal Subarachnoid Hemorrhage across Multiple Healthcare Utilization Settings in the United States
G. Maragkos, L. Macdonald, J. Zamirowski, J. Moore, C. Ogilvy, A. Thomas
- 10:55-11:05 Cerebrospinal Fluid Leaks After Skull Base Fracture: A 30-Year Two-Institution Experience
B. Stopa, O. Leyval, K. Truman, C. Harper, T. Smith, W. Gormley
- 11:05-11:15 MRI-guided Cryoablation for Metastatic Spine Disease: Intermediate-term Clinical Outcomes in 14 Consecutive Patients
Z. Moses, K. Huang, T. Lee, J. Guenette, J. Chi
- 11:15-11:25 Arterial Redundancy: Implications for Susceptibility to Dissection
H. Pikus
- 11:25-11:35 Bridging Nerve Gaps with Multichannel Nerve Guidance Scaffolds with Targeted Structures and Mass-Produced Quantities
D. Shahriari, Z. Loke, **I. Tafel**, S. Park, P. Chiang, Y. Fink, P. Anikeeva
- 11:35-11:45 **Invited Lecture: Dr. Christopher Shaffrey**
“How Deformity Concepts Impact the Management of Most Spinal Conditions”
- 11:45 **ADJOURN**

Saturday, June 29, 2019

- 8:00-8:05 **Welcome, Will Curry, MD**
- 8:05-8:15 Intraventricular Hemorrhage Induces Rapid Calcium Signaling in Rodent Choroid Plexus Epithelial Cells
C. Sadegh, N. Dani, F. Shipley, M. Lehtinen
- 8:15-8:25 Improved Functional Outcomes with Percutaneous Trans-carotid Mechanical Thrombectomy Following Failed Trans-femoral Revascularization
B. Cord, S. Strander, K. Sreeja, A. Wang, A. Kundishora, R. Hebert, P. Niles, C. Matouk
- 8:25-8:35 Gender Differences in Medical Student Perceptions of a Career in Neurosurgery
K. Callahan, J. Borden, R. Jewell, S. Durham
- 8:35-8:45 Development of 5-ALA Guided Fluorescent Exosomes as a Novel Strategy for Glioblastoma Liquid Biopsy
P. Jones, A. Yekula, J. Small, L. Balaj, **B. Carter**
- 8:45-8:55 MIS vs Open Surgery for Intermediate to High-Grade Spondylolisthesis: A 10-Year Retrospective, Multicenter Experience
A. **Lak**, A. Abunimer, A. Rahimi, I. Tafel, H. Zaidi
- 8:55-9:05 Effect of Lower Blood Pressure During the Acute Period of Aneurysmal Subarachnoid Hemorrhage in Functional Outcomes
L. Ascanio, A. Enriquez-Marulanda, G. Maragos, M. Salem, J. Moore, A. Alturki, K. Ravindran, C. Ogilvy, A. Thomas
- 9:05-9:15 Open Label Surgical Trials: Have We Learned from our Mistakes?
R. Alterman, G. Maragos
- 9:15-9:25 Intraoperative CT Navigation-Assisted Single-Position Lateral Mini-Open Thoracolumbar Corpectomy with Simultaneous Percutaneous Posterior Pedicle Screw Fixation
J. Yu, J. Fridley, A. Telfeian, Z. Gokaslan, S. Konakondla, S. Barber, J. Nakhala, **A. Oyelese**
- 9:25-9:35 Large Single Institution Series of Simple Tethered Cord Release Procedures
E. Day, C. Riordan, R.M. Scott, M. Proctor
- 9:35-9:45 The Ruptured AVM Grading Scale (RAGS): An Extension of the Hunt & Hess Scale to Predict Clinical Outcome for Patients with Ruptured Brain Arteriovenous Malformations
M. Silva, **P. Lai**, R. Du, M. Aziz-Sultan, N. Patel

Saturday, June 29, 2019 – continued

- 9:45-10:05 **NENS BUSINESS MEETING – MEMBERS ONLY**
- 10:05-10:30 **COFFEE BREAK**
- 10:30-10:40 Treatment of Ommaya Reservoir Associated Infections with an Aggressive Antibiotic Regimen may Avoid the Need for Surgical Removal
R. Dowd, D. Black, B. Zachariah, M. Glantz
- 10:40-10:50 Adult Sport-Related Traumatic Spinal Injuries: Do Different Activities Predispose to Certain Injuries?
S. Gupta, **B. Hauser**, D. Cote, M. Zaki, A. Khawaja, T. Smith, H. Zaidi
- 10:50-11:00 Decreased Wall Shear Stress at High-Pressure Areas Predicts the Rupture Point in Ruptured Intracranial Aneurysms
T. Suzuki, C. Stapleton, **M. Koch**, K. Tanaka, S. Fujimura, T. Suzuki, T. Yanagisawa, M. Yamamoto, Y. Fujii, Y. Murayama, A. Patel
- 11:00-11:10 Multimodal Analgesia in Lumbar Fusion Surgery: Impact Amidst the Opioid Epidemic
E. Bertoncini, **Y. Lu**
- 11:10-11:20 Task-Shifting and Task-Sharing in Neurosurgery: An International Survey of Current Practices in Low- and Middle-Income Countries and Global Perspectives
F. Robertson, I. Esene, A. Koliass, G. Fiegghan, J. Rosenfeld, N. Balak, A. Amar, M. Tisel, M. Haglund, T. Smith, I. Mendez, J. Brennum, S. Honeybul, A. Matsumara, S. Muneza, A. Rubiano, G. Rosseau, T. Khan, B. Misra, G. Bolles, D. Adelson, R. Dempsey, P. Hutchinson, W. Gormley, K. Park, M. Broekman
- 11:20-11:30 A Machine Learning Algorithm for Mortality Prediction in Chronic Subdural Hematoma Patients: A NSQIP-based Analysis
M. Wells, A. Boaro, **A. Hulsbergen**
- 11:30-11:40 Neurosurgery Interviews: The Impact of Inappropriate and Discriminatory Questions
N. Limoges, S. Zuckerman, J. Borden, L. Chambless, D. Benzil, S. Durham
- 11:40-12:10 **Invited Lecturer: Dr. Shabbar Danish**
“MRI guided Laser Interstitial Thermal Therapy: Where are we now?”
- 12:10 pm **ADJOURN**

2019 Award Winners

Scoville Resident Clinical Paper Award:

Nasya Mendoza-Elias, MD – Resident at Lahey Hospital and Medical Center, Burlington, MA
“Opioid Use Associated with Worse Post-Operative Lumbar Fusion Outcome at 1-year”

Matson Resident Basic Science Paper Award:

Cameron Sadegh, MD – Resident at Massachusetts General Hospital, Boston, MA
“Intraventricular hemorrhage induces rapid calcium signaling in rodent choroid plexus epithelial cells”

Shucart Medical Student Paper Award:

Coleman Riordan, BA – Medical Student at Harvard Medical School, Boston, MA
“Large Single Institution Series of Endoscopically Treated Infants with Craniosynostosis”

Opioid use associated with worse post-operative lumbar fusion outcome at 1-year

Nasya Mendoza-Elias, Melissa Dunbar, Robert S. Heller, Zoher Ghogawala,
Robert G. Whitmore

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Background: Opioid utilization and abuse has reached epidemic proportions in the U.S. Lower back pain is a dominant factor in opioid usage in America. It is imperative to fully understand the impact of opioids usage on outcome from surgery for lower back pain disorders.

Methods: A retrospective review of prospectively collected registry data on lumbar spinal fusion at a single center from 2015-2018 was performed. Opioid utilization was captured using a novel algorithm to extract these data from the electronic health record. Other variables: number of levels fused, type of fusion, minimally invasive surgery (MIS) status were collected from the registry. Patient-reported outcome: EuroQol-5D (EQ-5D) and Oswestry Disability Index (ODI) were obtained from registry data 1-year after surgery.

Results: 300 patients (mean age 62 years, 47% male) were included. Pre-operative opioid use predisposes a patient to post-operative opioid use (P-value= 0.0049, OR 2.24 (1.2, 4.0)). Of the 19.3% of patients taking opioids pre-operatively, 60.3% continued taking opioids post-operatively. Type of lumbar fusion (TLIF, PLIF, ALIF, XLIF, MIS) is not associated with post-operative opioid usage (P-value_{type}=0.5 30-day, 0.246 90-day; P-value_{MIS}=0.48 30-day, 0.27 90-day). Greater than 4 levels of fusion trends towards an association with 90-day opioid use (P-value=0.08). Worse 1-year ODI outcome is associated with opioid utilization before (P-value= 0.02; 28.2±22.9 vs. 16.3±16.8) and after (P-value= 0.013; 22.1±20.9 vs. 14.1±14.1) lumbar fusion, but not with 1-year EQ-5D scores (P-value= 0.17 pre-op, 0.19 post-op).

Conclusion: This registry finds that opioid use 3-months before and after lumbar fusion surgery is associated with worse outcome at 1 year. Preoperative narcotic use, and greater number of levels fused increases the likelihood of opioid use after surgery.

Management of mild traumatic brain injury in the emergency room using a pre-specified protocol is safe and effective

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Patricia Lanter³

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Background: Patients with mild traumatic brain injury (mTBI), defined as acute trauma with minor radiographic findings and a normal neurological exam, are typically admitted for inpatient monitoring. It is unclear if this is necessary. Alternatively, these patients could be managed in the emergency department (ED) without admission, potentially mitigating resource consumption and cost.

Methods: Over a three year period (May 2015 to April 2018) patients with mTBI were observed in the ED using a predetermined protocol. This included all patients >18 years old with isolated acute head trauma, a normal neurological exam at presentation, and a head CT with one or more of the following injuries: 1) cerebral contusion < 1cm, 2) convexity subarachnoid hemorrhage, or 3) closed, non-displaced skull fracture. After observation and a scheduled repeat CT, patients were discharged or, in the event of neurological or radiographic change, admitted for further workup. Patients were retrospectively analyzed for outcomes including radiographic worsening, neurological changes, admission rates, follow-up, and 30-day mortality.

Results: Over the study period, 60 patients were observed in the emergency room using the mTBI protocol (Mean age 64.47 [R 19-93]). Mechanisms of injury were ground-level fall (53.3%), fall from height (21.7%), motor vehicle collision (6.7%), altercation (5.0%), vehicle versus pedestrian (1.67%), and other/unspecified (11.7%). 55 (91.6%) were discharged after observation having no change on repeat CT or exam. 5 patients (8.3%) were admitted for continued monitoring and workup. Of these, 3 were admitted for unrelated medical reasons, and 2 (3.33%) had a small but demonstrable increased contusion size on repeat CT. They suffered no neurological sequelae and were subsequently discharged without further event. None of the 60 patients demonstrated a neurological exam change during the encounter. There was no known incidence of 30-day mortality.

Conclusion: Patients with mTBI observed in the ER with a predetermined management protocol had no known adverse outcomes, neurologic deterioration, or 30-day mortality. There was a small (3.33%) incidence of radiographic worsening without clinical sequelae. This management protocol can be used to safely mitigate inpatient capacity restraints and may be associated with cost benefits compared to inpatient admission; further research is warranted.

Choice of Treatment Intervention does not Predict 30- or 90-day Unplanned Readmissions after Treatment of Unruptured Aneurysms: A Study of the Nationwide Readmission Database

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Objective: Thirty- and 90-day readmission rates have increasingly been used by hospitals as proxies for quality of healthcare delivered. Currently, for unruptured cerebral aneurysms, wide national variation in physician and hospital practice have been identified. Few studies, however, have attempted to investigate whether choice of treatment between surgical clipping or endovascular coiling predicts 30- or 90-day readmission. The aim of this study was to investigate the differences, complications and impact of treatment modality on 30- and 90-day readmissions following intervention of unruptured cerebral aneurysm.

Method: The Nationwide Readmission Database years 2013 – 2015 was queried. Patient admissions undergoing microsurgical clipping or endovascular coiling for unruptured cerebral aneurysm were identified using the International Classification of Diseases, Ninth Revision, Clinical Modification coding system. Unique patient linkage numbers were used to follow patients and identify 30- and 31 to 90-day readmission rates. Patients were grouped by no readmission (Non-R), readmission within 30 days (30-R), and readmission within 31 to 90 days (90-R). Weighted multivariate analysis assessed impact of treatment choice and clinical factors associated with 30- and 90-day readmissions.

Results: We identified 5,316 patients undergoing either clipping or coiling for unruptured aneurysm, with 737 (13.9%) patients encountering a readmission (30-R: $n = 483$ [9.1%]; 90-R: $n = 254$ [4.8%]; Non-R: $n = 4,579$). There were similar proportions of microsurgical clipping and endovascular coiling between all three cohorts. The most common complications during index admission were bleeding complication (30-R: 5.7%, 90-R: 5.6%, Non-R: 2.6%), postoperative infection (30-R: 3.4%, 90-R: 7.3%, Non-R: 3.3%) and epilepsy (30-R: 4.3%, 90-R: 4.1%, Non-R: 3.0%). The most prevalent 30- and 90-day complications seen among the readmitted cohort were hemorrhage (30-R: 7.4%, 90-R: 5.4%), postoperative infection (30-R: 8.2%, 90-R: 2.5%) and cerebral infarction (30-R: 8.1%, 90-R: 2.4%). On multivariate logistic regression analysis, choice of intervention did not significantly predict 30- or 90-day readmission after treatment for unruptured aneurysm.

Conclusion: In this study we show in a nationwide studied cohort that the most common reasons for readmission after treatment of unruptured aneurysm were hemorrhage, postoperative infection and cerebral infarction. Furthermore, we demonstrated that treatment modality was not independently associated with 30- or 90-day readmission following treatment of unruptured cerebral aneurysm.

Direct vs indirect revascularization in a North American cohort of Moyamoya disease

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Background: In adult patients with moyamoya disease (MMD), the efficacy of direct versus indirect revascularization procedures remains a matter of debate.

Methods: Medical records of adult patients with MMD from 1984-2018 who underwent direct or indirect bypass at two tertiary teaching hospitals in Boston, Massachusetts, were retrospectively reviewed. Early postoperative events (<14 days) and outcome at more than 6 months postoperatively were evaluated using multivariate logistic regression analyses. Multivariate Cox proportional hazards regression analyses were used to evaluate delayed ischemic and hemorrhagic events. Multivariate analyses were performed adjusting for age at surgery, sex, race, hypertension, hyperlipidemia, diabetes, smoking history and Suzuki grade.

Results: A total of 104 adult patients with MMD and 139 hemispheres were included in this study. Four percent (3/63) and 6% (6/76) of patients had early surgical complications in the direct and indirect bypass cohorts, respectively (p=0.51). Direct bypass has lower long-term ischemic and hemorrhagic events at latest follow up (HR0.19, 95% CI 0.058, 0.62, p=0.006; mean followup 4±6 years). There was no difference between the direct and indirect bypass groups when the endpoint was limited to infarction and hemorrhage only (p=0.069). There was also no difference in outcome (mRS>2) between the two cohorts (p=0.32).

Conclusion: Direct and indirect revascularization in our North American adult MMD cohort demonstrated no difference in early postoperative events, long-term infarction or hemorrhage, or clinical outcome. However, there was a significant decrease in all ischemic and hemorrhagic events combined in the direct revascularization group.

Novel technique for atlantoaxial interlaminar arthrodesis utilizing a modified Sonntag loop-suture graft with posterior C1-2 fixation

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Background: Several surgical techniques for atlantoaxial fixation have been reported over the years to treat patients with atlantoaxial instability with the goal of achieving C1-2 fusion. Conventional techniques typically utilize cables or wires to secure the bone graft between the posterior elements of C1 and C2 to ensure bone graft immobilization. However, the passing of such cables underneath the C1 lamina can be associated with complications such as cerebrospinal fluid leak and neurologic injury. With the evolution of surgical fixation hardware, we propose that the stability provided by the cables is not needed and that the bone graft can be secured by alternative means.

Objective: To report a novel C1-2 fixation technique that avoids the morbidity and complications associated with passing sublaminar cables and wires. Clinical outcomes and fusion rates are assessed post-operatively.

Methods: This technique entails wedging and anchoring a structural iliac crest graft between C1 and C2 for interlaminar arthrodesis and securing it using a 0-Prolene suture at the time of C1 lateral mass and C2 pars interarticularis screw fixation. We demonstrate the utility of this approach in 32 consecutive patients and report clinical outcomes and fusion rates. The technique is illustrated and described.

Results: We identified 32 consecutive adult patients who underwent surgery between 2014-2018 for atlantoaxial instability due to trauma (60.0%), cervical spine degeneration (34.5%), and cervical deformity, including rheumatologic conditions (5%) by the senior author. Primary and metastatic tumor cases were excluded. Cases including occipital plate fixation were excluded. Patients with less than 6 months of follow up were excluded. The follow-up period ranged from 6 to 26 months (mean 18.2 months). A 60% improvement in pain from pre-operative baseline was demonstrated by Neck Disability Index (NDI), $p < 0.001$. The rate of readmission within 30 days after surgery was 3%. There were no neurologic deficits. Two patients had cerebrospinal fluid leaks related to the presenting trauma, 1 patient had a surgical site infection, and 1 patient developed transient dysphagia. The rate of radiographic atlantoaxial fusion was 96.8% by CT and x-ray imaging at 6 months, with no evidence of instrumentation failure, graft dislodgement, or graft related complications.

Conclusion: We demonstrate a novel technique for C1-2 arthrodesis that is a safe and effective option for securing bone graft with excellent rates of fusion.

Predictors of elbow flexion outcomes following reconstructive nerve transfers for brachial plexus injury: an analysis of 651 patients

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Introduction: Elbow flexion is perhaps the most important function to restore in the paralyzed upper extremity. There are a variety of reconstructive strategies, with nerve transfer procedures becoming more widely employed over the past decade. The goal of our study was to identify clinical predictors of elbow flexion recovery with a large cohort of patients with brachial plexus injury.

Methods: We retrospectively analyzed prospective data of 651 patients who suffered a brachial plexus injury resulting lost elbow flexion and subsequently underwent reconstructive nerve transfer at a single institution between 1995-2017 by an experienced surgeon. Outcomes in elbow flexion were classified as good (M4-5) or poor (M0-3). Multivariable logistic regression was performed to identify predictors of good outcome.

Results: A total of 651 patients were identified who underwent reconstructive surgery. 434 (66%) patients had a good outcome. Factors associated with a good outcome in our model were age (OR 0.96; $P < 0.001$), follow up time (OR 1.10; $P < 0.001$), timing of surgery (OR 0.85; $P < 0.001$), injury location, Ulnar to biceps nerve transfer with (OR 6.52; $P < 0.001$) or without (OR 5.81; $P = 0.003$) median to brachialis transfer and intercostals to musculocutaneous nerve transfer (OR 2.54; $P = 0.009$).

Conclusions: Loss of elbow flexion from brachial plexus injury can be repaired with good results in 2/3rds of well selected patients regardless of injury type. Age, adequate follow up length, shorter interval before surgical exploration, injury location and surgical technique influence motor outcome.

Medical Student Perceptions of a Neurosurgical Career and Factors Influencing Career Choice

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Background: Efforts to increase medical student interest in the field of neurosurgery early in their medical school education are currently underway at many institutions. Our institution has instituted a voluntary program for first year students that allows them to experience surgical subspecialties, including neurosurgery, during the first year of medical school in an effort to modify their perceptions of the various surgical fields. As part of that program, a survey was developed to examine baseline interest in surgical fields and to identify factors that influence the career choice of incoming medical students.

Methods: Entering medical students in the University of Vermont Larner College of Medicine completed a voluntary online survey to measure baseline interest in surgical subspecialties, assess their perception of specialty-specific characteristics and identify lifestyle factors that affect career choice prior to participation in the educational program.

Results: Twenty-seven male (33.75%), 52 female (65%), and 1 gender-unspecified (1.25%) first year medical students responded to the survey. Mean age of the respondents was 24.19 ± 0.24 years. Factors affecting medical student interest in neurosurgery were assessed on a three-point Likert scale (0=negative impact; 1=neutral; 2=positive impact). Factors that negatively impacted interest in neurosurgery were work hours per week, lifestyle, emotional burden, and number of call nights. Factors that positively impacted medical student interest in neurosurgery were patient outcomes, financial compensation, diversity of the field, research opportunities and prestige of the field.

Conclusion: This baseline survey serves to reaffirm factors that are commonly cited to influence neurosurgery as a career choice. It is our goal that by exposing medical students to neurosurgery early in their training, a more realistic perception of neurosurgery as a career is achieved serving to increase medical student interest in neurosurgery.

Large Single Institution Series of Endoscopically Treated Infants with Craniosynostosis

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Background: Endoscopic strip craniectomy (ESC) followed by helmeting for the treatment of craniosynostosis has gained increasing popularity since its introduction in the 1990s. Efficacy and safety remains to be determined.

Methods: 500 consecutive infants who underwent ESC for craniosynostosis at a single institution from 2004 to 2018 by a single neurosurgeon were identified from a prospective database. Patient demographics, operative and postoperative variables were analyzed. Main outcomes included the need for blood transfusion, postoperative complications requiring readmission, and reoperation. Longitudinal assessment of head circumference percentiles was based on WHO normative criteria.

Results: 500 infants (median age 3.0 months, IQR 2.5-4.1, 69% male, 31% female) undergoing ESC experienced low rates of blood transfusion (6.6%; 95% CI: 5-9%), ICU admissions (3.2%; 95% CI: 2-5%), and complications (1.4%; 95% CI: 1-3%) requiring readmission. Risk factors for transfusion included syndromic craniosynostosis ($P=.01$) and multiple fused sutures ($P=.02$). Median surgical time was 47 min, anesthesia duration 140 min, and length of stay 1 day. Only 3.0% (95% CI: 2-5%) of patients required a secondary open procedure. Rates of transfusion and reoperation were higher among syndromic patients (both $P<.001$). Head circumference normalized at 12 months of age relative to WHO criteria in infants with sagittal, coronal, and multi-suture craniosynostosis (all $P<.001$).

Conclusion: Minimally-invasive ESC is a safe, effective, and durable correction of infantile craniosynostosis. When diagnosed and referred early by pediatricians, ESC for infants with craniosynostosis can achieve normalization of head growth with low risk of transfusion, complication, or reoperation. Postoperative helmet therapy is a critical step for optimizing cranial morphology long-term.

Endoscopic-assisted mini-craniotomy versus craniotomy for management of subacute subdural hematoma: case-control study and technical report

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Background: Subdural hematoma (SDH) remains a common neurosurgical diagnosis with increased incidence and morbidity in aging populations. Subacute SDHs contain mixed density blood products and membrane formations, which typically require broader visualization for adequate evacuation. Compared to traditional craniotomy, endoscopic neurosurgical technique may provide a less invasive option for management of subacute SDH while improving patient outcomes.

Methods: We reviewed institutional case records of subacute SDH to identify 16 patients who underwent endoscopic-assisted mini-craniotomy (EAMC) and 47 contemporaneously matched control patients who underwent traditional craniotomy. We perform a case-control analysis of radiographic and clinical outcomes.

Results: Operative time for EAMC was similar to traditional craniotomy (99 min vs 94 min, $p=0.53$) and EAMC was non-inferior to traditional craniotomy with respect to major clinical and radiographic outcomes. We observed a trend toward a greater decrement in SDH thickness in endoscopic-assisted cases at time of follow-up (1.52 cm vs 1.13 cm, $p=0.06$). EAMC cases were associated with shorter length of stay, decreased reoperation rate, and less morbidity and mortality, though none of these differences met statistical significance.

Conclusion: EAMC is a technique that can be adapted for evacuation of subacute SDH. The procedure is non-inferior to traditional craniotomy and may provide improvements in rates of SDH thickness reduction after surgery as well as morbidity and mortality measures. Additional, prospective, randomized studies are needed to assess the clinical benefits of this approach.

A Computer Vision Approach to Identifying the Manufacturer and Model of Anterior Cervical Spinal Hardware

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Introduction: Recent advances in computer vision have revolutionized many aspects of society but have yet to find significant penetrance in neurosurgery. One proposed use for this technology is to aid in the identification of spinal hardware. In revision operations, knowing the manufacturer and model of previously-implanted fusion systems upfront can facilitate a faster and safer procedure, but this information is frequently unavailable or incomplete. We present one approach for the automated, high-accuracy classification of anterior cervical hardware fusion systems using computer vision.

Methods: Patient records were searched for those having received an anterior-posterior (AP) cervical radiograph following anterior cervical discectomy and fusion (ACDF) at our institution over a 10-year period (2008-2018). These images were then cropped and windowed to include just the cervical plating system. Images were then labeled with the appropriate manufacturer and system according to the operative record. A computer vision classifier was then constructed using the Bag-of-Visual-Words technique and Speeded-Up-Robust-Features feature detection. Accuracy and validity were tested using an 80%/20% training/testing pseudorandom split over 100 iterations.

Results: A total of 321 total images were isolated containing 9 different ACDF fusion systems from 5 different companies. The correct system was identified as the top choice in $91.5 \pm 3.8\%$ of cases and one of the top two or three choices in $97.1 \pm 2.0\%$ and $98.4 \pm 13\%$ of cases respectively. Performance persisted despite the inclusion of variable sizes of hardware (i.e. 1-level, 2-level, and 3-level plates). Stratification by size of hardware did not improve performance.

Conclusions: A computer vision algorithm was trained to classify at least 9 different types of anterior cervical fusion systems using relatively sparse datasets and demonstrated to perform with high accuracy. This represents one of many potential clinical applications of machine learning and computer vision in neurosurgical practice.

Burden of Illness of Aneurysmal Subarachnoid Hemorrhage across Multiple Healthcare Utilization Settings in the United States

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Background: This study aims to evaluate the current economic burden for aSAH patients across all settings of care, including emergency treatment, hospitalization, post-acute care, rehabilitation and other outpatient services.

Methods: The Inovalon MORE2 registry was utilized to conduct a retrospective cohort analysis on patients presenting with aSAH. This registry contains patient-level healthcare data from commercial, Medicare Advantage, and managed Medicaid plan members, who are followed longitudinally across different settings of care (inpatient, outpatient, post-acute care, and home health) post-discharge. Healthcare resource utilization and direct healthcare expenditures were measured among the identified cohort. Subgroup analyses were performed between various treatment pathways to identify their effects on resource utilization and cost.

Results: A total of 11,303 registry patients met inclusion criteria and were analyzed. Overall, the unadjusted mean total cost over a variable follow-up period was \$78,297. There were significant differences in cost among patient age groups, with the highest costs incurred in the 60-69-year subgroup (\$81,376, $P < 0.001$). Female patients had a 5.78% cost overhead in comparison with male patients ($P = 0.002$). Insurance type was significantly associated with overall costs, with Medicaid (\$85,369) and Medicare (\$84,480) significantly higher than commercial insurance (\$73,269, $P < 0.001$). Patients discharged with disability had higher costs (\$102,991, $P < 0.001$), while patients who died before discharge had lower costs (\$57,661, $P < 0.001$). Among various treatment pathways, patients receiving open or endovascular procedures with the addition of an extraventricular drain had the highest costs (\$114,200), while medically treated patients had the lowest (\$52,308, $P < 0.001$).

Conclusion: There have historically been limitations in following large numbers of patients across different settings of care to delineate costs. In the present study we attempt to overcome this limitation by utilizing a specialized registry. Healthcare interventions aimed at reducing the overall societal burden of aSAH should consider such factors that drive healthcare utilization costs.

Cerebrospinal Fluid Leaks After Skull Base Fracture: A 30-Year Two-Institution Experience

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Background: Cerebrospinal fluid (CSF) leaks are a known complication in patients with skull base fractures, but the incidence of such leaks is undetermined, reported in the literature between 2-30%. When left untreated, there is a risk that a CSF leak leads to meningitis, so a better understanding of CSF leak incidence would inform the clinical management strategy. Here we investigate the incidence and management of CSF leaks in skull base fracture patients, at two institutions across thirty years.

Methods: We conducted a retrospective chart review of two major academic medical centers for years 1989-2018. We identified all patients with a skull base fracture, according to billing codes. Variables included age, gender, presence of CSF leak and meningitis, and occurrence of lumbar drain and surgical repair. Analysis was done in R v3.0.1 software.

Results: Overall, there were 3,787 patients with skull base fractures, and 143 (3.8%) developed CSF leaks. Mean age was 44.5 (± 23.0) and 1,183 (31%) were female. 141 (99%) of the leaks were acute, of which 74 (53%) resolved with conservative therapy, 57 (40%) with lumbar drain, 6 (4%) with surgical repair, and 4 (3%) with lumbar drain plus surgical repair. Meningitis developed after 5 (3.5%) acute leaks, and the mean time to meningitis was 11.6 (± 14.2) days. 2 (1%) of the leaks were chronic, of which 1 resolved with surgical repair, and 1 with lumbar drain plus surgical repair.

Conclusion: The incidence of clinically significant CSF leaks in skull base fracture patients is relatively low, though the true rate of CSF leaks may be much greater. In the acute setting, we found that most of the leaks resolved with conservative management or a lumbar drain, though several did require surgical intervention. We also found that 1% of CSF leaks went undetected initially and became chronic leaks, which required surgical intervention to repair. This suggests that despite the relative infrequency of CSF leaks, skull base fracture patients should be monitored for such leaks during their initial presentation.

Laser interstitial thermotherapy for suspected radiation necrosis in non-malignant pathologies

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Laser interstitial thermotherapy (LITT) is an accepted option for treatment of recurrence and/or radiation necrosis (RN) following high dose radiation for malignant brain tumors. However, LITT for non-malignant pathology has been rarely described. We present our recent institutional experience with LITT for re-growing lesions after radiosurgery for non-malignant pathologies.

Three patients were treated with LITT for suspected RN after previous radiosurgery. Two patients had arteriovenous malformations (AVM) previously treated with multiple glue-embolizations and radiosurgery. A third patient with neurofibromatosis-2 had a frontotemporal meningioma that was previously resected and radiated with both 45Gy fractionated therapy and radiosurgery. All three cases presented with symptomatic perilesional edema refractory to steroids and, in one patient, also refractory to bevacizumab. One AVM patient underwent glue-embolization two weeks prior to LITT for small residual AVM. Biopsy pathology was consistent with RN in both AVM cases and residual tumor in the meningioma case. In all 3 cases, imaging 2-6 weeks after LITT treatment showed significantly decreased perilesional edema, and the patients were symptom-free and off steroids. The meningioma patient remains progression-free on imaging at 3-year follow-up.

LITT may be a viable option in re-growing lesions after radiosurgery for AVM or meningioma. In these cases, LITT can result in drastic reductions in perilesional edema within 2-4 weeks after treatment similar to malignant pathologies. For AVMs, LITT may be safely performed shortly after glue-embolization. In recurrent, previously radiated meningiomas, biopsy at the lesion center may demonstrate residual tumor although we suspect they behave more like RN at the lesion edges and respond readily to LITT with reduced perilesional edema and robust local control years after treatment. Further studies are needed to corroborate our experience.

MRI-guided cryoablation for metastatic spine disease: intermediate-term clinical outcomes in 14 consecutive patients

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Introduction: Minimal access ablative techniques have emerged as a less invasive option for spinal metastatic disease reduction and separation from neural tissue. Percutaneous image-guided cryoablation allows for more distinct visualization of treatment margins compared to heat-based ablation modalities. We report on a series of patients undergoing MRI-guided cryoablation as a feasible method for treating spinal metastatic disease.

Methods: A total of 14 patients with metastatic spine disease undergoing MR-monitored cryoablation were prospectively enrolled. Procedures were performed in an advanced imaging operating suite with the use of both CT and MR imaging to gain access to the spinal canal and monitor real-time cryoablation.

Results: The average age was 54.5 (range 35-81). Pre-operative mean Karnofsky Performance Scale (KPS) score was 79.3 (range 35-90). Average radiographic follow-up was 7.1 months (range 25-772 days) and average clinical follow-up was 9.8 months (range 7 – 943 days). In 10 patients with epidural disease, 7 patients had post-procedure imaging, and of these 71% (5/7) had stable or reduced radiographic disease burden. Bone regrowth was observed in 63% (5/8) of patients with bone ablation during the treatment who had post-operative imaging. Pre- and post-operative Visual Analogue Scale (VAS) scores were obtained and a significant reduction in these scores was found following ablation. There were no complications.

Conclusion: MR-guided cryoablation is a minimally invasive treatment option for metastatic spine disease. In patients with epidural disease, the majority experienced tumor reduction or arrest at follow-up. In addition, pain was significantly improved following ablation. Average hospital stay was short and the procedure was safe in a range of patients who are otherwise not ideal candidates for standard treatment.

Arterial redundancy: implications for susceptibility to dissection

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Background: Arterial redundancy (AR) is seen to increase in frequency with age. The implications of these findings are as yet uncertain. AR is not generally associated with an increased risk of stroke in the elderly. However, a subset of patients with AR can be found with a much younger age distribution. The implications of AR in younger patients is of unknown significance. There are several publications that report arterial tortuosity as a risk factor for dissection. However, a precise definition of arterial tortuosity is lacking. We report on a group of patients with vertebral dissection in an attempt to understand the relationship to arterial redundancy. AR may be due to weakening of the wall of the vessel, allowing the momentum of flow to distort the wall, creating turbulence. The turbulence, in turn, creates further asymmetric stresses on the wall and leads to further redundancy. There is no good animal or mathematical model currently available for demonstrating these forces in the formation of a redundant vessel. Clearly hypertension can play a role, but many younger patients are normotensive. The role of underlying genetic, inflammatory, infectious or post-infectious processes is postulated, but not definitively proven.

Methods: 25 consecutive patients with radiographically verified vertebral artery dissection were culled from our clinical and medicolegal database retrospectively. Imaging, demographic and health information is available for all patients. All identifying data have been removed. All patients underwent CT Angiography (CTA) in addition to other studies. The location of the dissection(s) is noted for all patients.

The extent of AR is measured using a simple algorithm. The angles of each turn of the vessel are measured and added together. We utilized an ordinal system of categorization. The common and internal carotid arteries, as well as vertebrals were analyzed. Smaller vessels and the external carotid arteries were excluded.

- Category 0 – no significant or measurable deviation from normal anatomy.
- Category 1 – sum of measured deviation is less than 136 degrees
- Category 2 – sum is 136 to 225 degrees
- Category 3 – sum is between 226 and 315 degrees
- Category 4 – sum is greater than 316 degrees

When multiple vessels are abnormal, the most severely affected vessel dictates the degree of redundancy. For the purposes of our analysis, AR was defined as categories 2,3 and 4.

We utilized historical / literature controls from Barbour, et al. They categorized vessels in an analogous manner. Statistical association was estimated using Pearson's Chi squared test. Assumptions include normal distribution of both data sets, which may or may not be true.

Results: Twenty-five consecutive patients were reviewed from our clinical and medicolegal database. All patients were given the radiographic diagnosis of cervical arterial dissection. No patients had been exposed to high-energy injury, such as vehicular trauma. Seventeen of 25 patients, 68%, had redundancy of one or more cervical vessels. Six patients, 24%, had at least one category 4 vessel identified. When compared to controls, cervical arterial dissection was associated with any AR with a chi-squared value of 24.75 ($p < .05$). When the comparison is limited to category 4 patients, the chi-squared value was 13.11 ($p < .05$).

Conclusion: This is a rudimentary analysis using historical/literature controls, a small number of patients and a potentially biased, unblinded observer. Having said that, the striking association between the presence of AR and dissection suggests that additional study is warranted with creation of a robust analytical tool for determining the presence and degree of AR. The grading system presented may be a reasonable starting point. Numerous other factors will also need to be considered, but were beyond the purview of this report, given the limitations of the historical/literature controls. This type of exploration may be helpful in pursuit of an understanding of the underlying causes and mechanisms associated with low-energy and spontaneous cervical arterial dissection.

Bridging Nerve Gaps with Multichannel Nerve Guidance Scaffolds with Targeted Structures and Mass-Produced Quantities

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Nerve guidance scaffolds have been demonstrated to linearly guide growing neurons along a nerve gap to reach distal targets. This is required due to a lack of a sense of direction in axons in the adult mammalian central nervous system, resulting in random growth orientation and failure to bridge long nerve gaps. Current techniques for scaffold production are not able to produce a combination of linear pathways for nerve growth, have flexibility over biomaterial selection, have porous walls to enable mass transfer and be mass-produced or custom designed for personalized treatment. We present a technique, thermal drawing, to enable the production of meter-long structures with control over porosity, geometry and length. Our approach involves combining salt leaching with fiber drawing to result in microchannels with customizable porosity and cross-sections. The scaffolds are produced from commonly utilized biomaterials for nerve tissue engineering – including polycaprolactone (PCL) and polylactic acid (PLA). The polymers are able to be constructed with pore sizes at a low micrometer scale and with porosity percentages of 0-35 vol%. Additionally, with the use of 3D printing, with a fuse-printer, we can produce microchannel scaffolds with control over scaffold geometries and dimensions to resemble the shape of an individual's injured nerve for personalized health care. We anticipate our technology will result in better nerve functional outcomes after injury and decreased need for allografts.

Intraventricular hemorrhage induces rapid calcium signaling in rodent choroid plexus epithelial cells

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Background: Intraventricular hemorrhage (IVH) leads to hydrocephalus in preterm infants by unclear mechanisms ranging from ependymal injury and subarachnoid scarring to choroid plexus (ChP) hypersecretion of cerebrospinal fluid (CSF). We focus on the embryonic ChP, while it is still maturing and when CSF composition is most critical to neocortical development. The earliest physiologic changes in ChP epithelial cells likely involve calcium, which is a known cellular messenger in other secretory epithelial cell populations. Our laboratory has generated a ChP epithelial calcium reporter system to enable rapid calcium imaging to evaluate whether calcium is involved and how it might be regulated.

Methods: Lateral ventricle choroid plexus is dissected at embryonic day 14.5 (E14.5) from a conditional calcium-reporting transgenic mouse line (Gcamp6f, limited to expression in ChP ciliated/epithelial cells using a FoxJ1-Cre system). The choroid plexus explants are kept viable with artificial CSF, exposed to focal blood injections, and imaged for calcium responses using epifluorescence and 2 photon imaging.

Results: Upon exposure to age-matched plasma or serum, embryonic ChP epithelial cells rapidly trigger a wave of calcium activity that is followed by the upregulation of high intensity, recurrent calcium transients in subsets of ChP epithelial cells. Using different conditions of calcium blockade, we identify intracellular endoplasmic reticulum storage as the primary source of calcium influx, which requires store-operated calcium channels for continued calcium release.

Conclusion: Intraventricular blood products cause an immediate intracellular calcium release by the choroid plexus epithelia. This calcium release is dynamic and occurs in waves; the release machinery is characterized with inhibitors of the calcium release pathway. Combined with other data supporting the rapid early response of choroid plexus, rather than ependymal cells, these changes may predict future choroid plexus dysfunction and altered CSF production, and contribute to our understanding of IVH-induced hydrocephalus pathophysiology.

Improved Functional Outcomes with Percutaneous Trans-carotid Mechanical Thrombectomy Following Failed Trans-femoral Revascularization

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Background: Mechanical thrombectomy for ischemic stroke due to large vessel occlusion provides significant improvements in functional outcomes with a relatively low “number needed to treat.” The time to revascularization is crucial, with prolonged or even failed mechanical thrombectomy due to difficult vascular access to the intracranial clot adversely affecting outcomes. We hypothesized that percutaneous trans-carotid puncture (PTCP) mechanical thrombectomy for failed trans-femoral revascularization would have improved radiographic and clinical outcomes.

Methods: We compared patients with unsuccessful trans-femoral mechanical thrombectomy due to inability to reach the intracranial clot to patients who PTCP mechanical thrombectomy as a salvage or primary method. In both methods, mechanical thrombectomy was performed using a stent-retriever with adjunctive aspiration. 3-month modified Rankin scale (mRS) was used to assess functional outcomes with an ordinal logistic regression to control for age and admission NIHSS. Associations with outcome were analyzed using ordinal logistic regression, adjusted for age and admission NIHSS.

Results: 17 patients with failed trans-femoral mechanical thrombectomy were compared to 19 patients with PTCP mechanical thrombectomy. Both groups were well matched for age, gender, and admission NIHSS (final combined cohort with a total of 36 patients, aged 82 years [SD 11], mean admission NIHSS 17). Successful reperfusion (TICI 2b-3) was achieved in 16/19 (84%) PTCP, with 26% achieving good outcome (mRS 0-3) at 90 days compared to 0/17 (0%) of failed trans-femoral, with 6% achieving a good outcome. In the shift analysis, PTCP was independently associated with lower (better) mRS scores at 3 months (adjusted common OR 5.2, 95% CI 1.02-24.5, $p=0.048$, Figure 1). Final infarct volume was also smaller in PTCP compared to failed trans-femoral (median 11 vs 48 ml, $p=0.041$) as well as greater reduction in NIHSS for PTCP vs failed trans-femoral (-4 vs +2.9, $p=0.034$). A single patient PTCP patient suffered a fatal carotid blowout on post-treatment day 4.

Conclusions: PTCP for emergent mechanical thrombectomy is a safe and effective strategy that yields high recanalization rates, decreased infarct volumes and improved functional outcome among patients with trans-femoral access failure.

Gender Differences In Medical Student Perceptions Of A Career In Neurosurgery

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Background: Gender disparity in neurosurgery remains problematic. While over half of US graduating medical students are female, less than 25% of applicants to neurosurgery are female. Of the 1418 active neurosurgical residents in 2018, only 18% are female. Further, women comprise only 6% of board certified, practicing neurosurgeons in the United States. Increasing the recruitment of females into the field of neurosurgery is important not only for the positive benefits of a gender-diverse workforce but also to ensure that neurosurgery attracts the best and brightest medical students. The present study sought to identify gender-specific factors influencing medical students' decision to pursue a career in neurosurgery.

Methods: All first-year medical students at the University of Vermont Larner College of Medicine were queried using a three-part Likert Scale questionnaire detailing their perception of specialty-specific characteristics and lifestyle factors pertaining to surgical careers (0=negative impact; 1=neutral; 2=positive impact).

Results: Eighty first year medical students responded to the survey (86.6%). Sixty-five percent of the respondents were female. There were no significant differences in the perceptions/influence of the emotional burden of the specialty, impact of work hours per week, patient outcomes, research opportunities, diversity of the field, number of call nights, prestige of the field, lifestyle considerations or financial compensation between female and male medical students.

Conclusion: Factors such as lifestyle, emotional burden, and patient outcomes previously thought to be major deterrents for females pursuing a career in neurosurgery may be less impactful than previously believed. Further research is necessary to identify additional factors that contribute to the gender gap in neurosurgery.

Development of 5-ALA guided fluorescent exosomes as a novel strategy for glioblastoma liquid biopsy

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Background: Our laboratory is developing novel liquid biopsy assays for brain tumors. 5-Aminolevulinic acid (5-ALA) fluorescence guided surgery offers a unique opportunity to capture fluorescent exosomes from the glial tumors as a novel strategy for liquid biopsy. We report on our experience combining 5-ALA guided resection of GBM with nano-FACS analysis of fluorescent exosomes in a multi-center study.

Methods: 20 patients at multiple centers underwent 5-ALA guided surgery with pre-dosing and 3 hour post-dosing collection of plasma samples. Tumors were characterized for the degree of fluorescence intraoperatively. (Video will be shown). Blood samples were analyzed by a novel in vitro validated nano-FACS procedure to identify fluorescent nano-particles (exosomes).

Results: An in vitro validation confirmed that 5-ALA exposed cells released fluorescent exosomes, detectable by nano-FACS. In 6 patients studied in detail (at the time of this abstract), this novel nano-FACS technique was able to identify fluorescent exosomes from brain tumor patients in all patients with brightly fluorescent tumors. The degree of fluorescent exosomes that were detected after dosing with 5-ALA correlated with the degree of intraoperative fluorescence detected.

Conclusion: Liquid biopsy remains a conceptually important advance for detecting and characterizing brain tumors during treatment. We have shown that it is possible to identify fluorescent exosomes in the blood of patients with glioblastoma. This creates a new strategy for monitoring patients with glioma non-invasively, and opens the path for more detailed studies of genetic biomarkers in tumor derived exosomes identified in the plasma of GBM patients.

**MIS vs Open surgery for Intermediate to High-Grade Spondylolisthesis:
A 10-year retrospective, multicenter experience.**

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Background: High grade spondylolisthesis is a relatively uncommon condition. The optimal surgical approach for management remains debatable. Although in-situ fusion is preferred due to its lower risk of neural injury, it does not correct spinal alignment. On the contrary, reduction corrects the deformity and provides a high rate of fusion, but has the potential for high rates of neural injury. We herein report our experience and surgical outcomes following MIS versus open management of intermediate- to high-grade spondylolisthesis.

Methods: A multicenter, retrospective cohort analysis of adult patients aged greater than 18 years old with grade II or higher spondylolisthesis, who underwent surgery from January 2008 until February 2019, was performed.

Results: Sixty-two patients were included in the final analysis. Forty-one patients were treated with an open approach and 21 with a minimally invasive surgical approach (MIS). More specifically, 18 patients underwent in-situ fusion, 11 underwent MIS reduction, and 33 had an open reduction. The total rate of complications was 40.3%. The rate of complications in the MIS group was 52.3% compared to 34.1% in the open surgery group ($p=0.166$). The rate of complications was 27.8% in the in-situ fusion group, 72.7% in the MIS reduction group, and 36.4% in the open reduction group. Our comparisons of the rate of complications in the no reduction group vs the MIS reduction group, and the MIS reduction group vs the open reduction group were statistically significant ($p=0.018$ and $p=0.036$, respectively). However, there was no statistically significant difference between the rate of complications in the no reduction group vs the open reduction group ($p=0.534$), nor the rate of complications in the MIS group vs the open surgery group ($p=0.166$).

Conclusion: MIS reduction is associated with a high rate of complications in the management of high-grade spondylolisthesis.

Effect of Lower Blood Pressure during the Acute Period of Aneurysmal Subarachnoid Hemorrhage in Functional Outcomes

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Background: Blood pressure (BP) variation in hemorrhagic stroke has been associated with poor outcomes. In aneurysmal subarachnoid hemorrhage (aSAH), however, this association is unknown. We evaluated the association of systolic BP (SBP) variation and clinical outcomes in patients with aSAH.

Methods: We conducted a retrospective chart review of all aSAH patients treated at BIDMC between 2007 and 2016. We recorded BP for the first 24 hours of admission, at a four-hour interval. Excluded patients had more than 4 BP values missing or had missing admission times. The SBP variability of each patient was assessed by the mean, standard deviation (SD), maximum, minimum, peak, trough, coefficient of variation (CV), and successive variation of all SBP values available in the first 24 hours. Patient demographics and aSAH characteristics were also recorded. The primary outcome was a composite of modified Rankin scale (mRS) as good (0-2) or poor (3-6) at last follow-up. Variable comparisons between outcome groups were performed. Each statistically significant SBP parameter was inputted individually into a logistic regression model that controlled for age, history of antihypertensive, antiplatelet or anticoagulant medication, Hunt and Hess, rebleeding, and management type.

Results: 202 patients were identified. The mean age was 56.6 years; 66.3% were female. The median follow-up time was 18 months; 57 (28.9%) patients had a poor outcome. Patients with poor outcomes had a lower minimum SBP (101.4 ± 13.3 vs 108.4 ± 14.1 mmHg, $p < 0.01$), a higher SD (17.16 vs 14.73 mmHg; $p = 0.014$), a higher peak (23.57 vs 20.0 mmHg, $p = 0.021$), a higher trough (22.66 vs 19.28 mmHg, $p = 0.007$), and a higher CV (13.93 vs 11.88 mmHg, $p = 0.004$). On multivariable analysis, only minimum SBP remained significant, (OR=0.96; 95% CI=0.93 - 0.99; $p = 0.04$).

Conclusion: A lower minimum SBP was found to be independently associated with poor outcomes in patients with aSAH.

Open Label Surgical Trials: Have We Learned from our Mistakes?

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Background: It is a recurring phenomenon for surgically administered experimental therapies for functional brain disorders to show great promise in the laboratory and positive results in open-label clinical trials (OLCT) only to fail to demonstrate clinical benefit greater than placebo in randomized, double-blind sham surgery-controlled trials (RCTs). A previous report attributed this phenomenon to observer bias inherent to OLCTs, which were likely to overestimate treatment effects, leading to underpowered RCTs. Those authors suggested a number of modifications to the conductance of pilot studies that might mitigate this problem. In this report, we expand and update that observation, comparing the results of open-label surgical trials in a variety of functional brain disorders to those of the subsequent RCTs.

Methods: PubMed was systematically searched for published RCTs for these conditions. ClinicalTrials.gov was searched for unpublished data. Reference lists were searched in a snowball fashion to identify any remaining relevant studies. OLCTs were identified and matched to their respective randomized trials based on publication date and being cited in the manuscript.

Results: We identified 9 RCTs for Parkinson's disease, 3 for major depressive disorder, 1 for Alzheimer's disease, 1 for obsessive compulsive disorder and 2 for Tourette Syndrome. OLCTs for PD reported an average 35% improvement, while RCTs reported only 13% improvement in the active group as compared to 5% for placebo. Similar results were noted for the other disorders (Figure). Notably, one RCT identified significant benefit for subthalamic deep brain stimulation for OCD. This study followed a well-conducted OLCT with rigorous, 36-month follow-up. Conversely, the investigators for ProSavin in PD, while showing a 36% improvement in open label, have not proceeded to an RCT until a more rigorous pilot study can be performed.

Conclusion: The cost of failed RCTs to patients, investigators, study sponsors, and the society are substantial. Well-conducted, rigorous OLCTs can inform decisions to proceed to an RCT protocol. With a few encouraging exceptions, however, most open label trials still fail to adequately account for observer bias, leading to multiple failed RCTs.

Intraoperative CT Navigation-Assisted Single-Position Lateral Mini-Open Thoracolumbar Corpectomy with Simultaneous Percutaneous Posterior Pedicle Screw Fixation

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Background: Intraoperative CT navigation assisted (iCT-NA) lateral mini-open thoracolumbar corpectomy (LMOTLC) has been described with good results. Supplemental stabilization is frequently by concomitant anterior instrumentation or staged posterior percutaneous pedicle screw fixation (PPPSF). iCT-NA single-position LMOTLC with PPPSF has not been described.

Methods: A retrospective review and analysis was performed of eleven patients with thoracolumbar burst fractures surgically managed via single-position, LMOTLC and supplemental PPPSF with iCT-NA (9 patients) and fluoroscopic guidance (FG) (2 patients). Surgical, clinical and radiographic outcomes were assessed.

Results: Mean follow up was 13.4 months in the iCT-NA group and 15 months in the FG group. Compared with FG patients, iCT-NA, single position LMOTLC and PPPSF resulted in a 6.5-fold lower potential radiation exposure to the surgical team but, higher overall radiation exposure to the patient from the pre- and post-instrumentation iCT scans. Pedicle screw accuracy was 94.7% in the iCT-NA group and 100% in the FG group using modified Wang criteria. 2/38 (5.3%) screws in the iCT-NA group and 0/8 screws in the FG group screws required intraoperative revision. There were no reoperations outside of the index surgery. EBL, improvement in VAS, postop length of stay (PO-LOS) were similar between groups. All patients experienced good or excellent outcomes as assessed by the McNab criteria.

Conclusions: iCT-NA LMOTLC with PPPSF is feasible and can be safely undertaken in patients with unstable thoracolumbar injuries while reducing the radiation exposure of the surgeon and OR staff as compared with fluoroscopic guidance.

Large single-institution series of simple tethered cord release procedures

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Background: There is a lack of consensus surrounding the indications to operate on simple tethered spinal cord prompted by the diverse clinical and radiographic presentations of the condition. We sought to retrospectively review the presenting symptoms of patients diagnosed with simple tethered spinal cord and evaluate the efficacy of the detethering procedure, with the goal of better informing clinical decisions regarding diagnosis and treatment of the condition, as well as maximizing symptom relief and reducing risk and cost to the patient.

Methods: The electronic medical records of 250 consecutive patients diagnosed with simple tethered spinal cord with a thickened and/or fatty filum terminale who underwent primary corrective surgery at Boston Children's Hospital between the years of 2005 and 2011 were retrospectively reviewed. Exclusion criteria included patients with incomplete follow up information, patients whose procedures were performed as part of a larger spinal deformity correction, and patients who had a prior detethering procedure. Included in the chart review were demographic data, clinical information from before and after surgery, operative notes, and anesthesia records.

Results: A total of 208 patients (111 F: 97 m) met inclusion criteria and underwent initial surgery for simple tethered spinal cord at Boston Children's Hospital between the years of 2005 and 2011. Eighty-four patients presented with no detectable clinical symptoms and were treated prophylactically for radiographic abnormalities discovered in the workup of associated conditions or neurocutaneous stigmata of tethering. 100% of patients followed up with a clinician in the Department of Neurosurgery following their procedure. Of those with symptoms, 18% showed scoliosis improvement, 55% reported reduced or eliminated back pain, 80% had reduced or eliminated bladder and/or bowel dysfunction, and 80% had reduced or eliminated neurologic dysfunction. Thirty-six patients who presented as symptomatic had no improvement or relief from their symptoms and 0 patients treated prophylactically experienced an onset of new symptoms related to retethering. Complication rate was 3.3% and average length of stay after surgery was less than 3 days.

Conclusion: Spinal cord detethering can effectively reduce or eliminate the symptoms typically associated with simple tethered spinal cord in 75% of patients who present symptomatically and prevent the onset of new symptoms in 100% of patients who present asymptotically and are treated prophylactically. The low complication rate and short length of stay confirm that the procedure is relatively safe to perform and does not require substantial recovery time in the hospital.

The Ruptured AVM Grading Scale (RAGS): An extension of the Hunt & Hess scale to predict clinical outcome for patients with ruptured brain arteriovenous malformations

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Background: Arteriovenous malformation (AVM) rupture is highly morbid. Outcomes after AVM rupture differ from other types of brain hemorrhage. There are no widely-used grading systems designed to predict clinical outcome after AVM rupture. We sought to develop an all-comers scoring system to grade patients with AVM rupture and predict clinical outcome more accurately than grading systems currently in use.

Methods: We retrospectively reviewed patients who presented to our institution with a ruptured AVM. Using change in modified Rankin Score (mRS) as our response variable, we generated an ordinal logistic regression model to test for significant predictor variables. The full model was sequentially condensed until the simplest model with the highest area under the receiver operating curve (AUROC) was achieved.

Results: A total of 115 patients who presented with ruptured AVMs were included in the study, with a mean follow up time of 4 years. The Ruptured AVM Grading Scale (RAGS) consists of the Hunt & Hess score (1-5), patient age (<35=0, 35-70=1, >70=2), deep venous drainage (1), and eloquence (1). The RAGS score outperformed other neurosurgical grading scales in predicting change in mRS, with an AUROC greater than 0.80 across all follow-up periods.

Conclusion: The RAGS score is a simple extension of the Hunt & Hess scale that predicts clinical outcome after AVM rupture more accurately than other grading systems.

Treatment of Ommaya Reservoir Associated Infections with an Aggressive Antibiotic Regimen may Avoid the Need for Surgical Removal

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Introduction: Neoplastic meningitis (NM) is an uncommon condition with a very poor prognosis. There is, unfortunately, little to be done surgically except to implant an Ommaya reservoir for intrathecal chemotherapy. This is the standard of care at most institutions and has been shown to improve outcomes. However, Ommaya placement is not without risk. Aside from the immediate surgical risks, there are risks associated with long term indwelling hardware which undergoes repeated needle access for treatment, namely, infection. The current school of thought amongst neurosurgeons and infectious disease doctors is that an infection necessitates removal of the device. This creates a vicious cycle by which a patient without a good prognosis to begin with is repeatedly subjected to neurosurgical procedures to receive treatment. Based on the experience at Penn State Hershey, we suggest that it may be possible to clear these infections with antibiotics alone, negating the need for further surgery.

Methods: The Penn State Hershey maintains an international neoplastic meningitis database. The database was queried regarding all patients at Penn State with reservoir-associated bacterial meningitis. We analyzed the outcomes of these patients and analyzed predictors of successful therapy. Successful therapy was defined as eradication of infection without reservoir removal

Results: 47 infections (9 recurrences) in 33 patients were identified. 17 patients were male; median age was 59 (range 38-78). Primary malignancies included primary brain tumor (9), breast cancer (6), lymphoma (5), leukemia (2) and other (4). Reservoirs were accessed a median of 6 (1-15) times prior to infection. The responsible organisms were *P. acnes* (25 cases), coagulase negative staphylococcus (6), *S. aureus* (4), *Enterobacter* (1), *S. epidermidis* (2), *S. lugdunensis* (1), *Candida* (1), *S. marcescens* (1) and *Pseudomonas* (1). Infections were eradicated without reservoir removal in 24 of 33 patients (73%) using a standardized treatment regimen consisting of oral rifampin, intraventricular vancomycin, and an intravenous antibiotic appropriate to the infecting organism (usually ceftriaxone, nafcillin, or vancomycin) for 2-3 weeks. Patients requiring reservoir removal suffered no complications from delaying this procedure. The only significant predictor of the need for reservoir removal was the presence of a surgical site infection at the time of infection diagnosis. Age, tumor histology, concurrent systemic chemotherapy, number of reservoir accesses, myelosuppression, or infecting organism did not predict need for reservoir removal.

Conclusions: A majority of patients with reservoir-associated infections can be successfully treated with an aggressive antibiotic regimen. This avoids the need for reservoir removal and subsequent replacement.

Adult sport-related traumatic spinal injuries: do different activities predispose to certain injuries?

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Background: Sports injuries are known to present a high risk of spinal trauma. We hypothesized that different sports predispose to different injuries and injury severities.

Methods: We conducted a retrospective cohort analysis of adult patients who experienced a sports-related traumatic spinal injury (TSI), including spinal fractures and spinal cord injuries (SCIs), encoded within the National Trauma Data Bank from 2011-2014. We used multiple imputation for missing data and estimated multivariable linear and logistic regression models.

Results: We included 12,053 cases of TSI, which represented 15% of all sports-related trauma. The majority of patients with TSI were male (82%) and the median age was 48 years (interquartile range [IQR]32-57). The most frequent mechanisms of injury in this database were cycling injuries (81%), ski and snowboarding accidents (12%), aquatic sports injuries (3%), and contact sports (3%).

Compared to non-TSI sports-related trauma, TSIs were associated with an average 3 day increase in length of stay (95% CI 2.9-3.1;p<0.001) and discharge to or with rehabilitative services (adjusted odds ratio [aOR] 2.7;95% CI 2.5-2.8;p<0.001). Among sports injuries, TSIs were the cause of discharge to or with rehabilitative services in 32% of cases.

SCI was present amongst 15% of cases with TSI and was most frequently at the level of the cervical spine (78%). This rate of SCI was 13% for cycling injuries compared to 41% and 50% of contact sports and aquatic sports injuries, respectively. Laminectomy was required in 3% of all patients with TSI overall, and 12% of patients with SCI. Independent of whether the spinal cord was involved, aquatic sports injuries were associated with need for a laminectomy (aOR 3.3;95% CI 1.4-7.5;p<0.001).

Conclusion: Of people discharged to rehab, one-third had TSIs. Cycling injuries were the most common cause, suggesting that policies to make cycling safer may be considered.

Decreased wall shear stress at high-pressure areas predicts the rupture point in ruptured intracranial aneurysms

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Background: Degenerative cerebral aneurysm walls are associated with aneurysm rupture and subarachnoid hemorrhage. Thin-walled regions (TWRs) represent fragile areas that may eventually lead to aneurysm rupture. Previous computational fluid dynamics (CFD) studies reported the correlation of maximum pressure (P_{max}) areas and TWRs; however, the correlation with aneurysm rupture has not been established. This study aims to investigate this hemodynamic correlation.

Methods: The aneurysmal wall surface at the P_{max} areas was intraoperatively evaluated using a fluid flow formula under pulsatile blood flow conditions in 23 patients with 23 saccular middle cerebral artery (MCA) bifurcation aneurysms (16 unruptured and 7 ruptured). The pressure difference (Pd) at the P_{max} areas was calculated by subtracting the average pressure (P_{ave}) from the P_{max} and normalized by dividing this by the dynamic pressure at the aneurysm inlet side. The wall shear stress (WSS) was also calculated at the P_{max} areas, aneurysm dome, and parent artery. These hemodynamic parameters were used to validate the correlation with TWRs in unruptured MCA aneurysms. The characteristic hemodynamic parameters at the rupture points in ruptured MCA aneurysms were then determined.

Results: In 13 of 16 unruptured aneurysms (81.2%), P_{max} areas were identified that corresponded to TWRs. In 5 of the 7 ruptured cerebral aneurysms, the P_{max} areas coincided with the rupture point. At these areas, the Pd values were not higher than those of the TWRs in unruptured cerebral aneurysms; however, minimum WSS, time-averaged WSS, and normalized WSS at the rupture point were significantly lower than those of the TWRs in unruptured aneurysms ($p < 0.01$).

Conclusion: At the P_{max} area of TWRs, decreased WSS appears to be the crucial hemodynamic parameter that indicates the risk of aneurysm rupture.

Multimodal Analgesia in Lumbar Fusion Surgery: Impact Amidst the Opioid Epidemic

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Spine surgery traditionally relies on opioid analgesics for postoperative pain management. Opioids are associated with prolonged hospital stays and opioid use disorders. Majority of those using opioids for non-medical indications received opioids through prescriptions. Opioid-focused prescribing habits in surgery have partially contributed to the opioid epidemic. In Massachusetts alone, overdoses were the leading cause of injury and resulted in 37% of injury deaths in 2013.

Retrospective analysis of data was performed comparing patients receiving a multimodal analgesia regimen after lumbar spinal fusion surgery versus control group patients receiving a standard analgesia regimen. The multimodal regimen consisted of Acetaminophen 975mg TID, Toradol 7.5mg Q6 hours for 24-hours followed by Celebrex 100mg BID for 7-days, Robaxin 500mg Q6 hours prn for muscle spasms, Gabapentin 300mg/100mg TID for 4-weeks, and prn narcotic. The standard regimen consisted of Acetaminophen 975mg TID, narcotic prn, and muscle relaxant prn. There were 12 patients in the multimodal group and 26 patients in the control group evaluated over 3-month and 6-month time periods respectively. Primary outcomes analyzed included hospital length-of-stay, total and IV narcotic requirements in Morphine Milligram Equivalent (MME), and VASS pain scores.

Study results demonstrate differences between patient populations when focusing on the opioid-naïve participants. Opioid-naïve patients in the multimodal group were found to have significantly lower IV narcotic requirement than the control (0.22 +/- 0.67mg/day for multimodal vs 5.36 +/- 5.56mg/day for standard group, p-value=0.001). These patients also had shorter hospital stays than the control (2.78 +/- 0.83 days for multimodal vs 3.53 +/- 1.17 days for standard group) but the difference was just below our threshold for significance (p-value=0.066). Including both opioid-naïve and opioid-tolerant patients, no significant differences were found in hospital length-of-stay, MME, IV narcotic requirement nor VASS score between the multimodal group and the control groups (p-values of 0.46, 0.81, 0.36 and 0.91, respectively).

Overall, the study favors using multimodal analgesia in those undergoing lumbar spinal fusion surgeries as evident by considerably reduced IV narcotic requirement and nearly significant shortened hospital length-of-stay in opioid-naïve patients compared to control.

Task-Shifting and Task-Sharing in Neurosurgery: An International Survey of Current Practices in Low- and Middle-Income Countries and Global Perspectives

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Background: The global neurosurgical workforce deficit of over 23,000 neurosurgeons has spurred the practice of task-shifting and task-sharing (TS/S), delegating neurosurgical tasks to non-specialists. Current practices and perceptions of neurosurgical TS/S are not well understood.

Methods: Two surveys were conducted between July 2018 and January 2019. A Capacity survey investigated TS/S practices in low- and middle-income countries (LMICs). A Perspectives

survey ascertained perceptions on TS/S in both high-income countries (HICs) and LMICs. Data were analyzed by descriptive statistics and univariate regression of Likert-scale scores.

Results: The Capacity survey yielded 126 responses from 46 LMICs; 21 countries (45.7%) reported ongoing TS/S. TS/S procedures primarily involved emergency interventions (e.g. burr holes, craniotomy for hematoma evacuation, external ventricular drain). A majority (65.0%) denied that their Ministry of Health endorses TS/S (24.0% unsure), and only 11% believed that TS/S training was structured. There were few opportunities for TS/S providers to continue medical education (11.6%), maintenance of certification (MOC; 9.4%), or receive remuneration (4.2%).

The Perspectives survey obtained returns from 105 of 194 WHO member countries (54.1%; 391 respondents, 162 HICs, 229 LMICs). The most agreed-upon statement was that task-sharing is preferred to task-shifting. There was broad consensus that TS/S should require competency-based evaluation, standardized training endorsed by governing organizations, and MOC. When perspectives were stratified by income class, LMICs agreed significantly more that task-sharing should be prioritized where human resources are scarce, task-shifting can be professionally disruptive, and call for additional TS/S regulation, such as MOC and formal consultation with a neurosurgeon (in-person or electronic/telemedicine).

Conclusion: TS/S is ongoing in many LMICs without substantial structure or oversight, which raises concerns for patient safety. Both LMICs and HICs agreed that task-sharing should be prioritized over task-shifting, and that additional recommendations and regulations could elevate care provision. These data invite future policy and training program discussions.

A Machine Learning Algorithm for Mortality Prediction in Chronic Subdural Hematoma Patients: A NSQIP-based analysis

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Background: The purpose of this study is to analyse perioperative factors potentially related to mortality within thirty days after neurosurgical intervention for chronic subdural hematomas (CSDH) and build a predictive model using machine learning techniques, with the aim to better inform the risks related to neurosurgical operation.

Methods: Data for patients who underwent surgery for CSDH between 2005 and 2016 was extracted from the National Surgical Quality Improvement Program (NSQIP) registry with the appropriate CPT codes. The incidence of mortality was examined for each covariate, using Fisher exact test to compute the p-values between each subgroup and respective reference level. After applying Random Forest algorithm to identify the factors with the highest Gini importance on the training set, a neural network was created to predict the outcome of mortality.

Results: A mortality rate of 15% was observed among the 1176 studied patients with CSDH from the NSQIP database. Statistically significant factors, which were defined to have a p-value < 0.05 , included blood transfusion, totally dependent functional status, and dyspnea at rest. From the Random Forest algorithm, the features implemented in the neural network included various preoperational lab values, such as creatinine levels, BMI value, and age. The neural network applied to a test set yielded a c-index of 0.74 compared to a null model (c-index = 0.5).

Conclusion: The mortality rates in the database of people who underwent neurosurgical procedures for CSDH is in the higher end from reported literature; however, this is in line with recent discussions about viewing CSDH differently from the established “benign” condition. Univariate analysis revealed different factors that may affect mortality in CSDH, and a computational neural network was developed with a c-index of 0.74. Further development of the model may lead to an interactive tool to better inform physicians and patients on most probable outcomes given patient features.

Neurosurgery Interviews: The Impact of Inappropriate and Discriminatory Questions

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Background: The harmful impact of workplace discrimination has gained widespread recognition as a result of current events. Nearly two thirds of all residency applicants have reported being asked potentially illegal interview questions. To date, no studies exist evaluating potentially harmful/illegal questions during neurosurgery residency interviews.

Methods: All 2018-2019 neurosurgery resident applicants to three geographically diverse programs were anonymously surveyed (n=341). To minimize selection bias, surveys opened after applicant rank list submission and closed before match results. The survey included 50 questions focused on the incidence and prevalence of harmful/illegal questions and whether such questions affected rank list formation.

Results: 133 US applicants (50%) responded to the survey. Males represented a significant majority of respondents (78%). Among all applicants, 24% married and 10% with children. Regarding inappropriate questions, shockingly, 78% were asked about marital status and 29% were asked about intent to have children. Moreover, 46% reported being counseled on their personal life by interviewers, 30% were asked about their ethnic background, and 15% were asked about their religion. Two candidates reported being asked questions regarding mental illness/disability and two candidates reported being asked about their sexual orientation. Marital status questions were similarly distributed between women and men (79% vs. 76%, p=0.703) but women were more likely to be asked about family planning (31% vs 22%, p=0.264) and were more likely to be counseled on their personal lives (59% vs 42%, p=0.068).

Conclusion: Eighty percent of neurosurgical residency applicants reported being asked at least one potentially illegal or discriminatory question during interviews. Females were more likely to be asked about family planning and counseled on their personal lives than males. Potentially illegal or discriminatory questions negatively affected how applicants ranked programs.

