Neurotrauma & Critical Care NEWS

AANS/CNS Section on Neurotrauma & Critical Care

Spring 2018

Editor: Martina Stippler, MD, FAANS

In This Issue...

CHAIR'S MESSAGE

Dear Colleagues,

Dr. Daniel B. Michael

As our section continues to fulfil its mission of improving the care of our patients by providing education, advocacy and encouraging research, I am pleased to report on our recent activities.

Finance: Total 2017 membership in our section is 2,492, which is up from 2,341 in 2016. The majority of members are residents. Projected revenue for 2018 is $117k, while projected expenses are $124k. The section has total net assets of $264k. We welcome input from the AANS & CNS leadership as we continue to attempt to find new revenue and efficiently utilize current resources to advance our mission.

Education: The Section continues to provide a wide selection of educational opportunities for neurosurgeons to keep neurotrauma and critical care knowledge and skills current. Traditional workshops and symposia were provided by the section at the 2017 CNS Annual Meeting in Boston. The Section received especially good feedback on the case presentation sessions. Online webinars, PowerPoint presentations (available on the Members Only section of the website) and content for the CNS App have been provided by the Section's leadership. We are working to see that the latest edition of the Brain Trauma Foundation guidelines for the management of severe TBI are available on the Guidelines App.
The CDC has compiled a Pediatric mild TBI evidence review and guideline statement. Working with the Washington Committee, the Section provided input to this document. Thanks to Katie Orrico, JD; Adair Prall, MD, FAANS; Shelly Timmons, MD, PhD, FAANS; and all who helped prepare our response to this document.

Liaison: Richard Ellenbogen, MD, FAANS; Jam Ghajar, MD, PhD; and others represented our interests at the American College of Surgeons (ACS) Clinical Congress and Committee on Trauma (COT) meeting. The COT will be updating the Orange Book. Others and I will work with the COT on the neurosurgeon's roll in the verification process. This will include updating the neurotrauma CME requirements for ACS trauma center verification. The Section has long espoused the view that staying current in neurotrauma and critical care requires updates in all areas of neurosurgery: spine, skull base surgery, pediatrics and pain management. We are therefore working with the American Board of Neurological Surgery and the COT to allow trauma credit for taking the new MOC exam.

Consensus: The Section has partnered with organizations to develop decision support tools for treatment of neurotrauma and critical care patients. Neurotrauma

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Chair's Message, cont'd

Section leaders have provided input to the ACS TQIP consensus statement, which is being updated. Greg Hawryluk, MD, FAANS, is working with Randall M. Chesnut, MD, and others to develop a TBI algorithm. This team is working towards a consensus meeting this summer, if funding can be secured. Many of the section leadership attended a consensus conference on decompressive craniectomy, organized by Peter Hutchinson, PhD, and held in Cambridge, UK. A paper based on the results is in preparation. The section has also provided input to a consensus group on concussion subtypes headed by Angela Lumba-Brown, MD, an emergency room physician at Stanford University.

Basic Science: Our section continues its partnership with the National Neurotrauma Society (NNS), which represents those involved with basic science research on neurotrauma and critical care topics. At the NNS annual meeting, the Section sponsors resident awards, provides abstract reviewers and hosts a clinical section with an opportunity to earn neurotrauma CMEs. This year, the NNS meeting will be held in conjunction with the International Neurotrauma Society (INTS) in Toronto, August 11-16. It promises to be another outstanding venue for clinicians and basic scientists to learn and interact.

An important subject in neurotrauma continues to be the relation between concussion and long- term sequelae, such as chronic traumatic encephalopathy (CTE). This was the subject of a special symposium organized by our section and held in conjunction with the 2017 CNS meeting in Boston. New data published by C. A. Tagge, et al. (Brain 2018: 0; 1-37) suggests the degree of severity of immediate concussion from impact symptoms do not correlate with those of blast injuries or long term neuropathological findings seen in CTE. The authors state, "Our results also suggest that concussion, TBI, and CTE represent distinct nosological entities subserved by different pathobiological mechanisms. Specifically, our findings indicate that closed-head impact injury, independent of concussion, represents a potent insult with potential to induce enduring neurophysiological dysfunction and persistent (and possibly progressive) sequelae, including CTE brain pathology." Our incoming chairman, Julian Bailes, MD, FAANS, a recognized authority on concussion, will continue to lead the Section's involvement in this high profile neurotrauma issue.

Hail and Farewell: Our section has endorsed Steve Kalkanis, MD, FAANS, for CNS president-elect. He is an exemplary neurosurgeon from the Henry Ford Health System in Detroit. He has served our profession admirably and, if elected, will continue to do so.

It has been a great honor to have served as your section chairman for the past two years. Whatever we have accomplished during my term is largely due to the members who contribute their time and treasure to further our mission. I am in your debt. Now, like the character in the old barracks song "old soldiers never die, they just fade away," I leave the Section in the capable hands of our future leaders.

Best,

Daniel B. Michael, MD, PhD, FAANS
Chairman, AANS/CNS Section on Neurotrauma & Critical Care

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Officer in the Spotlight: Randy Bell, MD, FAANS

The views expressed in this article are those of the author and do not reflect the official policy of the Department of the Navy, Department of Defense, or U. S. Government.

Cmdr. Randy S. Bell, MD, FAANS, (USN) received his undergraduate and medical school training in Arizona, graduating from Arizona State University with a degree and chemistry and from the University of Arizona with a degree in medicine. He received his neurosurgery training at the Walter Reed Army Medical Center and National Naval Medical Center in Bethesda, Md. and fellowship training in cerebrovascular neurosurgery and interventional neuroradiology at the Washington Hospital Center, under the direction of William Bank, MD, and Rocco Armonda, MD, FAANS. He is now an active duty neurosurgeon in the U.S. Navy and has served at the U. S. Naval Hospital in Okinawa, Japan, the Role III Multinational Medical Unit in Kandahar, Afghanistan, and now as Associate Professor and Chief of Neurosurgery at the Uniformed Services University and Walter Reed National Military Medical Center Department of Neurosurgery. His research focuses on the epidemiology, outcomes and medical and surgical interventions of severe closed and penetrating brain injury suffered during war.

1. ***What do you think is the biggest unanswered question in TBI.***

There are many that unfortunately remain unanswered!

Cmdr. Randy S. Bell (RB): For me, the Holy Grail in TBI research is the development of some pharmacological or surgical therapy that either stabilizes and/or reverses the effects of severe primary brain injury. Is there a medication/device/biologic that provides reproducible neuroprotection and improves outcomes after injury? We have made progress with secondary injury prevention, though we are by no means perfect. The litany of failure of pharmacotherapy is long and depressing. I am hopeful that this will change with time.

2. What are the changes in clinical TBI research?

RB: I think that the main emphasis of TBI research over the last 10 years has focused on mTBI and CTE. There is no question that this is important, and I think the advances in this area are palpable. I would like to see additional emphasis placed on severe closed and penetrating brain injury. I think that the reason for the relative paucity of funding in this area is simply a matter of numbers. The incidence and prevalence of the most severe TBI is without question, less than mild TBI. While the funding tends to go where the patients are, I think the impact of additional research and funding in severe TBI could be proportionally substantial.

3. What TBI question did you set out to answer?

RB: I started neurosurgery interested primarily in cerebrovascular disease. My initial work with my mentor, Dr. Rocco Armonda, focused on traumatic cerebrovascular injury. We sought to understand the natural history of traumatic aneurysms and whether or not there were viable endovascular solutions for these unpredictable entities. Turns out, there are. I am now focused on the effects of heparinoids in severe closed and penetrating brain injury. Because of our community's long standing reticence to utilize heparinoids in trauma, there is almost no good translational research in this area. I would like to know the answer to whether or not, and at what dose, heparinoids either worsen or improve outcomes after severe TBI.

4. What advice could you give to other neurosurgeons dealing with TBI patient?

RB: As a military neurosurgeon, I have operated in some hostile and resource poor environments. I trained in a time of war and continue to be privileged to care for the wounded men and women that defend us. It was during this time that I learned, again from my mentor Dr. Armonda, what may be one of the most valuable surgical principles. I learned that it is often not clear who we can help or not help with our interventions. When it is not clear, and even if I am pretty sure what I will do will not help, I tend to intervene rather than designate "non-survivable." This is especially true downrange, where the injuries can be beyond terrible. In that setting, what I do may not result in long-term survival, but may result in the patient surviving an air evacuation home so that his or her family can say goodbye. Sometimes, they pull through. My advice to other neurosurgeons dealing with TBI: Don't give up and throw in the towel too early. Your patient may surprise you.

Randy Bell, MD, FAANS

5. What is your biggest challenge during your day-to-day work?

RB: Medicine continues to advance and I think what we do helps people. I am, however, constantly amazed and depressed by the "advancement" of administration and regulation. There are now so many more administrators in healthcare environments than there are providers. I agree that some administrative backbone and regulation is necessary in medicine, but I think we have entered a time where regulatory agencies and by-proxy administrators paradoxically shift the focus of healthcare facilities away from the provision of care to the fulfillment of administrative and regulatory tasks. My biggest challenge is the constant barrage of meaningless, daily administrative requirements that take my focus from my patient.

The Role of Hospital Protocols in Neurotrauma Management

Richard B. Rodgers, MD, FAANS

Several years ago, we asked a well-known neurotrauma expert to perform a comprehensive review of our program and make recommendations for improvement. A part of that review was interviewing neurosurgeons, advanced practice providers (APPs) and bedside nurses. The problem most cited by far was "inconsistency," especially with respect to the care of traumatic brain injury (TBI). With over 20 neurosurgeons sharing a complex call schedule, it is easy to see how care could be inconsistent or fragmented. Opinions, training and experience are appropriately diverse in our large group. To be perfectly honest, interest in neurotrauma varies significantly as well. Unfortunately, this variability led to dissatisfaction with consulting teams and bedside care. Our problem, put simply, was that there were too many cooks and too many cookbooks. Potential solutions included limiting the number of neurosurgeons taking trauma call, or standardizing the care those taking call could provide. For our group, the former was not an option. Given that there are published guidelines, position statements and plenty of literature and expert opinion on neurotrauma care, we turned toward education and dissemination of management recommendations.

Neurotrauma patients have a wide range of needs, based on the specifics and severity of their injury. Providers must be equipped with the proper knowledge and tools to handle such complex care. Patient care algorithms and protocols serve a number of purposes: reduce practice variation, facilitate guideline adherence and serve as a resource for staff. Protocols can provide consistency and clarity in the daily management of patients when dealing with activities that are related to safety and regulatory requirements and can be used as quality assurance (QA) tools. When based on available evidence and published guidelines, patient care – and therefore outcome – may be improved.

The literature allows us to easily create straightforward evidence-based protocols for managing certain issues, such as DVT/VTE prophylaxis and clearance of the cervical spine. Other specific entities – for example, blunt cerebrovascular injury – may have less robust evidence, requiring published evidence to be extrapolated to a different population and using historical personal experience to create an institution-appropriate guide. When used for QA, outcomes can be monitored and protocols adjusted as needed. New publications can also influence changes to existing management algorithms.

As a group, we have formulated several protocols to help us care for the neurotrauma patient. These were not all created at once, but over time and with input from several care providers – physicians across specialties, APPs, pharmacy – and are seen as living documents to be modified as new knowledge arises. There has been marked improvement in satisfaction of bedside nursing, consulting teams and our own providers due to consistency and the ability to anticipate care. Incorporating protocols into order sets has had an added beneficial effect of fewer phone calls from the bedside for clarification of care. Have we improved patient outcomes? Our impression so far is yes, but that remains to be proven. QA reports indicate that DVT/VTE rates have improved compared to years past, but whether that is a direct effect of the protocol is difficult to prove.

Other protocols are more difficult to assess from a patient outcome standpoint.

With this type of care comes the realization that not all patients fit into the tight confines of an algorithm. An individual's response to TBI is varied and the effects are unpredictable. What is best for patients overall, per the protocol or algorithm, may not be appropriate for an individual. The literature does reveal evidence both for and against protocolled care and strict adherence to management plans. For example, Lee et al. (2015) found that high compliance with the TBI guidelines did not show a significant difference in mortality, when compared to those that had a moderate compliance rate. Interestingly, at a higher rate of compliance the rate of mortality began to increase slightly. Deviation from a care protocol may actually be in the patient's best interest – depending on who is directing that patient's care. Kahol et al. (2011) found that more experienced providers are able to adapt to the dynamic environment and deviate from standard protocols and algorithms, while minimizing the number of errors – innovative care. Novices, on the other hand, when deviating from a protocol, become mired in the procedural aspects of a situation and are unsuccessful with communicating care needs, causing a higher number of errors. This data lends itself to the thought that, at times, coloring outside the lines might be beneficial to patients from an individualized care standpoint and total adherence to a protocol may not be imperative and relative to an individual patient outcome.

Related to this, with the shift in healthcare drifting towards individual care, algorithms can alienate those who do not align with the majority. While protocols are meant to guide staff in decision-making, they are not meant to impede individualized care. Protocols that are inflexible can do harm by limiting the provider's ability to tailor care to a specific patient situation, thus compromising quality care. A practitioner needs to have the ability to look at the entire picture and be able to make clinical decisions specific to the patient. Our staff are instructed that our own written protocols are not standards of care which need to be strictly followed for fear of punishment, but are intended to assist care providers in maintaining continuity and consistency in patient management and quality assurance. We also recognize that deviating from an established protocol may lead to a favorable patient outcome. This thought mirrors the conclusions of Kahol et al. (2011), in that the acuity of critical environments is ever changing and may require providers to stray from set standards.

The practice of medicine never has been, and never will be, a completely straightforward activity. Providers must rely on shrewd clinical judgment and decision-making skills to treat these complex patients. Protocols should be evidence-based, but also institution and provider specific, based on local resources and expertise. Our experience is that formulating and providing algorithms (some of which are provided), for certain aspects of neurotrauma care has

Dr. Richard B. Rodgers

improved consistency of care and morale of the care providers. Our impression is that we have improved overall patient care and outcomes by making it easier to follow published guidelines and recommendations.

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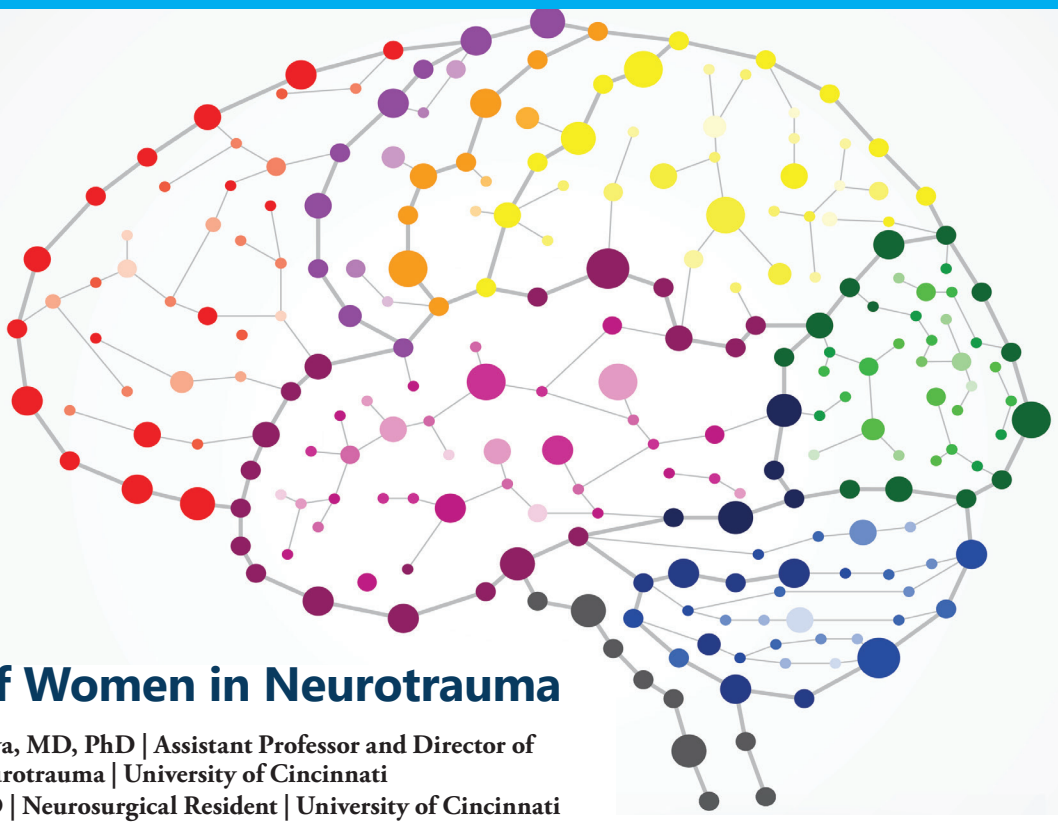
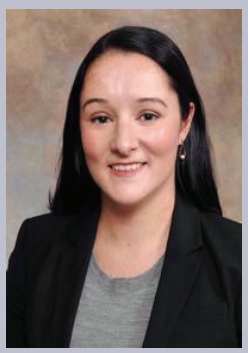


The Rise of Women in Neurotrauma

Laura B. Ngwenya, MD, PhD | Assistant Professor and Director of Neurotrauma | University of Cincinnati
Daryn K. Cass, MD | Neurosurgical Resident | University of Cincinnati

Dr. Laura B. Ngwenya



Dr. Daryn K. Cass

Neurotrauma as a neurosurgical subspecialty is an emerging field. Interest in neurotrauma, as indicated by membership in the AANS/CNS Section on Neurotrauma & Critical Care has more than doubled between 2007 (1,091 members) to 2016 (2,530 members).[1] Much of this growth is necessary to fit the needs of the aging and growing United States population. Reports by the Institute of Medicine and AANS/CNS have noted that the ability to provide emergency neurosurgical care is a challenge to the national emergency care system, as too few neurosurgeons are available to cover neurotrauma call.[2,3] An on-the-rise population that has the potential to help fill this gap is the slowly increasing population of women in neurosurgery.

Approximately half of medical school students are women, yet females comprise only 16 percent of neurosurgery residents. The challenge of recruiting and retaining female neurosurgeons is well known and, despite initiatives through AANS/CNS and Women in Neurosurgery (WINS),[4] the total number of practicing female neurosurgeons remains below 500. The presence of positive role models, leadership positions and opportunities for female mentorship can have a strong influence on career trajectories of women in academic medicine. A recent article that surveyed the career paths for women in neurosurgery noted that the most common neurosurgery subspecialty fellowship pursued by female neurosurgeons is pediatrics (33 percent).[5] The large numbers of female pediatric neurosurgeons encourages more women to enter pediatrics, due to the strong presence of female mentors and role models. There are currently only three neurotrauma/critical care fellowships that offer neurosurgical training, so in the aforementioned article, the data collected from 1964 through 2013 does not accurately represent women in the neurotrauma subspecialty. Obtaining a more accurate assessment of female representation in neurotrauma may assist with recruitment and retention efforts of female neurosurgery trainees interested in the field.

Self-identification as a neurosurgeon that specializes in neurotrauma may be an alternate way to capture neurotrauma subspecialization. Neurotrauma encompasses

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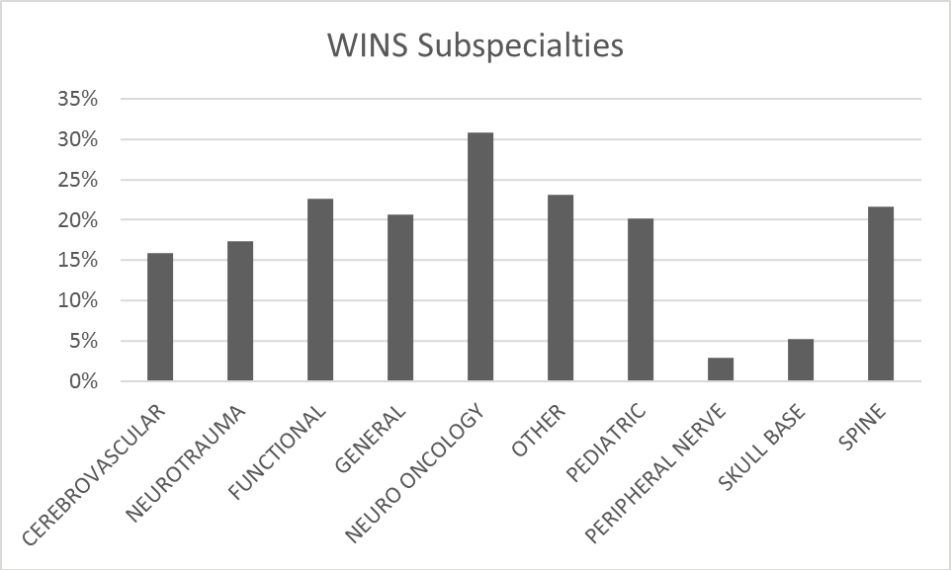

Figure 1: Subspecialty self-identification by 208 female WINS members. Data from AANS section membership (courtesy of Kristin Zefras).

emergency neurosurgical care, thus many general neurosurgeons and subspecialty neurosurgeons who take primary call at trauma centers across the country are ultimately involved in neurotrauma patient care; yet, only a select few self-identify as neurotrauma neurosurgeons. In the 2017 WINS membership, 208 female neurosurgeons listed subspecialties, of whom 6 percent listed neurotrauma/critical care as their primary subspecialty. General neurosurgery, pediatric and spine were each listed as subspecialties by approximately 14 percent of respondents. Seventeen percent of female neurosurgeons listed neurotrauma/critical care as either their primary, secondary or tertiary subspecialty of interest (Figure 1). Given that WINS membership represents only a subset of women in neurosurgery, there are at least a moderate number of female neurosurgeons that self-identify as neurotrauma surgeons.

Neurotrauma as a neurosurgical subspecialty has a robust research counterpart. Neurotrauma research, including basic, clinical and translational research in traumatic brain injury and spinal cord injury is a growing field with numerous opportunities for multidisciplinary approaches and collaborations. The National Neurotrauma Society (NNS) promotes neurotrauma research to help lead clinical advances and is a strong supporter of mentorship. The NNS membership group, Women in Neurotrauma Research (WiNTR) consists of over 200 female members. The majority of the members are basic science researchers in academics. The female membership of WiNTR includes 15 percent full professors, 46 percent other academic faculty and 40 percent postdoctoral fellows or graduate students (Figure 2). The number of female trainees in WiNTR suggests that there is a strong interest in neurotrauma among young graduates and that there will be continued entrance of female researchers into the field. Importantly, the steady number of established female academic neurotrauma researchers assures that there are continued senior faculty and role models within the field.

The number of female academic researchers and female neurosurgeons in neurotrauma will likely increase over time, in response to the expanding availability of female role models and mentorship. The NNS has had climbing numbers of female leadership since 1998 (Figure 3), and five consecutive female Presidents of the organization since 2012. The election of neurotrauma surgeon Shelly Timmons, MD, PhD, FAANS, as the 2018-2019 presiden of the American Association of Neurological Surgeons (AANS) will place women in neurotrauma in the spotlight. Dr. Timmons is the director of neurotrauma at the Milton S. Hershey Medical Center at Pennsylvania State University in Hershey, Penn. Dr. Timmons will be the first female

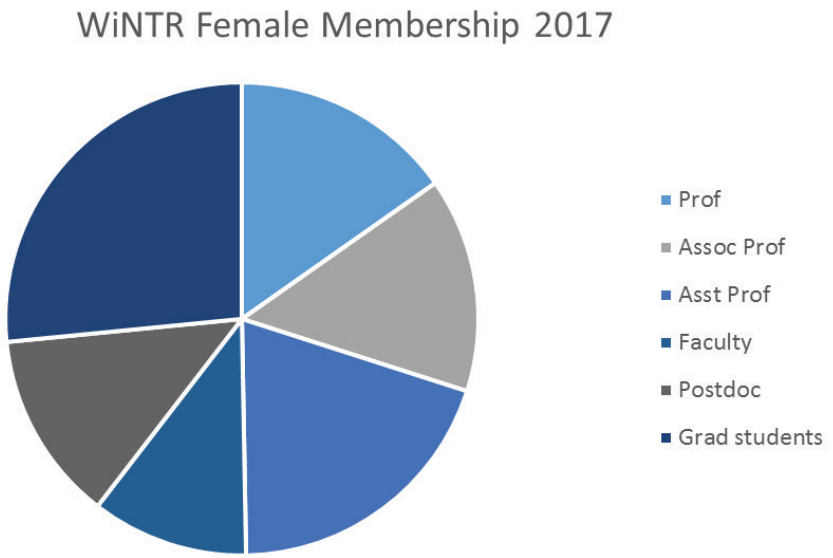

Figure 2: National Neurotrauma Society Women in Neurotrauma Research female member representation. Data courtesy of WiNTR (TEAM) Chair, Mayumi Prins, PhD.

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The Rise of Women in Neurotrauma

president in the modern history of the association. Her position as AANS president represents an acceptance of female leadership in organized neurosurgery and thus dismantles one of the obstacles to recruitment and retention of female neurosurgeons.

As we look to fill the needs in our communities, and encourage engagement in neurotrauma, it is important to recognize the expansion of female leadership in the field. The rise in the numbers of women specializing in neurotrauma research and surgery affords an opportunity for continued expansion of membership and service in the field of neurotrauma by young female neurosurgeons.

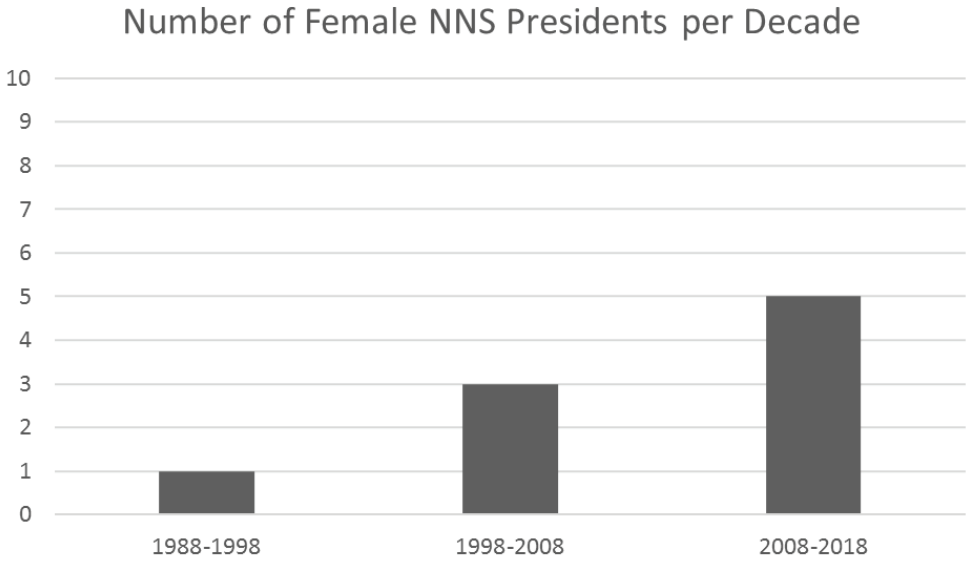

Figure 3: NNS Female Leadership since 1998. Data courtesy of NNS, at https://www.nationalneurotraumasociety.org/society-information/officer-history

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Should General Surgeons Manage Mild TBI Patients: A General Surgeon's Perspective

Bellal A. Joseph, MD | Professor of Surgery | The University of Arizona

Dr. Bellal A. Joseph

Traumatic brain injury (TBI) is one of the leading causes of death and disability. According to the Centers for Disease Control and Prevention (CDC), 2.8 million people sustain a TBI annually. About 2.5 million of these injured individuals are treated in an emergency department, with approximately 282,000 TBI-related hospitalizations and 56,000 deaths resulting in an estimated financial burden of $76.5 billion.[1] Although over the last decade there has been a tremendous increase in the use of healthcare resources due to TBI, the greatest increase has been seen in the subgroup of patients with mild TBI. It can be partly explained by the revolution in imaging technology, resulting in the detection of trivial and clinically insignificant findings on computed tomographic (CT) scans, which has led to over-diagnosis of mild TBI.[2]

The neurosurgeons comprise the main core of TBI management. However, over the past decade, the country is facing a severe shortage of neurosurgeons. According to the American Association of Neurological Surgeons (AANS), there is a big discrepancy between the supply and demand of the neurosurgery workforce: as a result almost 25 percent of the U.S. population is living in a county without a neurosurgeon. In addition, the neurosurgical workforce is aging, with almost 46 percent of neurosurgeons over the age of 55, which will further aggravate the decline of the workforce in future.[3] Classically, patients presenting with a suspected TBI are initially managed by a trauma surgeon. If an intracranial injury is identified on the CT scan, the common practice in most of the trauma centers is to get a neurosurgical consultation and perform a repeat head CT scan, regardless of the type or size of head bleed, clinical presentation or associated risk factors. This practice has put a burden on neurosurgeons who are already suffering from significant workforce shortage.[4]

The recent literature has opposed this approach because of three principal reasons. First, over 90 percent of these patients have mild TBI that does not require neurosurgical intervention and these patients are usually managed non-operatively and transferred to the trauma service within 24 hours.[5] Second, most patients with mild TBI have benign physical findings that resolve in 7-10 days. As a result, long-term follow-up in this patient population is very low. Around 10 percent of patients may develop a constellation of cognitive, physical and behavioral symptoms after mild TBI, referred to as chronic post-concussion syndrome, and they are mainly managed by neurologists and primary care physicians.[6] Third, TBI is a clinical diagnosis and serial clinical examinations can reliably predict the requirement for neurosurgical intervention or a repeat head CT scan in this subgroup of trauma patients.[5]

To improve and streamline the multidisciplinary management of patients with TBI, our institution has developed and implemented the brain injury guidelines (BIG) in collaboration with our neurosurgical colleagues (Fig 1). Patient safety is the basis and fundamental objective of these guidelines. BIG was developed by the analysis of 3,803 patients and prospectively validated and now proven to be safe in over 4,000 cases.[7,8] Since its implementation at our level-I trauma center, acute care service has been able to manage TBI patients with ICH and bleeds less than 8mm, normal neurological exam, not on any anticoagulant/antiplatelet and nondisplaced skull fractures by adhering to the protocol. This practice has resulted in a significant decrease in the rate of neurosurgical consultation, repeat head CT scans, hospital costs and hospital length of stay without any change in mortality (Fig 2a & 2b).[9] Five other level-I trauma centers have implemented BIG for the management of patients with TBI. In addition, the safety and efficacy of BIG have also been established in the management of mild-TBI among the pediatric population.[10] The application of BIG is especially important for institutions with limited resources. Martin et al. (2017) from the University of Cincinnati have validated BIG and concluded that implementation of BIG is both safe and feasible at a level-III trauma center without an increase in adverse outcomes.[11] Currently, an American Association for the Surgery of Trauma (AAST) sponsored multi-institutional trial is underway to implement BIG on a national level.

Over the last decade, there has been a paradigm shift in the management of patients with TBI. Acute care surgeons have assumed a critical role alongside the neurosurgeons for the management of these patients, resulting in an efficient resource utilization and reduction in the unnecessary burden on our neurosurgery colleagues.

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Should General Surgeons Manage Mild TBI Patients: A General Surgeon's Perspective continued ...

Brain Injury Guidelines

Variables	BIG 1	BIG 2	BIG 3
LOC	Yes/No	Yes/No	Yes/No
Neurologic examination	Normal	Normal	Abnormal
Intoxication	No	No/Yes	No/Yes
CAMP	No	No	Yes
Skull Fracture	No	Non-displaced	Displaced
SDH	≤ 4 mm	5-7 mm	≥ 8 mm
EDH	≤ 4 mm	5-7 mm	≥ 8 mm
IPH	≤ 4 mm, 1 location	5-7 mm, 2 locations	≥ 8 mm, multiple locations
SAH	Trace	Localized	Scattered
IVH	No	No	Yes

Figure 1. BIG: brain injury guidelines; CAMP: Coumadin, Aspirin, Plavix; EDH: epidural hemorrhage; IVH: intra-ventricular hemorrhage; IPH: intra-parenchymal hemorrhage; LOC: loss of consciousness; NSC: neurosurgical consultation; RHCT: repeat head computed tomography; SAH: subarachnoid hemorrhage; SDH: subdural hemorrhage.

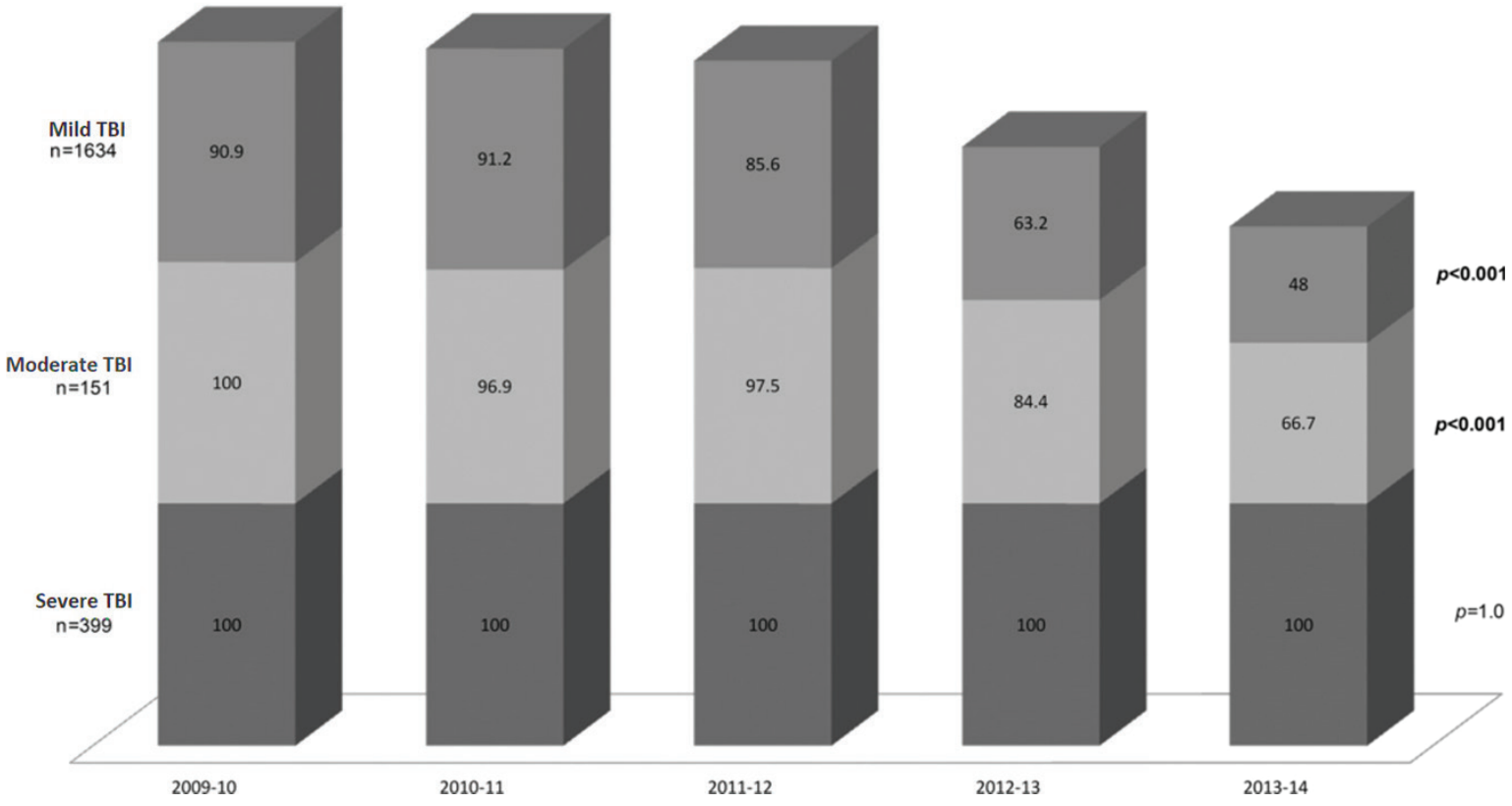

Figure 2a. Trends in neurosurgical consultations after implication of BIG guidelines.

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Should General Surgeons Manage Mild TBI Patients: A General Surgeon's Perspective continued ...

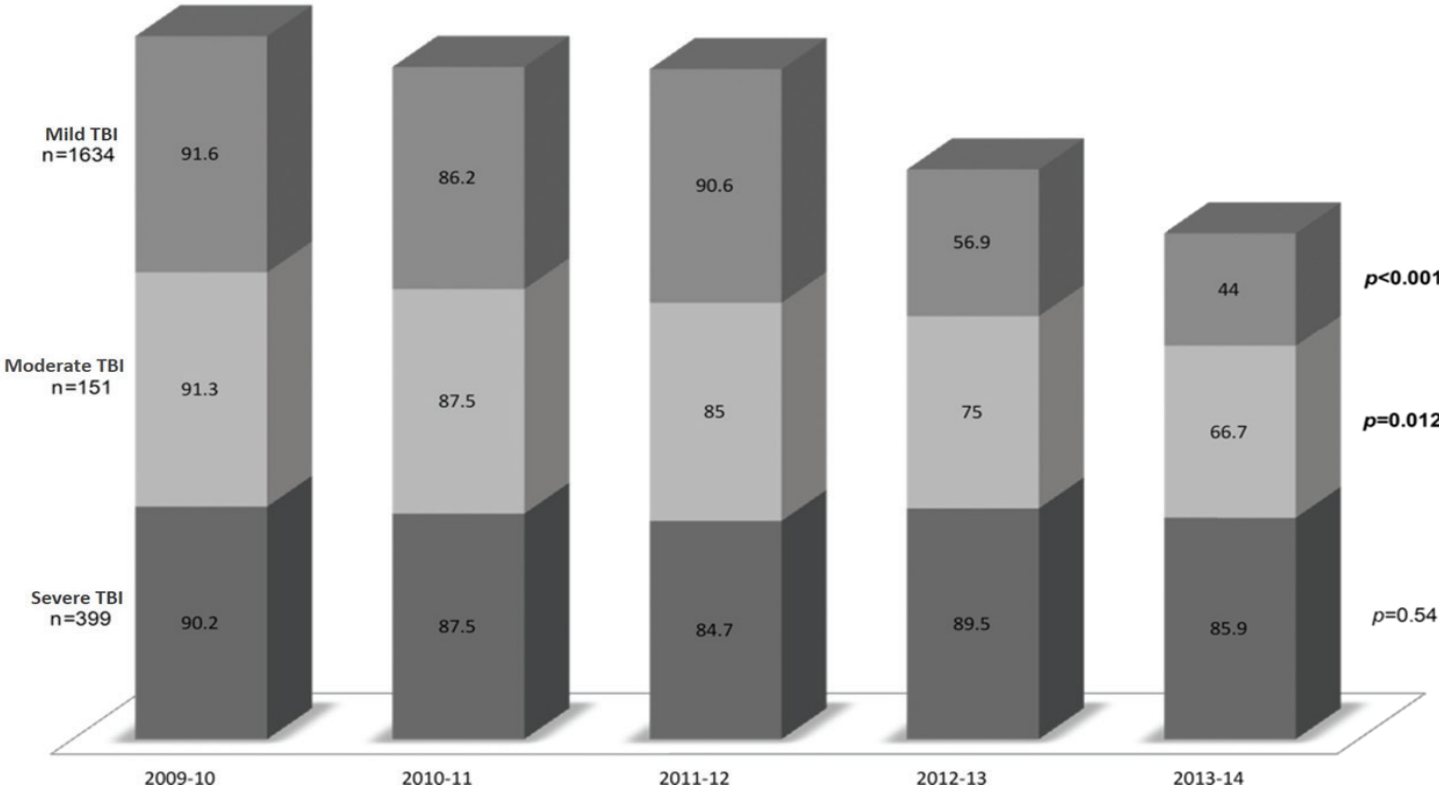

Figure 2b. Trends in repeat head computed tomographic scans after implication of BIG guidelines.

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Should General Surgeons Manage Mild TBI Patients: A Neurosurgeon's Perspective

Martina Stippler, MD, FAANS

Dr. Martina Stippler

What is the role of a neurosurgeon in the care of nonoperative complicated mild TBI? As the neurosurgeon workforce is shrinking and aging and fewer working neurosurgeons want to take care of trauma patients, the question of who will take care of these patients comes to mind.

An initiative by ACS to manage and triage complicated mild TBI without the input of neurosurgeons is a laudatory endeavor. The authors of the BIG protocol concluded that the protocol standardizes the treatment of patients with TBI without the need for neurosurgical consultation and unnecessary imaging. I concur with the authors that repeat head CT scanning in patients with complicated mild TBI is overused. Head CT scans obtained routinely and not prompted by an exam change rarely, if ever, lead to a neurosurgical intervention.

However, which patient should be admitted, to what level of care and the need and timing of a repeat head CT should be left to the neurosurgeon, as we will have to handle complications that arise.

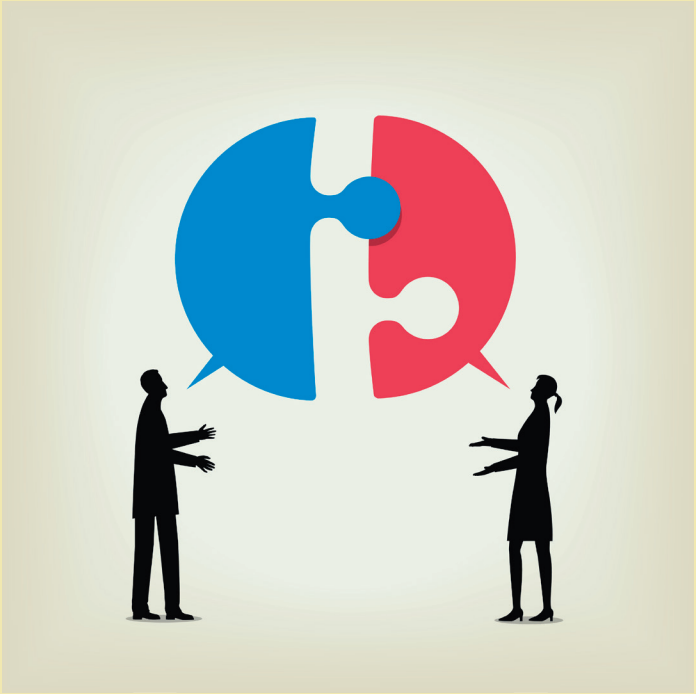
One of the biggest concerns with the BIG protocol is the inclusion of epidural hematomas, which have a high potential for deterioration and can be misleading when they present with the typical lucid interval before deterioration.

The BIG protocol also was introduced in level I trauma centers with neurosurgery colleagues readily available if a patient should deteriorate and need neurosurgical intervention. The real test of this approach, and where it would be most needed, will be in trauma centers without neurosurgery coverage. Whether ACS and emergency medicine physicians will feel comfortable with this approach remains to be seen.

I have worked in different parts of the country with very high and very low neurosurgery saturation rates and have encountered, in both situations, high reluctance of non-neurosurgeons to care for complicated mild TBI, even after a teleradiology consultation with a neurosurgeon.

Although follow-up standards for nonoperative TBI with intracranial hemorrhages varies, the BIG protocol begs the question of who the patient will follow up with once discharged. Nonoperative acute SDHs in particular necessitate close follow-up and sometimes neurosurgeon intervention as they become chronic and do not absorb, or even increase in size.

The most important point we can learn from the BIG approach is that, with standardized and protocolized medicine based on patient data, we can streamline patient care and avoid unnecessary health care costs in the form of repeat head CT or interfaculty transfers. A collaborative approach between trauma surgeons and neurosurgeons will best serve TBI victims.



Saturday, April 28

8:00 am - 12:00 pm | PRACTICAL CLINIC

011 EVD Insertions: Hands-on Practicum Course

Marianne E. Langlois, MS, PA-C; Gregory J. A. Murad, MD, FAANS; Izabela Tarasiewicz, MD, FAANS

2:12 pm - 5:00 pm

International Symposium - Session III: Neurotrauma

Geoffrey T. Manley, MD, PhD, FAANS; Daniel Bernard Michael, MD, PhD, FAANS; David O. Okonkwo, MD, PhD, FAANS

Sunday, April 29

7:30 am - 11:30 am | PRACTICAL CLINIC

038 Update on the Management of Spine and Spinal Cord Injury

Sanjay Dhall, MD, FAANS; Michael G. Fehlings, MD, PhD, FAANS, FRCS (Canada); James S. Harrop, MD, FAANS; Daniel Jin Hoh, MD, FAANS; W. Bradley Jacobs, MD, FAANS (Canada); Jesus LaFuente, MD (Spain); Nicholas Theodore, MD, FAANS; Claudius Thome, MD, IFAANS (Austria)

7:30 am - 11:30 am | PRACTICAL CLINIC

039 Neurotrauma and Neurocritical Care for the Practicing Neurosurgeon: MOC Review and Update

Perry A. Ball, MD, FAANS; Peter John Hutchinson, MD, FRCS (United Kingdom); Joshua Eric Medow, MD, MS, FAANS; Daniel Bernard Michael, MD, PhD, FAANS; David O. Okonkwo, MD, PhD, FAANS; Patricia B. Raksin, MD, FAANS; Philip Andrew Villanueva, MD, FAANS

7:30 am - 4:30 pm | PRACTICAL CLINIC

025 Case-based Management of Traumatic Brain Injury

Anthony Figaji, MD (South Africa); Gregory W.J. Hawryluk, MD, FAANS; Jack I. Jallo, MD, PhD, FAANS; Ryan S. Kitagawa, MD, FAANS; David O. Okonkwo, MD, PhD, FAANS; Haejoe Park, MD; Richard B. Rodgers, MD, FAANS; Uzma Samadani, MD, PhD, FAANS; Franco Servadei, MD (Italy); Martina Stippler, MD, FAANS; Shelly D. Timmons, MD, PhD, FAANS; Joseph Christopher Zacko, MD, FAANS

12:30 pm - 4:30 pm | PRACTICAL CLINIC

045 Neurosurgical Care of Athletes: Concussion, Spine, Peripheral Nerve and Return-to-play

Tim E. Adamson, MD, FAANS; Julian E. Bailes Jr., MD, FAANS; Joseph Charles Maroon, MD, FAANS(L); Michael McCrea, PhD, ABPP; Mark E. Oppenlander, MD; Allen Kent Sills, MD, FAANS

Monday, April 30

7:00 am - 9:00 am | BREAKFAST SEMINAR

100 Pediatric Neurosurgery for General Neurosurgeons

Richard C. E. Anderson, MD, FAANS; A. Graham Fieggen, MD, IFAANS (South Africa); Gerald A. Grant, MD, FAANS; Todd Cameron Hankinson, MD, MBA, FAANS; Mark D. Krieger, MD, FAANS

7:00 am - 9:00 am | BREAKFAST SEMINAR

103 Contemporary Management of Spinal Fractures

Steven Casha, MD, PhD (Canada); Bernhard Meyer, MD (Germany); Charles Sansur, MD, MHSc, FAANS; Nicholas Theodore, MD, FAANS; Claudius Thome, MD, IFAANS (Austria); Gregory R. Trost, MD, FAANS

7:00 am - 9:00 am | BREAKFAST SEMINAR

117 Cerebral Trauma: State-of-the-art Treatment

Deepak K. Gupta,, MCh (India); Daniel Bernard Michael, MD, PhD, FAANS; Andres Mariano Rubiano, MD (Colombia); Uzma Samadani, MD, PhD, FAANS; Franco Servadei, MD (Italy)

1:10 pm - 2:00 pm

Neurosurgery in Press: Latest Results of Clinical Trials in Neurosurgery and Allied Fields

Aviva Abosch, MD, PhD, FAANS; Frederick G. Barker II, MD, FAANS

2:00 pm - 5:30 pm

Scientific Session VI: Neurotrauma

Gregory W.J. Hawryluk, MD, FAANS; Seth A. Hoffer, MD, FAANS

Tuesday, May 01

2:00 pm - 5:30 pm

Advancements in Neurotrauma Care

Marianne E. Langlois, MS, PA-C; Cristina Matthews, MSN, FNP-BC; Joshua Eric Medow, MD, MS, FAANS; Kaine Chamberlain Onwuzulike, MD, PhD; Richard E. Temes, MD, MS; Jamie S. Ullman, MD, FAANS

2:00 pm - 5:30 pm

AANS/CNS Section on Neurotrauma and Critical Care

Patricia B. Raksin, MD, FAANS; Martina Stippler, MD, FAANS

Wednesday, May 02

7:00 am - 9:00 am | BREAKFAST SEMINAR

312 Return-to-play After Sports Injury II: Concussion

Julian E. Bailes Jr., MD, FAANS; Ann-Christine Duhaime, MD, FAANS; Mark D. Krieger, MD, FAANS; Joseph Charles Maroon, MD, FAANS(L); Mark R. Proctor, MD, FAANS; Allen Kent Sills, MD, FAANS

1:00 pm - 2:00 pm

Rapid Fire Abstracts: Neurotrauma; Pediatrics; Stereotactic and Functional

Mark D. Krieger, MD, FAANS; Neil R. Malhotra, MD, FAANS; Uzma Samadani, MD, PhD, FAANS

Delayed Progression of Edema in Severe TBI

Phiroz E. Tarapore, MD, FAANS | University of California, San Francisco

Dr. Phiroz E. Tarapore

Case

This case involves a 35-year-old man who was ejected from his motor vehicle. The vehicle was traveling at approximately 100 mph and collided with a concrete barricade. The patient was intubated in the field. He had a Glasgow coma score (GCS) of 3 upon initial examination by EMS, after transport to the emergency department, and upon initial examination by neurosurgery. He had reactive but asymmetric pupils, a cough and gag and was overbreathing the ventilator. He underwent a full body CT, which demonstrated a right temporal epidural hematoma (5cc), left holohemispheric subdural hematoma (SDH) (6mm), left temporal contusions and left-to-right midline shift (MLS) (4mm) (Fig 1).

The patient was admitted directly to ICU, where he underwent placement of a ventriculostomy and brain tissue oxygen monitor (PbtO2 monitor). Opening intracranial pressure (ICP) was 8cm of H2O. The repeat head CT, approximately 4h later, demonstrated interval increase in the left SDH (8mm), expansion of the temporal contusion and increased left-to-right MLS (6mm) (Fig 2). The patient's ICPs experienced intermittent elevation to the mid-20s, but responded well to drainage. His cerebral autoregulation was intact and his ICPs responded to mild increases in mean arterial pressure (MAP) as well.

Over the subsequent week, the patient's neurological exams improved; he localized consistently with his left arm and would become agitated off sedation. He had rare spikes in his ICP, which required drainage 1-2 times per 24h. PbtO2 levels were 15-20. His autoregulation remained intact and his ICPs continued to respond well to mild hypertension. Multiple attempts were made to wean the ventriculostomy, but he continued to depend on occasional CSF drainage to control ICP (Fig 3).

On hospital day (HD) 10, the patient's exam worsened; his left arm demonstrated flexion, instead of localization. His ICP remained between 18-24, but a test of his cerebral autoregulation revealed it to be absent. Given these developments, a CT angiogram was performed, which revealed a stable left SDH (8mm), new left MCA/ACA vasospasm and worsening left-to-right MLS (12mm) (Fig 4). The patient was subsequently taken to the OR for evacuation of his SDH. The craniotomy was fashioned as a typical trauma, with a large fronto-temporo-parietal bone flap, but after evacuation of the SDH the brain was relaxed and had ample room, so the bone flap was replaced. Post-operatively the patient's exam returned to baseline and his post-operative scan demonstrated good evacuation of the SDH (Fig 5).

On HD11/post-op day 1, the patient's right arm again became weaker, but his autoregulation was intact, and his ICPs remained under 25 with 10 cc of CSF drainage. On HD12/post-op day 2, however, the patient's right arm was profoundly weak, his pupils became sluggish, his ventriculostomy ceased to drain, he lost his cerebral autoregulation and his left scalp flap was tense. CT head demonstrated worsened left temporal swelling, greater left-to-right MLS and effacement of the left lateral ventricle (Fig 6). He was taken emergently for removal of the left bone flap. Post-operatively, his neurological exam returned to baseline and his MLS improved (Fig 7).

The patient subsequently experienced steady improvement. He required placement of a temporary tracheotomy and percutaneous gastrostomy tube, but his ventriculostomy was weaned on HD18 and he was transferred out of ICU on HD20. He did develop a surgical site infection requiring operative washout and long term antibiotics. He was transferred to acute rehabilitation on HD46. On the last follow-up visit (4 months after his trauma), he was alert and oriented x 3, fluent, conversant, walking without assistance and living at home with family (Fig 8).

Discussion

This case is illustrative of the complexities inherent to complex, severe traumatic brain injury and the long-term vigilance that must be exercised in such cases. Although the patient's exam was grave upon admission, he rapidly improved to brisk localization and stayed at this new baseline for 10 days. During this period, he also maintained his cerebral autoregulation and had mildly elevated ICPs that required occasional, modest intervention. However, after

Continued on the next pages.

this period of relative stability, the patient experienced a clear worsening in his exam and neurophysiological parameters, requiring evacuation of the SDH mass lesion. Despite an initially favorable response to this intervention, he progressed 36h later and required a full hemicraniectomy.

The markedly delayed progression in this case is reminiscent of another notorious injury pattern in TBI patients: bifrontal contusions. Bifrontal contusion patients tend to progress around post-injury day 4-8 and often have a precipitous decline in their neurological exam.[1] The pathophysiology of this phenomenon, although not clearly understood, may be related to the development of cytotoxic edema surrounding the contusions.[2,3] In this case, the contusions were temporal rather than frontal, so lateral displacement of the uncus into the midbrain was the most likely cause of the patient's eventual hemiparesis.

Another notable result of the predominantly temporal contusion was the lack of severe elevation of ICP as detected by the ventriculostomy transducer, despite clear radiographic evidence of temporal swelling and uncal herniation. This discrepancy was most likely a result of the relative isolation of the temporal lobe from the lateral ventricle, where the ventriculostomy was located. Temporal swelling, therefore, resulted in uncal herniation and clinically significant brainstem compression before it was detectable in the ICP monitor. It must be remembered that ventriculostomy-based ICP transduction is a broad measure of most of the supratentorial compartment, but it may not reflect more localized processes that can threaten critical structures, such as the brainstem. In the future, one might consider using a localized intraparenchymal pressure monitor within the temporal lobe to capture more relevant data.

Also of interest in this case is the role of cerebral autoregulation. Throughout the first 10 days of his course, the patient's autoregulation remained intact. Indeed, this mechanism proved useful in controlling his ICP: modest elevations in blood pressure resulted in compensatory vasoconstriction, decreased volume and thereby decreased ICP. However, the patient lost his autoregulatory capacity at the same time as his swelling peaked. Which of these developments occurred first is unclear; most likely, as the cytotoxic edema peaked, cerebral vasoreactivity was compromised, leading to hyperemia, which in turn worsened the swelling. Eventually, the brain shift resulted in enough brainstem compression to cause brainstem compression and hemiparesis.

Finally, one must consider the timing of surgical intervention in this case. Some might argue that the original injury was severe enough to warrant immediate decompressive hemicraniectomy: a MLS of 5mm with an overlying acute subdural meets the generally accepted surgical criteria. In this case, however, the patient's initial ICP of 8 and his rapid improvement to a localizing exam suggests that immediate surgery was not necessary; indeed, it may have worsened his temporal contusions. Furthermore, the stability of the patient's exam for the subsequent 10 days suggests that surgery may have been avoided altogether, were it not for his late decompensation, which few would have predicted. The decision to replace the bone flap after his initial operation seemed reasonable at the time, given a relaxed brain with plenty of overlying space; in retrospect, however, his rapid return for bone flap explantation suggests that an eventual hemicraniectomy was unavoidable.

The management of severe TBI remains one of the most unpredictable and challenging pathologies in neurosurgical practice. Predictive models, although improving, are far from perfect and may not accurately predict the clinical course of a specific patient. Constant re-evaluation of neurophysiological parameters, such as ICP, cerebral autoregulation and brain tissue oxygen tension, is essential, as these parameters can change from hour to hour and call for vastly different interventions. Clinical vigilance and an open mind are indispensable when managing these patients.

References

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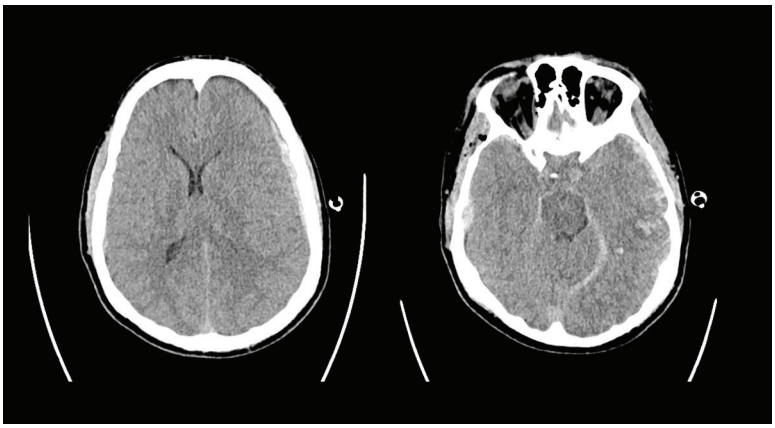
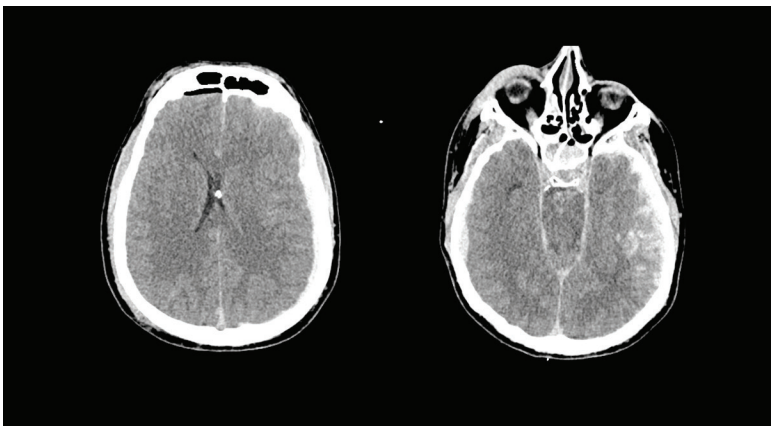


Figure 1. A full body CT, demonstrating a right temporal epidural hematoma (5cc), left holohemispheric subdural hematoma (SDH) (6mm), left temporal contusions and left-to-right midline shift (MLS) (4mm).

Figure 2. The repeat head CT, approximately 4h later, demonstrating interval increase in the left SDH (8mm), expansion of the temporal contusion and increased left-to-right MLS (6mm).



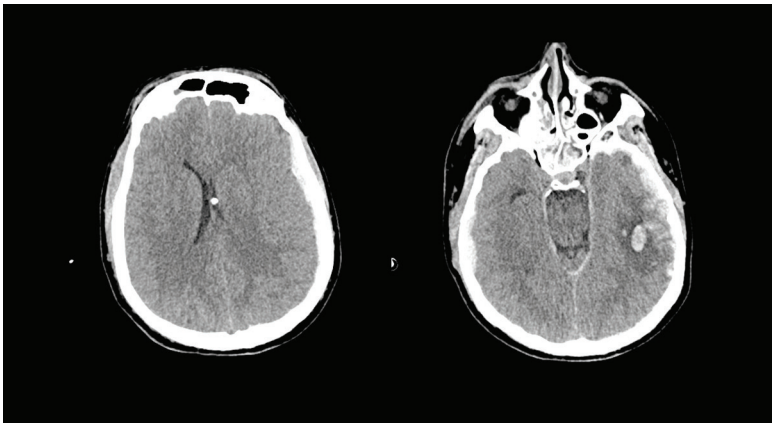
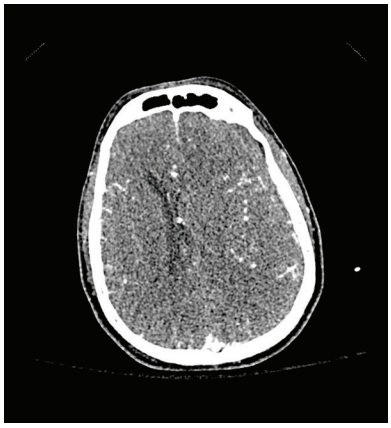


Figure 3. Multiple attempts were made to wean the ventriculostomy, but the patient continued to depend on occasional CSF drainage to control ICP.

Figure 4. A CT angiogram performed revealed a stable left SDH (8mm), new left MCA/ACA vasospasm and worsening left-to-right MLS (12mm).



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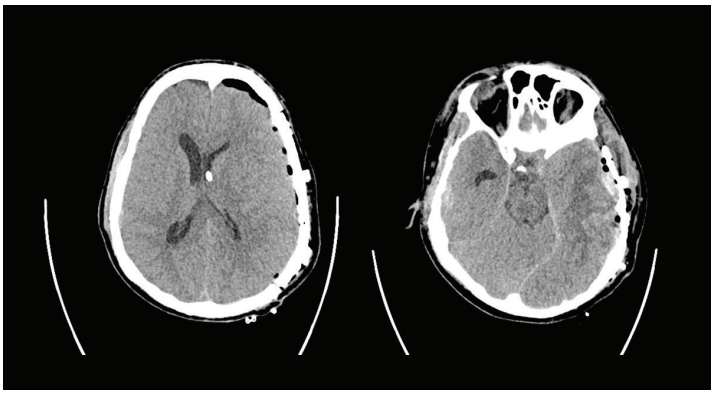

Figure 5. Post-operative scan demonstrating good evacuation of the SDH.

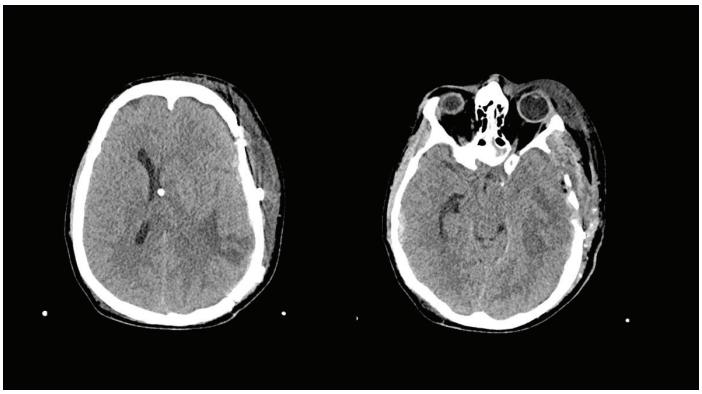

Figure 6. CT head scan demonstrating worsened left temporal swelling, greater left-to-right MLS and effacement of the left lateral ventricle.

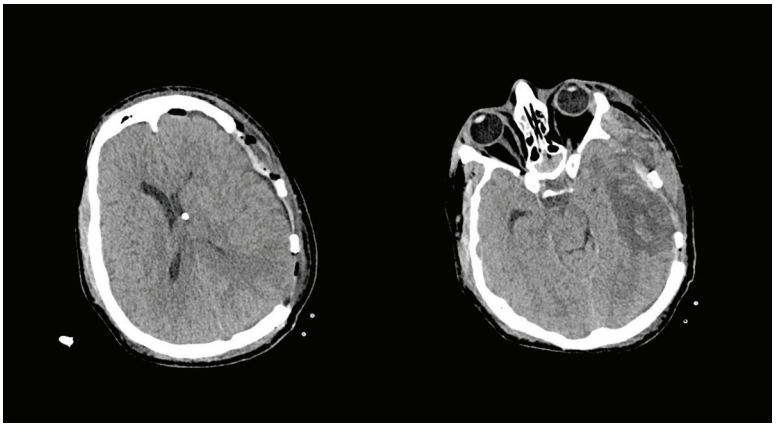

Figure 7. After being taken emergently for removal of the left bone flap. Post-operatively, the patient's neurological exam returned to baseline and his MLS improved.

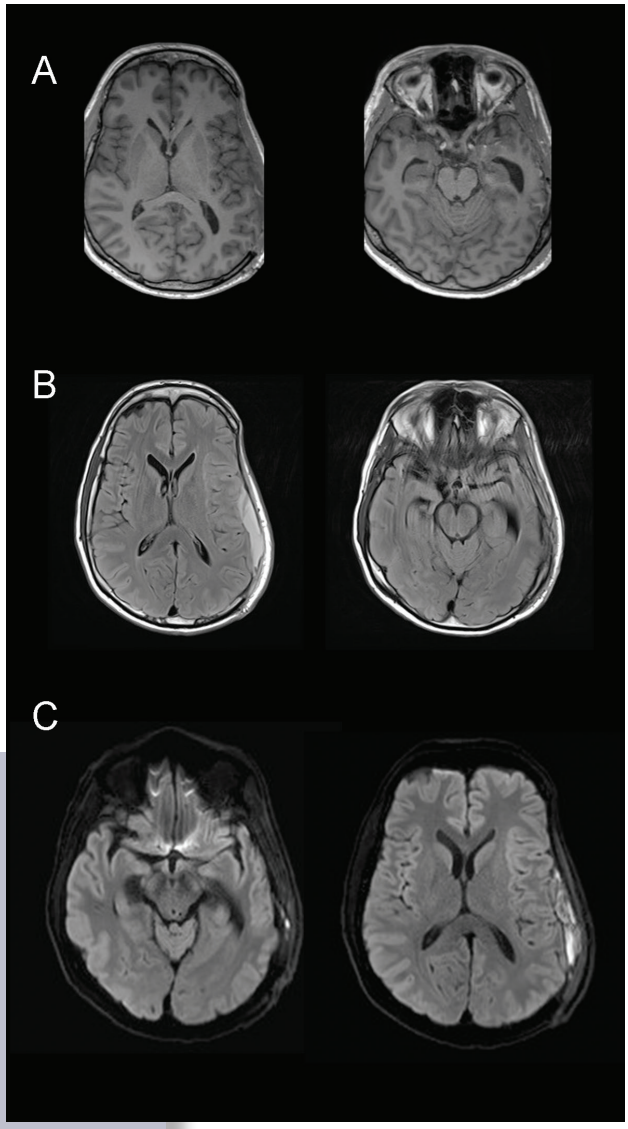

Figure 8. On the last follow-up visit (4 months after the trauma), the patient was alert and oriented x 3, fluent, conversant, walking without assistance and living at home with family.

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