CURRENTS

Neurocritical Care Insights and Perspectives From Around the World • October 2024

WAVES OF THE FUTURE

NEUROCRITICAL CARE SOCIETY

CURRENTS

News magazine of the Neurocritical Care Society

October 2024

Neurocritical Care Society

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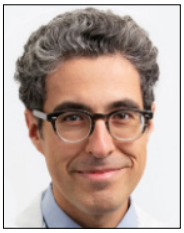
TABLE OF CONTENTS

NEUROCRITICAL CARE SOCIETY

MESSAGE FROM THE EDITOR



Dear Colleagues,

I'm excited to welcome you to the 2024 annual issue of Currents, which we're releasing just in time for you to enjoy along with the 22nd NCS Annual Meeting in San Diego. This year's meeting theme aims to celebrate the ways NCS and its members are making waves every day, whether they're in our day-to-day practice or in each new wave of cutting-edge advances. After the whirlpool of the last few years, the tide is turning for the better, and each ripple of progress promises an even better tomorrow. In keeping with this spirit, we invite you to wade into the water with us and collectively imagine what the future of neurocritical care might look like.

Of course, we expect the future will bring with it new technologies to integrate into our practice and our patients' lives. To help shine a light on these new technological frontiers, our Tech Corner is back with an article that heralds the advent of brain-computer interfaces for patients with severe neurological injury. But there's also lots of practice-changing technology already out there, and our POCUS section features articles that illustrate how point-of-care ultrasound should get even more recognition as an essential skill in neurocritical care settings.

The future also offers the prospect of evolving practice paradigms utilizing both new and familiar treatments alike. For example, ICH management is on the verge of being completely revolutionized with strategies focused on bundled care and timely interventions, and we've got an article that details a roadmap to bringing ICH care in line with acute ischemic stroke. Meanwhile, articles from our NCS Twitter Journal Club, Pharmacy, and NEWS sections offer new updates on expanding the use of peripherally administered 3% hypertonic saline, mindful dose adjustments of cefepime in patients at risk of neurotoxicity, and the potential role of albumin in preventing delayed cerebral ischemia in patients with subarachnoid hemorrhage.

But even more than new technology and treatments, the future should center around people—with ever higher standards of care for our patients and more interconnectedness among clinicians and practices around the globe. As NCS continues to grow its international footprint, we've got articles from our colleagues in Africa, Latin America, and Asia/Oceania that discuss opportunities and collaborative efforts to enhance neurocritical care in low- and middle-income countries with a diverse range of resources and practices. Meanwhile, back in the US, we highlight efforts to address health disparities in hemorrhagic stroke through innovative research platforms centered around patients and their unique perspectives. No matter the setting, though, the future we envision is built on optimism and hope. Our Stories of Hope series continues to inspire and uplift us with each new chapter, and we've included two of our most popular stories from the past year.

Finally, as we navigate the waters of the future, we're also making sure to give a wide berth to practical concerns that could throw us off course if we don't take heed. Our business section explains new updates to reimbursement requirements that will help prepare you for the changing landscape of value-based care. And in cautionary articles that serve as calls to action, our nursing section aims to stem the tide of nurse burnout and a looming staffing crisis, while our advocacy section offers suggestions to prevent ongoing shortages of critical medications that threaten to become more frequent in the future.

As Editor-in-Chief, I continue to be amazed by the dedication and generosity of our editorial board and contributors, as well as the outpouring of support from our readers and the entire neurocritical care community. My thanks go out to all of you for everything you do—Currents wouldn't be where it is today without you, so here's to staying the course! If you like what you see here, make sure you check out our website to revisit all of our content from the past year, and stay tuned for even more great Currents content in the future. Who knows, one of the next voices we feature might be yours—so if you've got an idea you'd like to turn into an article, please reach out to discuss.

As we set sail on another year of making waves, remember that a rising tide lifts all boats—so let's all continue reaching beyond our grasp and building the future of neurocritical care together. We'll be seeing each other next year at the 23rd Annual Meeting in Montreal before you know it—so make sure to brush up on your French, and à bientôt!

Sincerely,
Michael Reznik, MD
Currents Editor-in-Chief

NEUROCRITICAL CARE SOCIETY

NCS Leadership 2023-2024

Welcome to the NCS 22nd Annual Meeting in sunny San Diego! We're thrilled to have you here, as we challenge our minds and rekindle our passion for neurocritical care.

With our theme, "Making Waves: Actualizing the Extraordinary," this meeting is all about inspiring resilience and pushing the boundaries of neurocritical care. We begin with powerful stories of perseverance, as John Moon shares the incredible history of the Freedom House — laying the foundation for the U.S. EMS system and demonstrating how diverse, intentional strategies enhance access to care for all.

We're just getting started! INCC keynote speaker Sheeren Thor is energizing us with humor and thought-provoking insights, encouraging each of us to challenge the norm and step up as thought leaders in both our workplaces and communities. Later, we'll have an opportunity to hear from the Curing Coma Committee as they dive into discussions about disorders of consciousness and explore the future of coma care research.

Of course, it's not all business — we hope you're also taking the time to connect and recharge. Whether you're reconnecting with old colleagues or forming new friendships, this is the time to celebrate our shared passion for the care of neurologically injured patients and their families. Don't miss our evening networking reception aboard the USS Midway, where you can explore the flight simulators and honor those who served. Plus, your contributions to the Neurocritical Care Foundation during this event are supporting research, scholarships, and educational opportunities to help our community grow.

As we make waves here in San Diego, we're also looking toward the future. NCS is committed to expanding our initiatives over the next year, starting with establishing ourselves as the educator of choice for the nursing community — kicked off through our collaboration with Sharp Grossmont Hospital on a hands-on 3-D neuroanatomy workshop led by experts DaiWai Olson and Linda Littlejohns. We're also developing our strategy based on the recently completed needs assessment for advanced practice providers and registered nurses.

We're excited to also grow our strategic partnerships, with opportunities for outreach and collaboration already in the works. We'll share more on this as it progresses.

Our commitment to diversity, equity and inclusion remains a key focus as well. The newly established HEARD Center honors Dr. Galen Henderson's legacy by working to eliminate disparities in neurocritical care. Inspired by W.E.B. Du Bois' "The Talented Tenth," this center is advancing research, mentorship and leadership opportunities for underrepresented health professionals. We're excited to see this grow, and we welcome your support to help us make a real impact.

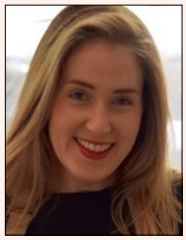
These are just a few ways that we're making waves together, and I'd love to hear how you are making an impact. Share your "wave-making" stories by emailing **info@neurocriticalcare.org** — let's celebrate the positive changes we're creating together.

Thank you for being here, for contributing and for being part of this incredible community. Let's take what we learn and apply it — whether at our hospitals, our institutions or globally. Let's make waves together!

Sincerely,
Susan Yeager, DNP, RN, CCRN, ACNP-BC, FNCS
Vice President

Story of Hope: Elisabeth

By Elisabeth Beraquit; Lauren Koffman DO, MS, Section Editor



In September 2013, I was entering my senior year at Boston University, and although I had already secured a position with PricewaterhouseCoopers (PwC) post-graduation, I still had a difficult year ahead of me. I was taking extra classes to obtain eligibility to become a certified public accountant, working as a nanny after class five days a week and assisting with the bookkeeping for my professor's restaurant. By the time spring rolled around, I was very ready to graduate, move closer to home, and focus on my career.

On May 16, 2014, my mother, father, three sisters and their families made the 6-hour road trip to Boston to see me cross the stage and secure a diploma. Later that evening, we attended a baseball game at Fenway Park. Growing up, we would take road trips up to New England often to see our family friends, the Jameses. My dad and Mr. James were huge Red Sox fans, so we always made it a point to catch a game with them when we were in town. Since all those visits and Sox games were part of the reason I chose Boston for college, it only made sense to have our celebrations continue at Fenway.

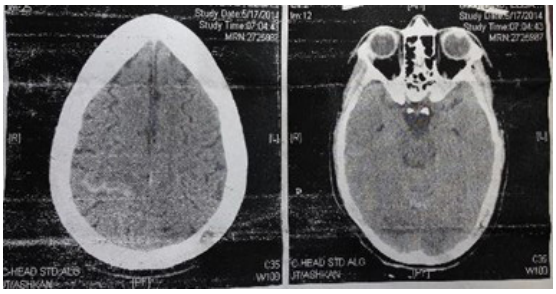
Elisabeth celebrating her graduation with her parents

Listen to Elisabeth's inspiring story now available on the NCS Podcast, and stay tuned for more episodes coming soon!

A rain delay postponed the game, so my mom and two of my sisters took their kids home to get some rest — but I stuck it out to finish the game with my dad, sister (Sarah) and brother-in-laws. We ate some Fenway franks and belted along with the crowd when "Sweet Caroline" came on in the middle of the eighth inning. All three of us were in a state of pure joy. Sarah and I were just happy to be together as we'd spent the last seven years attending schools in different states and my father was on his own cloud nine. His fourth and last daughter had now graduated college, and he was celebrating at one of his favorite places in the world. It didn't even phase us that we had just witnessed one of the most boring baseball games with the Sox losing to the Detroit Tigers, 1-0.

As the game ended, we headed toward the elevator since our seats were located on the fourth floor. Channeling this excitement, I

Elisabeth enjoying the game with her sister and father



Copy of the initial CT Head

jumped up to hug my dad from behind. When I came down from his back, I bumped the elevator door. Rather than uphold my weight, the door swung in, similar to how a doggie door opens. I descended roughly 30 feet, landing on top of the elevator car, which was on the first floor at the time. The door swung shut behind me and it was as if I had disappeared into thin air. My family went into panic mode very quickly. Sarah sprinted down the stairs to stop other patrons from operating the elevator and to get help. Fenway staff had the power cut off to the elevator and first responders including members of Boston EMT, police, and fire departments were quickly on the scene.

I was alone in the elevator shaft for roughly thirty minutes, with first responders working to secure the elevator. My family was in pure agony, knowing what the outcome would be if I wasn't able to breathe on my own. Thankfully, the responders were able to descend into the elevator on ropes to safely get me out of the shaft and on my way to Beth Israel Deaconess Hospital. Although I was initially breathing on my own, I was unconscious and placed on a breathing machine. I was sedated for comfort while intubated, but when they paused the sedating medications, I was not responding and the team was concerned about a traumatic brain injury. Sedation was resumed, and according to my family, I remained in the induced coma for five days. It was clear from the injuries to my jaw that my head took the brunt of the fall. X-rays confirmed that there was an open mandibular fracture and a few shattered teeth, along with some minor facial fractures. A computed tomography (CT) scan revealed vertebral fractures and several kinds of brain injuries in the right hemisphere. There was blood outside the brain (subarachnoid hemorrhage) and in the fluid filled spaces of the brain (intraventricular hemorrhage), as well as tearing of the brain fibers (diffuse axonal injury). My left lung had collapsed from a pneumothorax, and I had to have a chest tube placed to allow the lung to re-expand. After undergoing all these tests and initial assessments, I was moved up to the ICU.

For the first 48 hours, my family barely left my side. They took shifts to get food, but there were still so many questions at the time and no one felt comfortable leaving. Since it was such a large crowd, most of them stayed in the waiting room until I was moved up to the ICU. Here, they were able to stand by and watch for any signs of improvement, such as a wiggle of the toes or some pressure with my thumb. The nurses kept assuring them that I was getting better but that it would take time for the swelling in my brain to dissipate. By the third day, my father begged the nurses to ease up on my sedation so that I would have the opportunity to awaken on my own for a brief time. As my family gathered around me praying, it was in that short window of time that I opened my eyes for the first time. My eldest sister remembers this moment vividly as she recalls that it didn't look like "Lizzy" in the gaze I held, but it was enough reassurance that I was still in there. After meeting with the doctor in charge of my overall care and receiving some additional assurance that I was stable, my family left the hospital to get some much needed rest. They knew I was in good hands with the staff at Beth Israel.

The weeks to follow would be filled with a rollercoaster ride filled with highs and lows. By Monday, May 19, I was improving from the brain injury, so the team decided it was time to address getting my jaw repaired. During the surgery, they discovered that I had sustained a puncture that left an open wound from under my jaw straight through to my tongue. Dr. Chigurupati, my oral surgeon, used this opening to place a C-shaped plate across the front lower part of my jaw to hold the bones in place. To undergo these necessary surgical repairs, I had a tracheostomy performed to replace the breathing tube in my mouth and a PEG tube placed to allow me to receive nutrition. Although the surgery was successful and Dr. C was very pleased with her work, the recovery seemed to come with some setbacks. Due to the exhaustion and medications needed to keep me out of pain, I was having difficulty performing any of the commands that I had been able to do just two days prior and was kept very sedated. Nurses at Beth Israel such as Cara, Patty, Beth, Maureen (Mo), and Jared continued to take such great care of me. Cara even washed my hair and braided it every shift so that I would be able to keep my long hair.

Almost a week after the accident I was starting to flail my legs around, which is apparently a common response after brain injury, and I was able to be moved to a chair rather than the bed for the first time. As I started to wake up in the ICU, one thing became clear. This was not a scene from a movie where the patient wakes up after months in a coma and is immediately acting like themselves. My family describes my awakening as a rebirth, where I slowly went through each age and stage of life again. I quickly started working with both physical and occupational therapists who would help in my recovery. After spending seven days in the ICU, I was moved to the surgical floor. It may or may not be a coincidence, but this happened to be the same day the Red Sox ended the 10-game losing streak they'd been on since my accident.

> "My family describes my awakening as a rebirth, where I slowly went through each age and stage of life again."

By the time I moved to the surgical floor, I was in my toddler phase of recovery. I vaguely remember feeling disoriented and wondering who the "sit-in" nurses in my room were, but I'm not sure if these are personal memories or based on stories others told me. Similar to when I was an actual toddler, we definitely had some "terrible twos" moments. For my safety, I had a one-to-one assistant when my family was not there. I even slept in a "Posey Bed," which was essentially a large green tent wrapped around a hospital bed. Despite being under 24/7 supervision, I still found a way to pull my PICC line out. As I started to learn to communicate again, I still wasn't able to speak because of the trach. My family brought in my computer, and I started to slowly type out a few words. While these were great signs of recovery, the next steps were unclear. My family learned that recovery time was going to be a lot longer than initially expected and that I wouldn't be able to be moved back to New Jersey for a matter of weeks to months. Ultimately, it was determined that the best place for my recovery would be across town at Spaulding Rehabilitation center, a newer acute rehabilitation facility located in the seaport of Boston.

On May 29, 14 days after my injury, I was transferred by ambulance to rehab. While I had started walking to and from the bathroom with assistance, identifying family members, and listening to music to lift my spirits at Beth Israel, I really homed in on all of these activities and more at Spaulding. Over the next few weeks, I would undergo physical, occupational, and speech therapy each day. During physical therapy, I worked with mounted parallel bars to improve my balance and upper body strength. Shortly after I arrived at Spaulding, the therapists identified that my ability to walk and perform fine motor skill activities was being inhibited by a cranial nerve palsy that caused double vision and issues with depth perception, meaning my eyes weren't moving properly. I was given a pair of non-prescription glasses with prisms on the lenses. The prisms were supposed to help align images so I could see things more clearly. Since I only had double vision in the lower quadrants of my vision, the prisms were attached only at the bottom of the lenses, and I quickly adapted to looking over the prisms instead of through them. Either way, it helped avoid double vision, and I started progressing with my therapies. The following week, I was able to join a group activity bike ride that took place outside the therapy facility on adaptive bikes.

Typically, when you think of occupational therapy, you might think of a therapy that helps individuals with the things they'll need to do on a daily basis, such as work, school, hobbies, or household tasks. While occupational therapy achieved these goals in the end, the primary focus early on was helping me remember who I was. One of my biggest ongoing issues was my memory. When I first got to Spaulding, they had me fill out a sheet where they asked me my favorite movie, my address, and the names of my siblings. I got most of them wrong. My memory for big events was completely gone for the three months leading up to the accident. With the help of one of my best friends, Caroline, my family started a journal of activities I had participated in during senior week, the week prior to my accident, so I could read the journal and remind myself later.

Early on, my parents started going over what had happened to me and how I ended up at Beth Israel and then Spaulding. Since my short-term memory was also affected, I would have to be reminded often. At Spaulding, they found additional ways to help me recall who I was prior to the accident. One day, we visited a test kitchen in the facility and baked a batch of chocolate chip cookies from scratch. Baking had always been something I loved to do so I think this really helped center me. According to the journal my family kept, the day I spent baking was the first day I actually started saying that I felt "alive" since the accident.

Speech therapy was probably one of the most necessary and impactful of the three disciplines. It had been two weeks since my accident, and I was still unable to use my voice. At the time, everyone was unsure if my vocal cords had been injured during intubation or if it was just the placement of the trach that was making it difficult to form words. My speech therapists, Jenna and Brian, were able to use music to retrain me to speak. Brian would strum along on his guitar and have me breathe in to a number of beats and then hum as I breathed out. After my very first session with him I managed to say "mom," then "good morning" three days later, and by the fourth day, I spent the session singing "Trouble" by Taylor Swift.

After passing a few more tests like a swallow test and an independent living test, it was determined that I could continue these therapies on an outpatient basis closer to home, so I was discharged from Spaulding on June 25. I was able to enjoy a quick last supper with my friends from Boston before my parents and I started the journey back to Brigantine, New Jersey. Here, I picked back up with my physical, occupational, and speech therapy three times a week for the next six weeks. Once this was completed, I underwent a neuropsychological consultation at Malamut & Moss to determine where I stood and what I needed to focus on. The evaluation indicated that my fine motor speed was still severely impaired at this point and that there were residual impairments in many areas including visual disturbance, impulsivity, cognitive fatigue, residual memory, disorganization,

diminished reading comprehension, and slow reaction time. After the accident, PwC was very understanding and postponed my employment start date until January 2015. Upon receiving these results, I requested to postpone it further so I could focus on improving these deficits.

In the fall of 2014, I started studying for the CPA exam, along with doing some odd jobs like dog-sitting here and there, but since my driver's license had been suspended due to the issues with my vision, my options for employment and other activities were quite limited. By November, my neuro-ophthalmologist, Dr. Grant Liu, gave me the clearance to drive. Once I re-tested and renewed my license, I began looking for part-time employment to build up mental stamina and improve my executive function. By March 2015, I was working as a secretary at a veterinarian hospital, a human resources assistant at Career Opportunity Development, Inc., and as an assistant for a tax preparer during tax season. This was all while I studied for the FAR portion of the CPA exam. During this time, I was checking in with the NJ Division of Vocational Rehabilitation Services to ensure I was on track for a July start date with PwC.

Upon hearing that I had successfully passed the first part of my CPA exams in April, I was ready to start my journey with PwC in Philadelphia. I moved into a studio right in Center City, just a fifteen-minute walk from the office. Over the next eighteen months, I worked here as I continued to study and take the remaining three parts of the CPA exam. After two years with PwC, I realized the hustle and bustle of busy seasons with long hours and little time for friends and family might not be the life for me. Although accounting had been the safe route, I started looking into a career in baking because it had always been a dream in the back of my mind. I enrolled in a baking and pastry program at the Art Institute of Philadelphia and looked for part-time jobs in the industry to gain some experience while I was attending school. My classes at the Art Institute started less than a month after leaving PwC and I began working at J'aime French Bakery shortly after that. I initially obtained a position as a barista at J'aime, but once the owner and chef, Bastien, heard I had goals of becoming a baker, he would have me come in early before my shifts to help in the kitchen as well.

I'm not sure if it was the early mornings (with a 4 a.m. start!) that deterred me, or just a fear of being out of the industry for too long, but after six months I decided to look for a more suitable job back in the accounting industry. In January 2018, I started

> "I look back and I'm really proud of how far I've come from the confused young woman in the hospital bed nine years ago."

with the CPA firm, Morris J. Cohen, MJC, with the hopes of being able to achieve more work-life balance than I had back at PwC. MJC handled a wide variety of clientele and assisted each of them in many facets of business, so I was able to gain a lot of great experiences there. I loved working with my colleagues and employers at MJC, but ultimately my path kept veering back to baking.

In January 2020, I married my husband, Adrian, at what many of our friends and family consider the last fun event of 2020. Shortly after, COVID-19 began to spread across the U.S. Soon, the only reason we were leaving our apartment was to stock up on essentials from the grocery store. During quarantine, I stayed connected with family and friends by baking, distributing, and celebrating birthdays and other life events through video conferences. Baking was also a good distraction and stress reliever since our homes were now considered the place we ate, drank, slept, and worked. This year really cemented the idea of wanting to pursue baking as a full-time career. In November 2020, I purchased a building with a space that would allow me to do so. I continued working with MJC through April 2021, but after this point I focused fully on the construction and development of Beehive Bake Shop, which officially opened in November 2021.

After running my own business for almost two years, I still look back to "pre-fall Lizzy" and wonder if she would have had a different path. Remember, impulsivity was indeed one of the residual impairments previously identified. When I forget the baking time and temperature of my favorite cookies, or I can't remember how old my nieces and nephews are, I wonder if these are normal things to forget or if it's because of memory deficits due to the traumatic brain injury. At the end of the day, I look back and I'm really proud of how far I've come from the confused young woman in the hospital bed nine years ago. It certainly would not have been possible without the strong support system my family provided, the thoughtful and intensive care from all the nurses and doctors I encountered, and a lot of determination on my part. ●

Unbroken Stride: Cameron's Story of Hope, Overcoming Brain Injury to Cross the Finish Line

By Cameron Kuklick; Dea Mahanes, DNP, APRN, CCNS, HEC-C, FNCS; Bhiken Naik, MBBCh, MSCR; Lauren Koffman DO, MS, Section Editor




In many cultures, the gingko tree symbolizes hope and resilience. After Cameron Kuklick experienced a severe traumatic brain injury (TBI) at the age of 30, a gingko tree in a hospital courtyard became a symbol of hope and healing for him and for his family. Cameron and his family hope that by sharing their story and experiences, they too can provide hope and healing for others.

The Journey Through Brain Injury Begins: The Accident

On September 24, 2022, Cameron fell from a motorized rental scooter while returning to his hotel after celebrating his brother's wedding in Harrisonburg, Virginia. Although Cameron doesn't recall the accident, his parents Susan and Eric Kuklick received the call that every parent fears. Cameron, a previously healthy 30-year-old heavy equipment trainer, known for his love of running and adventure, was unconscious and had been airlifted to the University of Virginia Medical Center in nearby Charlottesville. No one at that time knew he would spend the next month in the Nerancy Neuroscience Intensive Care Unit (NNICU).

After Cameron arrived at UVA, a computed tomography (CT) scan of his brain showed contusions (or bruising) and swelling in multiple areas, along with fractures at the base of his skull. Other imaging demonstrated bruising to his lungs. The teams taking care of him decided to place an intracranial pressure (ICP) monitor, which revealed elevated pressure inside his skull. When traumatic brain injuries cause elevated pressures there is risk for additional brain injury, and action had to be taken quickly to prevent further damage. A team of physicians, advanced practice providers, nurses, and respiratory therapists began working to control the pressure with measures including using sedation to induce a coma, as well as medically treating the brain swelling. Cameron's brain wasn't the only area that had been seriously injured, though, as he required the help of a ventilator because of the injury to his lungs, and the team also diagnosed him with pneumonia, which required treatment with antibiotics.

Family as Part of the Team: Getting to Know Cameron

During daily rounds in the neurocritical care unit, the goal is to be as collaborative as possible, and this is accomplished by interprofessional rounding. Rounds are a time for everyone providing care to share information and develop a management plan. In the UVA NNICU, families are invited to participate, listen to the team, ask questions, and contribute information. In Cameron's case, rounds also became an opportunity for the entire team to learn more about Cameron before his injury through his mom, Susan, and dad, Eric.

Bhiken Naik, MBBCh, is the Associate Medical Director of the NNICU and was part of Cameron's neurocritical care team. "To me, the most memorable part of Cameron's care – besides his medical complexity – were the daily anecdotes about his life and the pictures that his mother shared with the team," Dr. Naik remembers. "We got to see the vibrant life he enjoyed before his injury, and one that we hoped to give back to him."

> "We got to see the vibrant life he enjoyed before his injury, and one that we hoped to give back to him."
>
> — DR. BHIKEN NAIK, ASSOCIATE MEDICAL DIRECTOR OF THE NNICU

Each day after the treatment plan was developed and questions were answered, Susan showed the team a picture of Cameron often doing something adventurous like running an ultramarathon in New Zealand, working high up in the trees as an arborist in Virginia, or climbing Mt. Hood in Oregon, but also sometimes just spending time with his family. These pictures became an anchoring point for the family and the care team, and rounds became a time for hope – hope that the care team and family working together could not only save Cameron's life, but also minimize the long-term impact of his TBI.

> "I sat stunned, not believing what I just saw. At that moment, I had hope. I thought, 'he's going to be okay.'"

A Bump in the Road

About 10 days after Cameron's accident, things seemed to be getting better. The ICP monitor was removed and he was starting to show signs of waking up as the sedating medications were weaned. Although still suffering from the bruising to his lungs from the initial accident and subsequent pneumonia, everyone was hopeful that Cameron would soon be free of the breathing machine. However, Cameron's oxygen levels suddenly declined, requiring more support from the ventilator. A CT scan of his chest was performed and revealed a serious complication. A large blood clot had formed in the inferior vena cava (the vein that returns blood from the lower body to the heart) and was moving around dangerously close to the heart. Some parts of the clot had already blocked blood flow from the heart to areas of the lungs. Dr. Naik and the team were very concerned that even more of the clot would break free, block off even more blood flow to Cameron's lungs, and possibly lead to weakening of his heart.

Blood thinning medications were started, and after extensive discussion with vascular specialists and Cameron's parents, a decision was made to attempt to remove the clot. This would be accomplished by inserting a catheter into the vein, which would then use a suction device to remove the clot. Although not without risk (as additional clot could be dislodged), the procedure provided Cameron the best chance of recovering with good lung function, something that was important to Cameron's previously active lifestyle. Luckily, the clot was successfully removed, and Cameron once again began to improve.

Continued Recovery

A few weeks into Cameron's hospital stay, a tracheostomy and feeding tube were placed to help support him while he recovered. As the sedation and ventilator were weaned, Cameron began to show signs of physical and cognitive improvement. His father Eric recalls the memory that he says stands out most as a moment of hope. "Cameron turned 31 while in his coma in the ICU. Once he started waking up, the nurses would always ask him basic questions to gauge his level of responsiveness and awareness. At first he never responded, until one day he did! He was asked 'Cameron, how old are you?' Cameron raised his hand and signed that he was 30 years old. I was so in shock that he finally answered a question that I thought I was hallucinating. But it got even better. After about five seconds, he changed his answer to 31! I sat stunned, not believing what I just saw. At that moment, I had hope. I thought, 'he's going to be okay'."

Cameron enjoying some fresh air outdoors with his parents

Cameron (with his brother Cory) while in rehab

Cameron and his family show off the gingko leaf tattoos they got as symbols of hope and healing

Cameron with Neuro ICU nurse Jason Hall, who cared for Cameron during some of his most challenging days

Cameron celebrating at the Charlottesville marathon finish line with family and friends

Meanwhile, Cameron's mom Susan adds, "When Cam was first coming out of his coma, during a PT session where Cam was aided in standing up for the first time, the therapist asked him if he'd like to hug his parents. He nodded yes. She helped him keep his balance and he embraced Eric and I. Hands down the best hug ever!"

About four weeks after his accident, Cameron was ready to transfer from the ICU to the step-down unit, but not before his detour to see the hospital's gingkos. His nurse, anticipating that time outside would be healing for her 31-year-old patient with a love of nature, suggested taking a detour through the hospital's courtyard, which was lined with gingkos turning their brilliant autumn yellow.

Cameron's mom Susan recalls the moment: "It was a beautiful day and Cam seemed to soak up the sun and looked at all the gingko trees. I remember feeling incredibly hopeful and grateful in that moment." Then days later, toward the end of October, Cameron transferred to Sheltering Arms Institute for Rehabilitation. While there he progressed quickly from inpatient to outpatient rehab, finally arriving back home to his parents' house in Ashburn, Virginia on November 5. By the start of the new year, he was starting to ease back into his role as a traveling heavy equipment trainer.

> "It was a beautiful day and Cam seemed to soak up the sun and looked at all the gingko trees. I remember feeling incredibly hopeful and grateful in that moment."

It Takes a Village

In addition to the medical care that he received (and his underlying level of physical fitness), Cameron and his family credit much of his recovery to a wide support network. Cameron notes that when he first started to wake up, his family told him about the outpouring of love and support they received from their family, friends, coworkers, and neighbors. "Still confused and half-drugged, I responded, 'It takes a village.' That became something of a refrain for us throughout my recovery." The Kuklicks are quick to admit that their village did not stop its support even once Cameron left the hospital and was back home and at work.

On April 1, only five months after leaving Sheltering Arms, Cameron's family was at the finish line to help celebrate his completion of the Charlottesville marathon. But they were not the only ones who rejoiced in this accomplishment. News quickly spread among their village and beyond, especially once Cameron and his family triumphantly walked from the finish line to the ICU. As the gingko trees in the nearby courtyard were beginning to sprout their leaves, Cameron was able to reunite with the ICU staff that had helped care for him and show them just how far he'd come, and how their hard work had paid off in the end. ●

Innovation for Health Disparities Research in Hemorrhagic Stroke

By Nirupama Yechoor MD, MSc; Rachel Forman, MD; Christine Fox MD, MAS



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Social Determinants of Health Impact Recovery After Hemorrhagic Stroke

As clinicians working with patients who have sustained an acute brain injury, we are naturally focused on caring for the injury itself. Until recent years, the clinical severity of brain injury was regarded as the main driver of prognosis and outcomes.[1,2] However, we are beginning to understand how non-clinical factors, including the social determinants of health (SDOH), contribute to differential risk for all brain injuries, including hemorrhagic stroke, and continue to impact our patients' recovery even after injury.

Understanding the complex interplay between clinical and social determinants of health is crucial for clinicians caring for hemorrhagic stroke survivors, not only for recovery and secondary prevention, but also to effectively counsel families on primary prevention. Current methods of assessing patients' SDOH are often limited to collecting and analyzing information focused on individual SDOH, such as race, ethnicity, primary preferred language, household income, zip code, marital status, and educational attainment. These individual-level SDOH, as well as community-level SDOH such as geographic region, air pollution, and food security, have also been shown to impact access to care, knowledge of health related-behaviors and healthcare policy.[3] Recognizing the impact of these factors and their potential role in health disparities is a first step in addressing inequities. However, simply describing the existence of health disparities does not improve health equity nor the quality of care we provide to our patients. We must also develop innovative approaches that investigate how SDOH influences our patients' healthcare, enabling practice and policy changes that specifically address inequity.

Innovation for Intervention Development Is Crucial

A fundamental pitfall in measuring individual-level social determinant data from the medical record is that these measures often do not provide actionable steps forward. For instance, some studies have shown that a patient's zip code can impact various health outcomes, including time to arrival to ED when experiencing an ischemic stroke.[4] While useful to understand where disparities originate, there are limitations to developing interventions at an individual or community level.

A novel approach to improve patient-centered care is speaking with patients directly to understand how social and structural determinants, such as geographic location, impacts their healthcare access and healthcare decision making. This practice requires a paradigm shift from our traditional models of extracting large, computational data to incorporating patient and family perspectives and utilizing qualitative research methodology, along with quantitative data analytics approaches.

> "Understanding the complex interplay between clinical and social determinants of health is crucial for clinicians caring for hemorrhagic stroke survivors, not only for recovery and secondary prevention, but also to effectively counsel families on primary prevention."

Qualitative Research Methods as a Vehicle for Patient Engagement

We have proposed a novel model to engage patients, families, and caregivers to be our partners in research to improve health equity and outcomes after hemorrhagic stroke. With these partnerships, we hope to better understand the facilitators and barriers that impact our patients' recovery, through a lens of SDOH. With support from the American Heart Association's Henrietta B. and Frederick H. Bugher Foundation, we have established a multicenter network dedicated to using qualitative research methods to understand the impact of SDOH on recovery after hemorrhagic stroke. Our three centers — Massachusetts General/Brigham and Women's Hospital (MGB), Yale, and University of California, San Francisco (UCSF) are committed to working with patients and their families to establish patient-centered outcomes across the lifespan for hemorrhagic stroke survivors.

Using focus groups and individual interviews, our objective is to uncover the downstream impacts of various SDOH on recovery. This methodology allows us to hear the lived experiences of patients, identify gaps in the current health system, understand how SDOH impact healthcare decision making, and discover novel targets for interventions to promote recovery and secondary prevention after hemorrhagic stroke that traditional research approaches may not capture. Our recruitment methods have included traditional approaches using fliers and advertising in our clinics. However, to engage a broader audience, we have recruited participants through online portals, stroke survivorship organizations, and through engaging community-based organizations. We have also leveraged using virtual visits for all our participants to maximize diverse representation and minimize travel and time off work. The flexibility of our study design has allowed us to connect with stroke survivors nationally, in addition to those in our hospital catchment areas.

In parallel to our first aim of taking a patient-centered approach to better understanding SDOH and recovery, we will also examine the structural determinants that impact recovery at the health systems level. We are convening multidisciplinary stakeholders in the intensive care units across our three centers to perform a systematic assessment of provider communication to identify gaps in how we facilitate stroke education and recovery. Understanding the downstream impacts of social determinants from our patients' perspective and matching structural gaps in the health system together will be crucial to making a lasting impact in improving health equity.

Building Upon Shared Expertise

Importantly, our three centers have already been working to engage patients and communities and are now unifying our shared expertise through our AHA-Bugher initiative. Yale University has embraced this notion of learning from our patient's lived experience and has also started a Patient Advisory Board in October 2023, comprised of 12 diverse stroke survivors recruited through stroke clinics and the inpatient stroke service. The focus of the board, which meets every two months, is to understand their experience interfacing with the healthcare system, potential barriers to blood pressure management, and their opinions on various blood pressure interventions. Through early engagement and partnership with our community of stroke survivors, we hope to develop a desired and realistic blood pressure intervention together as partners. For instance, the concept of mistrust of medical providers has already emerged as a theme that is a barrier to care for a number of patients. Members have already expressed interest in the idea of peer and group support.

At UCSF, we are building on a prior qualitative research study that looked at life after pediatric hemorrhagic stroke in the context of home, school, and community. As a next step, we will be conducting interviews with teenage stroke survivors and parents of children who have sustained a hemorrhagic stroke to ask about the physical, mental, and social aspects of their recovery. We will analyze these discussions for themes of health and wellbeing that are not captured in traditional stroke outcome scales. By listening to their stories, we hope to create better, more patient-centered measures of stroke outcomes that can be used clinically or in research.

At MGB, a systematic assessment of communication practices and standards has led to an implementation study of physical models to promote patient and family education in the ICU for improved shared decision making. First, we convened a group of stakeholders who routinely work in the Neurosciences ICU to understand current practices and have identified several targets for intervention. From this qualitative assessment, we are studying the impact of a physical model for tracheostomy education and its impact on clinician communication and healthcare outcomes.

Our overall goal is to use qualitative research methods to better understand the facilitators and barriers that shape our patients' recovery after hemorrhagic stroke, using a lens of social determinants of health. We hope to show the feasibility and utility of partnering with our patients and families as a powerful research framework to improve health equity.

If you know any stroke survivors who may be interested in participating in our focus groups, note that everything is virtual and we are able to recruit remotely. Please e-mail **nyechoor@mgh.harvard.edu** or **Rachel.forman@yale.edu** for more information. ●

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"Time Is Brain" for ICH Too!

By Sasha Yakhkind, MD; Qi Li, MD, PhD; Joshua Goldstein, MD, PhD; Stephan Mayer, MD




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Imagine you are a stroke clinician on call alone at night. Your pager goes off. Somehow, the jarring ringtone never fails to startle you. *Code stroke.* You sit bolt upright and quickly walk to the ER. You rush to get a NIHSS score between triage and the CT scanner. It's at least a 21 for a left MCA syndrome. The patient's last known well was only 45 minutes prior. A crowd encircles the CT technician as they scroll through the CT scan for the first time and it seems as if everyone is holding their breath.

An intracerebral hemorrhage (ICH) is seen in the left temporal lobe. Slowly, the emergency physician, the pharmacist, and the patient's nurse file out of the room.

"Admit to neuro, right?" The emergency physician asks on their way out. As a stroke specialist, you are left to manage this patient alone and all sense of urgency seems to have disappeared.

If a large vessel occlusion had been seen and thrombolytics and embolectomy were on the table for an ischemic stroke, there would have been no collective exhale, and everyone involved would have been moving faster, not slower, to get this patient time-sensitive brain saving therapy.

Time is brain, right? Why does this sentiment not apply to ICH in the same way it does to the management of ischemic stroke? The answer is multifactorial and stems from a time in the not-so-distant past. The first trials supporting thrombolysis for ischemic stroke were published in the early 1990s and set off a cascade of time-based treatment metrics and standardization guidelines.[1] The ICH score was also developed around this time, and with its focus on an increasingly high mortality risk, may have inadvertently perpetuated a culture of pessimism, with some using this tool and others like it to justify limitations of aggressive care.[2,3,4] Meanwhile, studies on blood pressure control and surgical evacuation yielded inconclusive results that failed to definitively establish whether, and for whom, these treatments worked[2,5] (**Figure 1**). As a result, it too often seemed as if there was no urgency in providing any particular treatment for patients with ICH.

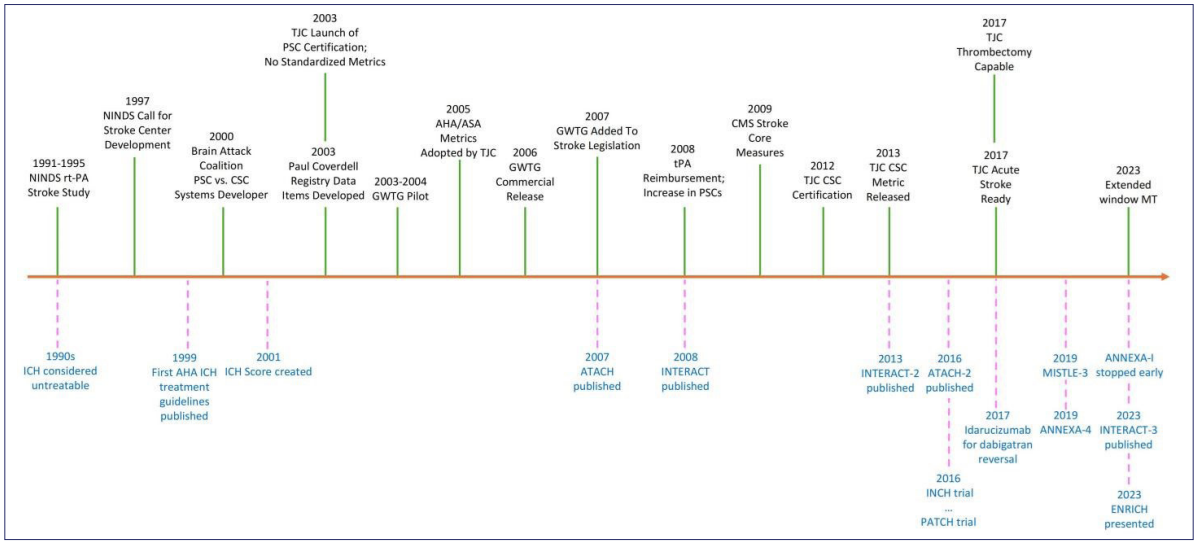

Figure 1. *A non-exhaustive timeline of milestones in the treatment of ischemic stroke vs. ICH since 1990, adapted from a graphic presented by Anne Alexandrov at the NCS Annual Meeting in 2022*

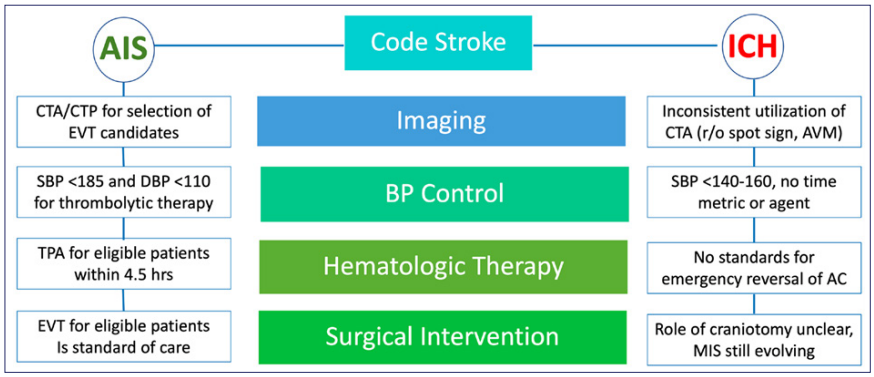

Figure 2. *Differences in Approaches. Schematic comparison of how imaging, blood pressure control, hematologic therapy, and the role of surgical intervention currently differ between acute ischemic stroke (AIS) and intracerebral hemorrhage (ICH). BP indicates blood pressure; CTA, computed tomography angiography; EVT, endovascular therapy; and MIS, minimally invasive surgery.* Originally published in Stroke, 2023.

National Joint Commission Ischemic Stroke Time Metrics		CODE ICH Proposed Hemorrhagic Stroke Time Metrics	
Door to Doc	≤ 10 minutes	Door to Doc	≤ 10 minutes
Door to Stroke Team	≤ 15 minutes	Door to Stroke Team	≤ 15 minutes
Door to CT scan start	≤ 25 minutes	Door to CT scan start	≤ 25 minutes
Door to CT scan read	≤ 45 minutes	Door to CT scan read	≤ 45 minutes
Door to Needle (tPA)	**≤ 60 minutes**	**Door to Lab results**	**≤ 45 minutes**
Door to arterial puncture	**≤ 90 minutes**	**Door to BP control**	**≤ 60 minutes**
		Door to reversal agent	**≤ 60 minutes**
		Door to burr/evacuation	**≤ 90/180 minutes**

Figure 3. *Proposed ICH Time Metrics. Originally presented at the NCS Annual Meeting in 2022 by Anne Alexandrov, Stephan Mayer, Joshua Goldstein, Jennifer Frontera, Christopher Kellner and Sasha Yakhkind*

Our recent paper published in *Stroke*, riding in the wake of recent trials supporting bundled ICH care and promising results from the ENRICH trial of minimally invasive hematoma evacuation, argues that time-based bundled care for ICH is the way of the future.[5]

Here are some key takeaways from this publication:

- There are a number of interventions now supported by recent evidence, with further evidence of their efficacy in combination as part of an ICH bundle of care.
- These treatments include:[6]
  - » Rapid and smooth blood pressure control without overcorrection
  - » Prompt and targeted anticoagulation reversal
  - » Consideration of minimally invasive surgical evacuation in some patients
- There is evidence that these interventions are more likely to be effective when they are initiated as soon as possible.
- Bundled care increases compliance with best practices, improves clinical outcomes and should be adopted broadly across stroke centers.[7]

With this in mind, the acute management of ICH needs to catch up to that of ischemic stroke and should include blood pressure control, anticoagulation reversal, consideration of surgical intervention in some patients, and interdisciplinary and patient-centered application of bundled care (**Figure 2**). As always, further research is needed to better elucidate more specific treatment targets and facilitate more patient-tailored care. In the meantime, we advocate for accreditation bodies to adopt time-based metrics for the acute treatment of ICH akin to those of acute ischemic stroke (**Figure 3**).

For more information, please refer to Code **ICH: A Call to Action**, published in *Stroke* in December 2023. ●

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Can Albumin Lower Delayed Cerebral Ischemia in Patients With Subarachnoid Hemorrhage? A New Take on an Old Treatment

By Preethi Ramchand, MD

*The following article is a discussion of "***Effect of an Albumin Infusion Treatment Protocol on Delayed Cerebral Ischemia and Relevant Outcomes in Patients with Subarachnoid Hemorrhage.***"*

Gempeler A, Gaviria L, Ortiz A, Jaramillo N, Beltrán L, Escobar S, Rondón M, Rosselli D, Martinez-Buitrago JE, Mejía-Mantilla JH. Effect of an Albumin Infusion Treatment Protocol on Delayed Cerebral Ischemia and Relevant Outcomes in Patients with Subarachnoid Hemorrhage. Neurocrit Care. 2023 May 25. doi: 10.1007/s12028-023-01731-3. Epub ahead of print. PMID: 37231237.

Background

Numerous interventions have been studied to decrease the risk of delayed cerebral ischemia (DCI) after aneurysmal subarachnoid hemorrhage (aSAH). Among these, targeted fluid administration to prevent hypovolemia has become one of the mainstays of treatment, although there is not clear consensus on fluid types and dosing. Human albumin (HA) has been shown to have benefits in multiple other pathologies including shock and trauma, and some data points to benefits in preventing DCI for patients with aSAH. This study attempted to determine if HA administration decreased rates of DCI and to assess for adverse outcomes associated with HA.

Methods

This was a non-randomized, quasi-experimental study comparing patients in a cohort admitted to a tertiary referral hospital between 2015-2018 to historical controls admitted to the same hospital between 2011-2014. Inclusion criteria were all adult patients with evidence of subarachnoid hemorrhage on head computed tomography (CT) or lumbar puncture. Patients were excluded if they died within 24 hours of presentation, had severe SAH (defined as World Federation of Neurosurgical Societies [WFNS] score 4-5), or did not have aneurysm securement because of transition to palliative care. Standard of care related to imaging, early aneurysm securement, nimodipine, and TCDs was the same across both cohorts.

Patients in both groups received vascular imaging, early aneurysm treatment, invasive hemodynamic monitoring, nimodipine treatment, and vasospasm monitoring with Transcranial Dopplers (TCDs). The control group received intravenous crystalloid fluid administration at the discretion of the intensivist but was guided by pulmonary artery catheter monitoring in most high-grade SAH or hemodynamically unstable patients. Those in the intervention arm were treated with 5% intravenous albumin infusion at a fixed dose of 60 g/day for the first five days of admission, as well as an intravascular volume goal of euvolemia. For the intervention group, euvolemia was explicitly determined by invasive hemodynamic monitoring utilizing PiCCO transpulmonary monitoring and global end-diastolic volume.

Outcomes

The primary outcomes were the incidence of DCI and death during ICU and hospital stay, while secondary endpoints included Glasgow Outcome Scale Extended (GOSE) score and death at 6 months. Adverse events including pulmonary edema,

> "This study attempted to determine if [albumin] administration decreased rates of DCI and [was associated with] adverse outcomes."

hypo- or hypernatremia, aneurysm rebleeding, and vasospasm were also investigated.

Analysis

Effects of the intervention on the primary and secondary outcomes were reported in terms of hazard ratios and relative risks, with multivariable logistic regression and sensitivity analyses performed to adjust for confounding variables while calculating the effects of the protocol on the intervention arm. Post hoc analyses were performed to adjust for competing risks, as DCI incidence could be biased because patients who experience DCI are more likely to die. Daily and cumulative volumes of fluids administered were also compared between groups to assess overall volume status.

Results

A total of 189 patients with a median age of 58 and of whom 72.2% were women were included in the final analysis, including 63 in the historical control arm and 126 in the intervention arm. The two groups were well-matched overall in terms of demographics, although the intervention group was slightly older and had a higher number of patients with high-grade subarachnoid hemorrhage (19% in historical controls and 34.9% in the intervention group). For the primary outcome, there was a consistently lower incidence of DCI in the intervention group in the primary, adjusted, and post-hoc analyses. However, this did not translate to a lower incidence of ICU or hospital mortality, nor was there a significant difference in functional outcome at 6 months between groups.

> "Treatment with an early intervention of iso-oncotic albumin was associated with a decreased incidence of DCI without an increase in hospital complications."

In regard to secondary outcomes, those in the intervention arm had a significantly decreased risk of hyponatremia while also receiving less crystalloid fluid resuscitation during the time of albumin infusion. There was a non-significant increase in incidence of pulmonary edema in the intervention group (RR 2.7, 95% CI 0.8-8.8), but the study was not powered to detect a meaningful statistical difference in this metric between the two groups. There was no difference between the two groups for any of the other secondary outcomes, including vasospasm, rebleeding, hydrocephalus, or pneumonia.

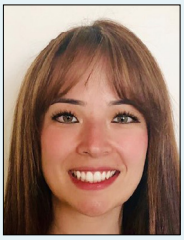
Commentary

The primary finding of this study was that for patients with aSAH, treatment with an early intervention of iso-oncotic albumin was associated with a decreased incidence of DCI without an increase in hospital complications. Albumin administration in the post-subarachnoid hemorrhage period has been studied in pre-clinical animal trials as well as prior retrospective studies, with findings that suggest multifactorial effects, ranging from decreasing inflammation, increasing neuroplasticity, promoting endothelial homeostasis, and augmenting hemodynamic stabilization. This study does have several limitations, specifically its small sample size, lack of randomization, and lack of standardized fluid management in the control group, which was left to the discretion of individual intensivists.

However, part of the explanation for the findings of this particular study could simply be the favorable impact of a more sophisticated invasive hemodynamic monitoring system for assessment of fluid status as well as more protocolized treatment of fluids and volume assessments in the intervention group. This type of monitoring has been independently evaluated in other subarachnoid hemorrhage studies with positive results, and therefore could represent a confounding variable in this study. That being said, the utility of albumin in the subarachnoid hemorrhage population is clearly one that has generated significant interest, and further randomized clinical studies are needed to address this question in more detail. ●

Unlocking Autonomy With Brain-Computer and Brain-Machine Interfaces: Current Insights and Future Frontiers

By Shalane Morales-Nunez, MD and Nilufer Yalcin, MD



Brain-Computer Interfaces (BCIs) and Brain-Machine Interfaces (BMIs) are revolutionizing neuroscience and tech. They intend to link our brains directly to machines, potentially letting us control devices with our thoughts. Initiatives like Neuralink's PRIME clinical trial, as well as ventures such as Synchron's Stentrode and NextMind's wearable brain sensing device, offer hope to individuals with spinal cord injuries and neurological conditions by implanting devices in the brain or utilizing non-invasive wearable technologies. But there are crucial ethical concerns to consider, including informed consent and privacy protection. Collaborative efforts are key as we navigate this new frontier, aiming for a future where tech and humanity unite to unlock the mind's potential while protecting individual rights.

What Are BCIs and BMIs?

BCIs/BMIs decode neural signals to establish a line of communication between the brain and external devices. Through advanced signal processing and harnessing the brain's neuroplasticity, these interfaces empower individuals to control devices with their thoughts, which ultimately enhances interaction effectiveness with continued use.

BCIs have thus far been focused primarily on decoding neural signals for tasks like controlling computer cursors, typing, or operating assistive devices such as robotic arms or wheelchairs. They promise significant benefits to individuals with severe physical disabilities or conditions like locked-in syndrome, where traditional means of communication or control are limited.

In contrast, BMIs integrate neural signals with mechanical or robotic systems, allowing direct control by the brain. BMIs are commonly used for controlling prosthetic limbs, exoskeletons, or other robotic devices, providing invaluable assistance to individuals with spinal cord injuries, amputations, or other neuromuscular disorders.

Beyond mobility assistance, BCIs/BMIs may have other diverse clinical uses, including restoring communication abilities and aiding in neurorehabilitation and cognitive enhancement. Ongoing research explores their potential in treating various neurological disorders and revolutionizing human-computer interaction, potentially paving the way for even more innovative healthcare solutions in the future.

A New Clinical Trial: Neuralink's Precise Robotically Implanted Brain-Computer Interface (PRIME) study

In one noteworthy example of BCI/BMI technology, Neuralink has developed a cortical implant that uses thin polymer probes and customized high-density electronics (as well as a specialized neurosurgical robot) to facilitate the modulation of neural activity between the brain and an external machine. Its objective is to help individuals dealing with spinal cord injuries or degenerative diseases like amyotrophic lateral sclerosis (ALS) regain independence and improve their quality of life, and potentially to restore cognitive functions in individuals who have lost them.

> "Collaborative efforts are key as we navigate this new frontier … where tech and humanity unite to unlock the mind's potential while protecting individual rights."

Although already receiving significant press coverage, details about Neuralink's clinical trial remain limited, including participant eligibility and preliminary results. According to the Neuralink website, the study is projected to continue for 6 years. Participants will engage in 2 research sessions per week with 9 at-home or in-person clinic visits over the course of 18 months. The primary phase of the study will then be followed by a long-term follow-up period spanning 5 years and consisting of a total of 20 clinic visits. Among the study's disclaimers, however, are that specific trial details may be subject to change and that certain information could be restricted due to confidentiality or regulatory reasons. Further insights into the study will depend on future public announcements and, hopefully, peer-reviewed publications.

In the meantime, the X platform shared a live video this past March featuring a human subject using the Neuralink device for the first time. The inaugural participant, 29-year-old Noland Arbaugh, described how this experimental device has already transformed his life, and he has also played a role in advancing the technology by collaborating with Neuralink and offering feedback on enhancing the device's precision and capabilities based on his firsthand experience.

Potential Applications of BCIs/BMIs in Neurocritical Care

In the realm of neurocritical care, BCIs/BMIs serve as transformative tools with diverse applications. From monitoring brain activity to informing treatment strategies and restoring independence for individuals contending with conditions such as stroke, traumatic brain injury, and various neurological disorders, these technologies offer life-changing possibilities.

Despite the tireless efforts of rehabilitation, many individuals continue to grapple with diminished quality of life. However, through the innovative integration of BCI/BMI technologies, some patients could be granted a newfound sense of autonomy. By seamlessly controlling assistive devices for fundamental tasks like eating, bathing, and dressing, individuals can reclaim independence. Moreover, these devices can play a pivotal role in facilitating motor recovery by providing real-time feedback during therapy sessions, potentially enhancing individual well-being while helping alleviate the emotional, physical, and financial burdens shouldered by caregivers. These technologies could also predict and prevent complications by continuously monitoring brain activity, assisting in the diagnosis of neurological conditions, and facilitating personalized treatment plans. Ultimately, BCIs/BMIs bring hope for better quality of life and integration into society for those with neurological disability.

> "BCIs/BMIs bring hope for better quality of life and integration into society for those with neurological disability."

> "The potential for technology to influence or manipulate individuals' thoughts, behaviors, or decision-making processes raises profound ethical questions regarding agency and control."

Potential Controversies

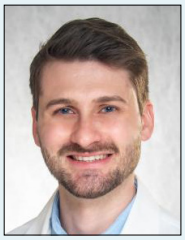
Like any emerging technology, there are various ethical concerns surrounding BCIs/BMIs. First, informed consent is crucial: individuals need to fully understand the risks of brain implantation procedures, as well as uncertainties about the long-term effects of these technologies on individuals' physical and mental health and their social and psychological well-being. This involves transparent communication to empower them to make independent decisions. Safeguarding privacy is also vital to prevent unauthorized access to and misuse of neural data, which could eventually become vulnerable to identity theft, manipulation, or surveillance. Other major concerns include autonomy and regulatory oversight. The potential for technology to influence or manipulate individuals' thoughts, behaviors, or decision-making processes raises profound ethical questions regarding agency and control. Strong regulations are therefore needed to mitigate risks and protect the rights of participants. Ultimately, addressing these controversies requires interdisciplinary collaboration among researchers, policymakers, and ethicists to develop guidelines and safeguards that prioritize the well-being and rights of individuals while promoting innovation and progress in neuroscience and technology.

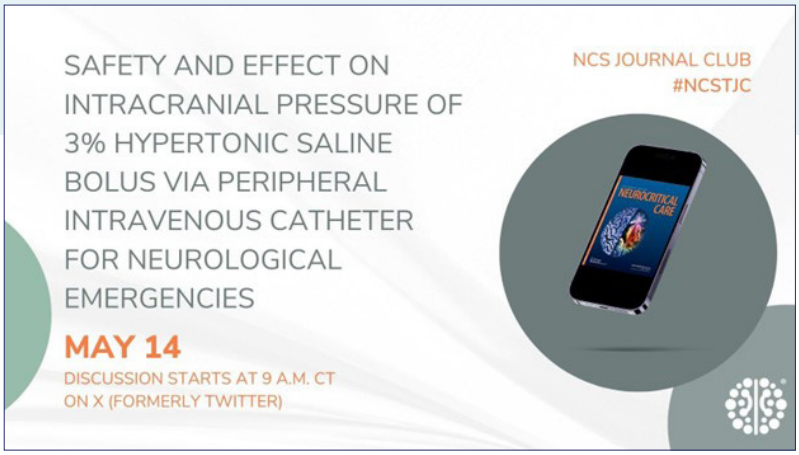
Looking Forward

Both highly innovative and controversial, BCI/BMI technology has sparked hope among many. Projects like Neuralink's PRIME study, Synchron's Stentrode, and NextMind's wearable brain sensing device are pushing the boundaries of what is possible in patients with neurological diseases. While these technologies are still in their early stages and widespread availability is distant, their potential to improve the lives of mobility-challenged individuals makes them worth the wait. ●

NCS Twitter Journal Club Round-Up: May 2024

By Alex Hanson, MD; Eric C. Lawson, MD



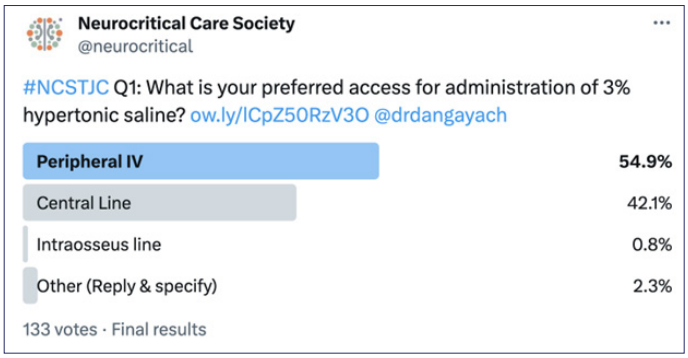


Link to Twitter Thread: **https://x.com/neurocritical/status/1790384213625016369**

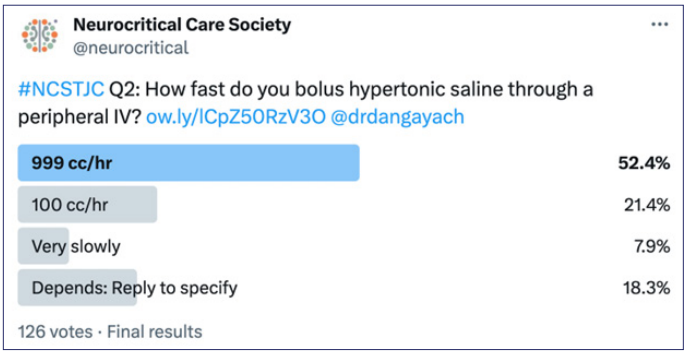
Access the article here: **https://link.springer.com/article/10.1007/s12028-024-01941-3**

Moderator: @drdangayach

The May NCSTJC addressed the much-debated topic of hypertonic solution administration in managing cerebral edema. This month's article was titled "Safety and Effect on Intracranial Pressure of 3% Hypertonic Saline Bolus Via Peripheral Intravenous Catheter for Neurological Emergencies," published in Neurocritical Care in February 2024. This observational study assessed the incidence of complications with peripherally administered 3% hypertonic saline. The authors found that the complication rates were relatively low, questioning the need for central lines for administration.

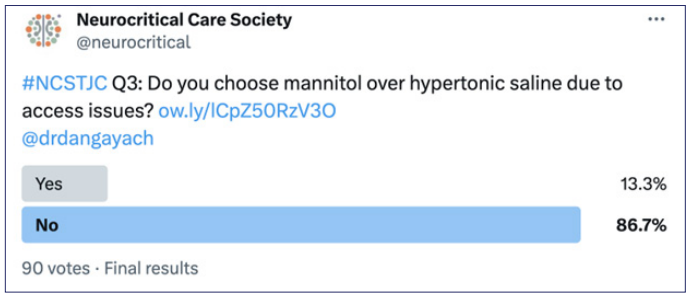


The first question was a poll asking about clinicians' preferred access for administration of 3% hypertonic saline: 54.9% of respondents chose "peripheral IV," 42.1% preferred "central line," 2.3% selected "other," and 0.8% chose "intraosseous line." Additionally, @CharlenePringl1 commented: "PIV is fine for a bolus, CVL for infusion (will do 2% through a PIV) if CVL access is an issue." @DCM7200 commented: "There is literally no thought given when it comes to administration of epinephrine pushes in a code. Bolusing HTS should be considered the same. The question is when it's being run continuously for an arbitrary goal with no exit strategy."

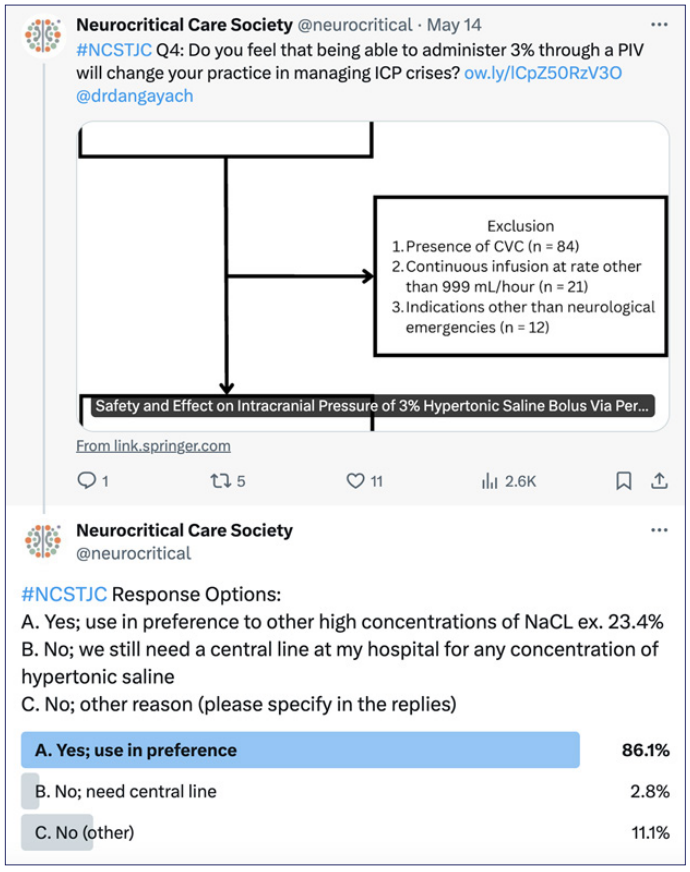


The second question asked how fast clinicians bolus hypertonic saline through a peripheral IV: 52.4% of respondents said "999 cc/hr," 21.4% said "100 cc/hr," 7.9% said "very slowly," and 18.3% responded "it depends" and provided comments. @KeatonSmetana was the first to comment: "Conventional wisdom cautions against solutions >900 mOsm via PIV due to extravasation risks, based on TPN studies over extended periods. However, for acute needs, administering 3% HTS at 999mL/hr = safe + effective. Ideally small bore, large vessel, no flexion area." @dcm2700 responded: "I would controversially add - administration of HTS for an arbitrary goal or at a high rate for an undefined period of time is nonsensical to me." Other responses included 75 cc/hr, 20 minutes and 750 ml/hour. @EmToxRx added that it can depend on the gauge of the IV and that their biggest issue is that their "bags are 500mL and usual

dose we use is 250mL. Especially once you pump up the pressure bag it's hard to see how much is left."

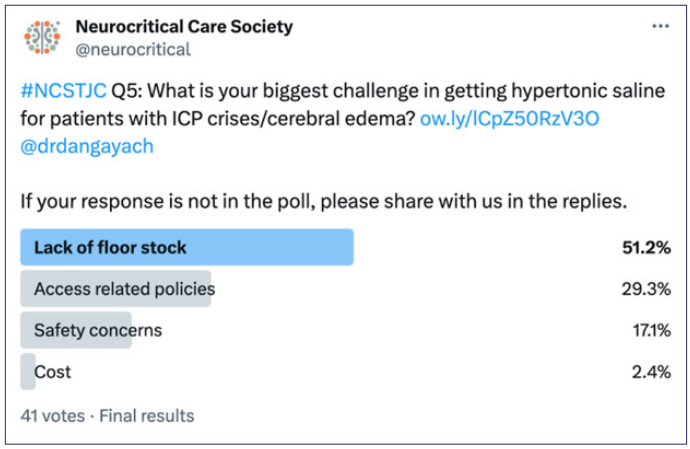


Question 3 asked participants if they preferred mannitol over hypertonic saline due to access issues, with 86.3% replying "no" and 13.3% replying "yes." @kelseyel_ asked a follow up question: "Curious what concentration mannitol those who voted yes use? Mannitol 20% & 25% both higher osmolarity versus 3% NaCl?" @Drdangayach and @visasht both replied "20%." While the route and speed of administration of 3% may be up for debate, it is clear participants preferred hypertonic saline over mannitol.



Question 4 asked if the ability to administer 3% hypertonic saline through a peripheral intravenous line (PIV) would change clinicians' practice in managing intracranial pressure (ICP) crises: 86.1% of respondents said yes (in preference to other high concentrations of NaCl), while 13.9% said no (2.8% because of a continued need for a central line at their hospital for any concentration of hypertonic saline, and 11.1% for other reasons). Overall, most participants agreed that the ability to utilize 3% hypertonic saline peripherally may change their practice patterns.

> "For many participants, institutional issues such as policies regarding type of access and ready availability of the medication limits their ability to utilize hypertonic saline."



Question 5 asked about the biggest challenges in administering hypertonic saline for patients with ICP crises and cerebral edema: 51.2% of respondents indicated a "lack of floor stock," 29.3% noted "access-related policies," 17.1% said "safety concerns," and 2.4% said "cost." @KeatonSmetana added that administering hypertonic saline can lead to "hyperchloremic metabolic acidosis, which can be mitigated with sodium acetate / bicarbonate." For many participants, institutional issues such as policies regarding type of access (peripheral IV versus central line) and ready availability of the medication limits their ability to utilize hypertonic saline.

May's NCSTJC featured a thoughtful discussion about the current landscape surrounding the use of hypertonic solutions in treating elevated ICP. It underscored the diversity of practices, as well as institutional guidelines and logistical challenges regarding rapid administration. The potential to administer 3% NaCl peripherally is a major step in addressing these barriers and highlights the increasing evidence supporting the safe and timely use of hypertonic solutions, as well as the research required to overcome other existing obstacles. ●

Emergency Neurological Life Support: Understanding Its Applicability and Limitations in Africa

By Morgan Prust, MD[1]; Susan Yeager, DNP[2,3]; Halima Salisu Kabara, CCRN[4]; Ismail Hassan, MBBS[5], Misbahu Ahmad, MBBS[5]; Mustafa Miko Abdullahi, MBBS[6]; Becca Stickney[3]; Sarah Wahlster, MD[7]; Sarah Livesay, DNP[3,9]; Yasser B. Abulhasan, MBChB[3,9]

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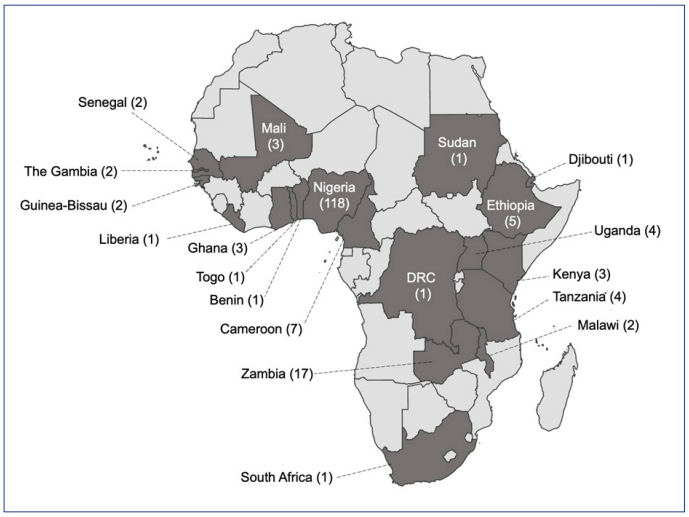
Introduction

The Emergency Neurological Life Support (ENLS) certification course sponsored by the Neurocritical Care Society provides standardized approaches to the acute management of commonly encountered neurologic emergencies. Initially published in 2012, ENLS is currently in its fifth version, and reflects the most up-to-date standards of emergency neurologic care.[1] Instruction in ENLS is commonly delivered over a short course spanning 1-2 days and is applicable to any healthcare worker participating in the early chain of survival and recovery for common neurologic emergencies. The course covers 14 modules including intracranial hypertension, traumatic brain injury, ischemic stroke, and approach to coma, to name a few.

The management algorithms embedded in ENLS have been developed and fine-tuned over the past decade by experts predominantly in high-income countries (HICs) practicing in well-resourced healthcare environments. These algorithms, therefore, are predicated on timely access to a variety of diagnostic and therapeutic resources to guide acute decision-making and intervention. They may have more limited applicability in resource-limited settings where key resources are absent or unavailable within an ideal time frame for patients with an acute neurologic injury.

There is growing interest in the applicability of ENLS in low- and middle-income countries (LMICs), where the burden of acute neurologic illness is high and the availability of neurologic or critical care expertise is severely constrained.[2–4] Because ENLS can be delivered asynchronously via remote access to online course modules, it represents a feasible and effective means of disseminating neurocritical care knowledge to healthcare workers in remote regions with a low density of neurologic or critical care expertise, and may help strengthen the early chain of survival for patients in those settings. Cohort studies of LMIC healthcare workers undergoing ENLS training have been published from Nepal,[5] Cambodia,[6] and Sub-Saharan Africa.[7] These studies have demonstrated widespread enthusiasm for ENLS and recognition of the need to advance neurocritical care training in LMICs. Participants across each of these studies demonstrated increases



Geographical representation of participants across Africa

(Left to right) Dr. Ismail Hassan (AKTH Neurosurgery), Dr. Susan Yeager (The Ohio State Wexner Medical Center), Halima Salisu-Kabara (AKTH critical care nurse) and Dr. Morgan Prust (Yale School of Medicine).

Course participants view an ENLS lecture in at the Aminu Kano Teaching Hospital in Kano, Nigeria

in knowledge and subjective comfort managing neurologic emergencies, but expressed concerns about ENLS's limited applicability to their local healthcare contexts, where access to resources taken for granted in most HIC hospital settings is severely limited or absent.

The current standard of care for patients with acute neurologic injuries is highly resource intensive. Also, neurological emergencies are often time sensitive. As practiced in HICs, standard neurocritical care practices rely on immediate access to a variety of high-tech, high-cost diagnostic and treatment modalities delivered in dedicated neurosciences ICUs by large teams of highly specialized practitioners who are available for bedside and operative care at all hours of day or night. By contrast, care delivery in most of Sub-Saharan African healthcare settings is limited by resource gaps across the continuum of care, including prehospital care systems, ICU beds, neurology and neurosurgery expertise and availability, nursing staff, neuroimaging, essential medications, and neurorehabilitation.[4] Moreover, even if services are available, widespread pay-in-advance fee-for-service models place them out of reach for patients and families unable to finance the cost of care.

> "After each ENLS module, participants completed their neurocritical care capacity surveys and asked questions, often focused on how to approach challenging clinical scenarios without key resources."

Recognizing the potential of ENLS to enhance neurocritical care knowledge and support the delivery of life saving care for patients in resource-limited settings, yet wishing to better understand its current limitations in LMIC contexts, we formed the ENLS Africa Task Force in 2022. Our goal was to investigate the implementation challenges of ENLS in Africa, with the ultimate aim of proposing rational, data-driven adaptations to ENLS that may enhance its utility in Africa and other LMIC settings.

Partnership With Aminu Kano Teaching Hospital in Kano, Nigeria

Leveraging pre-existing partnerships between NCS and colleagues at Aminu Kano Teaching Hospital (AKTH) in Kano, Nigeria's second largest city, we developed a plan to host a 2-day live training event for healthcare workers from across the African continent. In order to maximize representation from as many nations and levels of resource availability as possible, we designed a hybrid event that would allow 100 participants to join in person at AKTH, and 100 to join remotely. We recruited our participants through an extensive word-of-mouth campaign among networks of contacts and professional organizations in Africa. We designed surveys to capture data regarding the neurocritical care capacity and level of resource availability

> Given the enormous unmet burden of acute neurologic disease in LMICs, building a global workforce of providers skilled in the … management of acute brain injury must be a leading priority.

specific to each ENLS module for participants to complete throughout the course. These surveys were designed to assess participants' access to neurocritical care resources at their local institution (number of ICU beds, availability of neurologists and neurosurgeons, availability of general emergency medicine and critical care resources, and availability of key neurocritical diagnostic and treatment resources), and for each ENLS module, queried the specific resource gaps that limit the management algorithm's utility in their practice settings, and asked open-ended questions regarding existing protocols and barriers to delivering care for individual ENLS diagnoses.

After several months of planning, participant recruitment, and coordination among our task force, we hosted the event on July 10 and 11, 2023. Dr. Morgan Prust, a neurointensivist at Yale School of Medicine with a focus on global health and neurocritical care, and Dr. Susan Yeager, a neurocritical care doctor of nursing practice at The Ohio State Wexner Medical Center and current NCS treasurer, both traveled from the US to Kano to direct the course in person. Dr. Ismail Hassan, director of neurosurgery at AKTH, Dr. Mutapha Miko Abdullahi, director of anesthesia at AKTH, and Halima Salisu-Kabara, senior nursing educator and retired critical care RN, worked to coordinate the recruitment and logistics for the in-person event in Kano. In parallel, NCS hosted an online platform for participants joining remotely, which was coordinated by NCS operations specialist Becca Stickney, with multiple ENLS trainers joining live to answer participants' questions. Our participants represented 20 African nations and included physicians from multiple specialties, nurses, and physiotherapists.

Dr. Prust and Dr. Yeager listen to a course participant discussing challenges in managing patients with traumatic brain injury in Nigeria.

Despite occasional power failures to the packed lecture hall in Kano, the in-person and virtual courses ran smoothly and generated tremendous energy from participants. After each ENLS module, participants completed their neurocritical care capacity surveys and asked questions, often focused on how to approach challenging clinical scenarios without key resources. Course participants demonstrated a keen desire not only to master the content of the ENLS course but also to engage with the challenge of designing treatment algorithms that may be more reflective of the resource gaps that exist in many LMIC hospital settings. Through our conversations over the two-day event, we heard about many of the resource constraints that limit acute care delivery, and the creative solutions to work around them. For example, if power outages affect the lighting in the neurosurgical operating theater at AKTH, OR staff will illuminate the surgical field with flashlights from their phones.

During their visit to Kano, Dr. Prust and Dr. Yeager experienced the irreplaceable value of face-to-face encounters in forming new connections. They discussed the course with the chief medical officer and chief nursing officer of AKTH. Discussions are underway to integrate ENLS into the standard platform of trainings within the hospital Life Support Center for physician and nursing education. We are also partnering with hospital leadership at AKTH to establish a Nigerian NCS chapter. From our sample of participants, we have recruited a working group of physicians, nurses, and physiotherapists from Nigeria, Ghana, Cameroon, Ethiopia, Uganda, Zambia, and Senegal, who will partner with our task force to analyze the survey data generated from the course and develop a curriculum for emergency neurologic care in resource-limited settings. This process is just getting started and we look forward to reporting on the results of our work over the next several months.

Translating Data Into Action

Given the enormous unmet burden of acute neurologic disease in LMICs, building a global workforce of providers skilled in

ENLS course participants at pose for a group photo at the conclusion of the course's first day in Kano, Nigeria.

Dr. Yeager poses with the chief medical officer (front center) and chief nursing officer (front left) and other senior hospital staff at AKTH.

the acute diagnosis, stabilization, and management of acute brain injury must be a leading priority of the worldwide neurocritical care community. Short courses like ENLS cannot replace longitudinal training opportunities for workforce development in LMICs, nor can they close gaps in essential material resources like CT scanners or essential medicines. ENLS does, however, provide a platform to deliver standardized training on key neurocritical care topics to a wide spectrum of providers. We strongly believe that understanding the limitations of ENLS in resource-limited environments can provide the basis for evidence-based guidelines that organize treatment around optimal use of available resources. We are hopeful that equipping front-line providers in LMICs with decision support tools that reflect the realities they face on the ground will improve standards of care for patients with acute neurologic illness worldwide.

Beyond the contents of the ENLS course, we are also hopeful that our engagement with leaders in neurology, neurosurgery, and critical care from across Africa will provide further opportunities for capacity-building, and that the momentum and connection generated during this event may catalyze further conversations at local, national, and regional levels on how to advance care for the enormous and growing population of patients with acute brain injury worldwide. Moreover, we know that the resource constraints commonly encountered throughout Africa also affect healthcare workers and patients in LMICs across the globe. We welcome any engagement with clinicians, researchers, policymakers, or other stakeholders seeking to make a difference in advancing global neurocritical care.

Acknowledgements

We gratefully acknowledge the following faculty members who recorded lectures for the ENLS Africa course: Yasser B. Abulhasan, Mary Kay Bader, Jamil Dibu, Salia Farrokh, Jennifer Frontera, Sarah Livesay, Casey May, Morgan Prust, Sarah Wahlster, Katja Wartenberg, and Susan Yeager. We also wish to thank the following faculty members for joining remotely to answer online participants' questions: Raffaele Aspide, Sylvia Bele, Walter Mickey, Remi Okwechime, Shaheen Shaikh, and Sarah Wahlster. ●

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Traumatic Brain Injury in a Resource-Limited Setting: A Reflection on the Importance of Timely Interventions in Neurocritical Care

By Rommel Morel, MD; Clio Rubinos, MD, MS

I work as a physician in the emergency room of one of the busiest hospitals in the Dominican Republic, which also functions as an international referral center. I was just about to finish an especially long shift after having completed what I thought was my last patient evaluation. Suddenly, the emergency room doors burst open, accompanied by the frantic screams of family members and emergency medical technicians urgently seeking directions for where to place the patient they were transporting.

The patient, a 28-year-old male, had crashed into a lamppost. At the scene, 911 was called, but the responding unit, typically staffed by a driver without medical training, lacked adequate medical supplies. Often this is their first job in the medical field and these providers might carry basic medications but usually have no access to oxygen, defibrillators, or airway management equipment.

Initially taken to the nearest public emergency room, the patient was administered mannitol and a saline bolus through two large-bore IVs. However, his condition deteriorated quickly; his oxygen levels fell, and his hemodynamic stability worsened. His family, deeply concerned, insisted on transferring him to a larger medical center about 20 minutes away, a drive lengthened by late-night rush hour traffic.

Upon arrival, I assessed the critically ill patient, who was unable to protect his airway and had not been intubated. His oxygen saturation was perilously low in the 40s. Immediate intubation was attempted but proved challenging due to active bleeding in the upper airway. Despite these challenges, the medical team successfully secured the airway. The patient soon went into cardiac arrest due to hypoxia and hypotension, and after 35 minutes of CPR, spontaneous circulation was restored.

The team then stabilized his condition and performed a CT scan of the entire body, which revealed a large left pneumothorax, a small amount of free fluid in the abdomen, diffuse cerebral edema, and traumatic subarachnoid hemorrhage (**Figure 1**). A chest tube was inserted on the left side, and the patient underwent an exploratory laparotomy, where a damaged spleen was removed. He was then transferred to the intensive care unit.

By the second day, the patient displayed clinical signs of intracranial hypertension, including anisocoria and bradycardia with elevated blood pressure — symptoms of Cushing's triad. An urgent CT scan showed worsening cerebral edema and right temporal and bi-frontal contusions (**Figure 2**). A decompressive craniectomy was performed, but malignant edema continued with excessive transcalvarial herniation and midline shift (**Figure 3**). Despite all efforts and optimizing medical management, the patient's condition declined neurologically until he was declared brain dead through a neurological examination, an apnea test, and transcranial doppler methods.

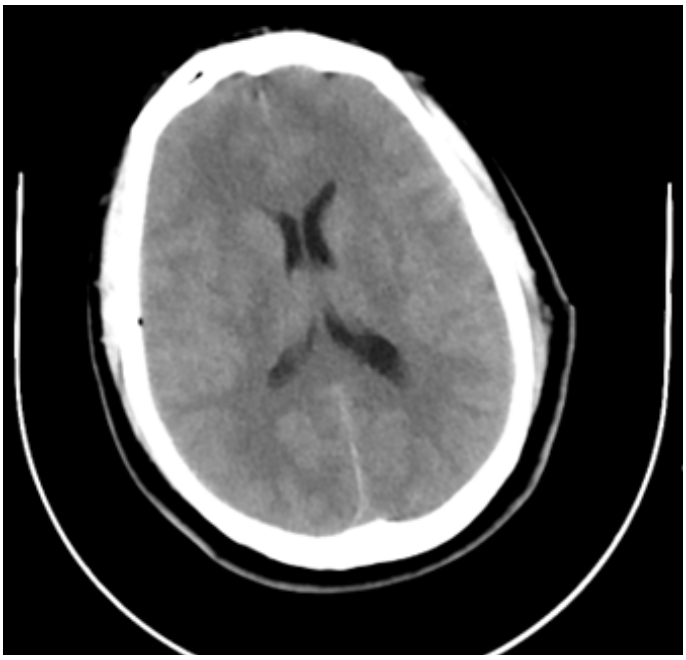

Figure 1. *Initial computed tomography of the head*

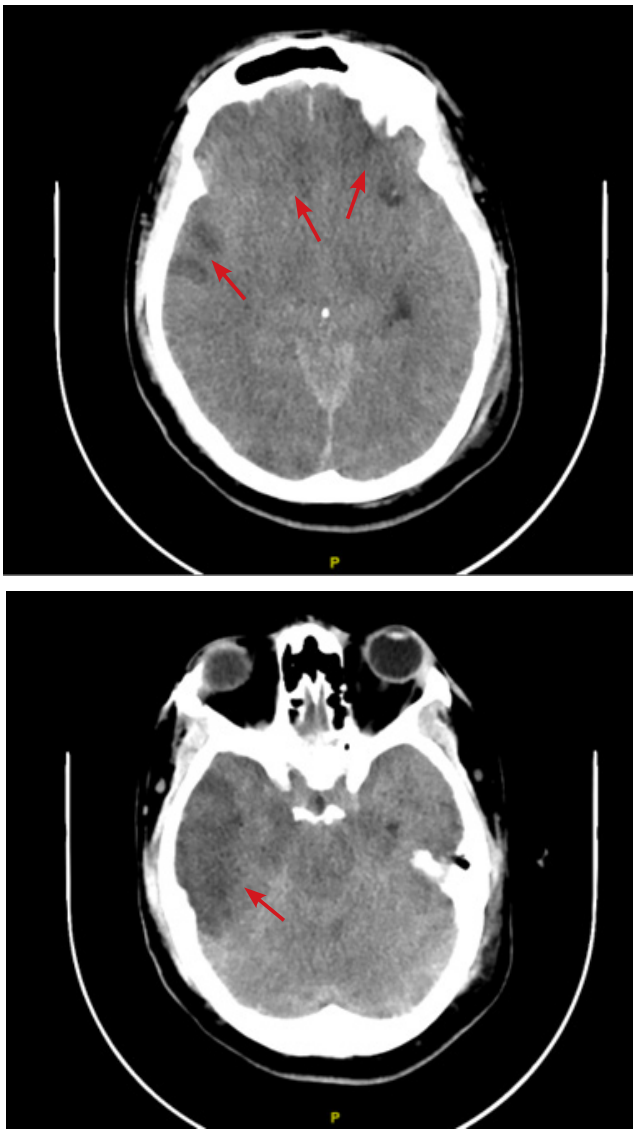

Figure 2. *Computed tomography of the head on the second day of hospitalization showing worsening cerebral edema and multifocal contusions (red arrows)*

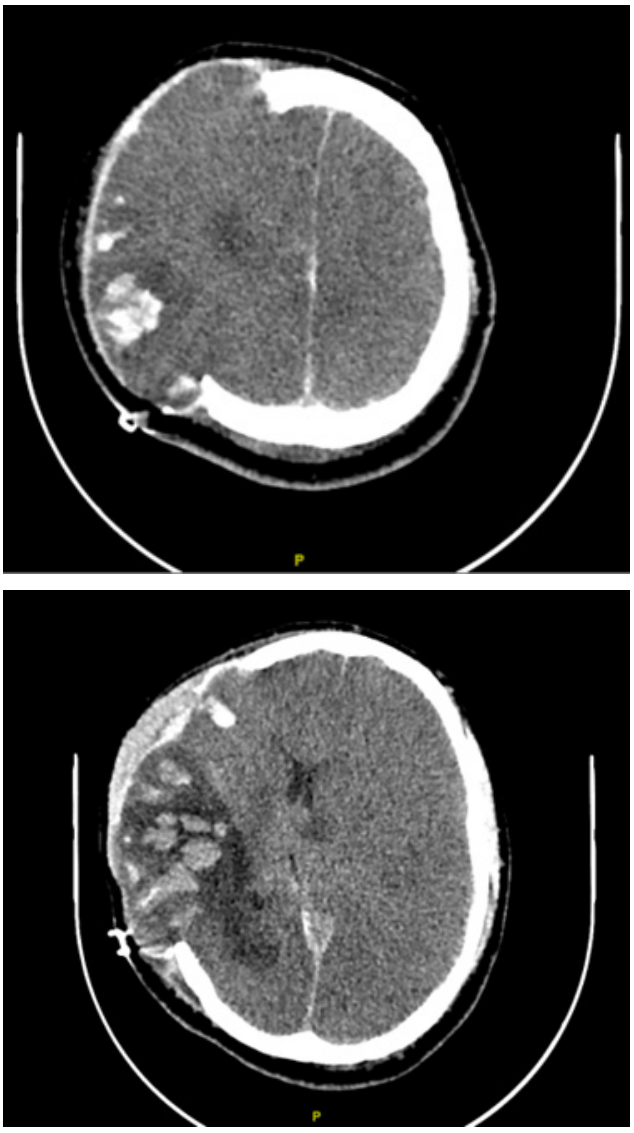

Figure 3. *Computed tomography of the head showing worsening cerebral edema with effacement of gray/white matter differentiation, worsening midline shift, and transcalvarial herniation.*

Commentary

The case presented here of a young man who succumbed to what could have been a survivable brain injury highlights systemic issues in the Dominican Republic, where motor vehicle accidents are the leading cause of death, much like in many other low- and middle-income countries (LMICs). This tragic event underscores the critical need for improved on-scene airway management and resuscitation efforts.

Traffic injuries are a global issue, but their impact is disproportionately severe in LMICs. In fact, LMICs account for about 85% of global traffic injury fatalities.[1] In cases like this one, immediate administration of supplemental oxygen is recommended for all patients with suspicion of moderate or severe TBI, regardless of their baseline oxygen saturation.[2] Indeed, TBI management begins at the scene of the injury, emphasizing the importance of resuscitation and preventing secondary insults caused by hypotension (by maintaining SBP > 110) and hypoxia (maintaining SatO2 > 90%).[2]

However, adopting best practices for pre-hospital care is challenging in resource-limited settings like the Dominican Republic in comparison to higher-income countries. A systematic literature review showed significant challenges in pre-hospital care across various LMICs.[3] Poor infrastructure, including road access, inadequate availability of basic materials, and a lack of coordination and fragmented systems, were frequently cited as obstacles to the efficient operation of pre-hospital care services.[3] As in other countries, members of the public

who often lack medical training are the first responders for the majority of patients in these settings, resulting in potential delays in receiving appropriate care. There is a notable lack of standardized protocols for transporting patients to hospitals, with many studies indicating that patients are often transported by family members or private vehicles rather than ambulances. As a result, many patients arrive at definitive trauma centers well beyond the recommended "golden hour" for optimal treatment.[1,3] Only a minority of ambulances in LMICs are staffed by physicians or equipped with personnel trained in basic life support.[3] These personnel might not fully understand how brain hypoxia triggers cerebral vasodilation through autoregulatory mechanisms, contributing to intracranial hypertension.[2] In the case presented, the patient's severe hypoxia not only contributed to these complications but also led to a cardiac arrest that could have been prevented with more prompt and appropriate medical intervention.

To optimize the management of TBI patients in LMICs, various protocols have been developed to address resource limitations. Among these, a noteworthy protocol named "Beyond One Option for Treatment of Traumatic Brain Injury: A Stratified Protocol (BOOTStraP)" stands out for its inclusion of pre-hospital care.[4] This innovative approach offers ten protocols tailored to different resource contexts, ranging from minimal to high levels of resources. Users can select the most suitable treatment option based on available resources and transition to other options as resources fluctuate, reflecting the common challenges faced by practitioners in resource-constrained regions.

However, we may soon gain insights into how to improve pre-hospital care for patients with TBI. The MOTOR trial, a two-armed parallel multiple-period cluster randomized controlled clinical trial, is currently in progress.[5] This trial in Ugandan trauma centers aims to assess the impact of a locally adapted rural trauma team development course (developed by the American College of Surgeons) on process and patient outcomes such as morbidity and mortality. The findings of this trial have the potential to inform the design, implementation, and scalability of rural trauma team development programs in similar low-resource settings.

> By involving and empowering communities, there is potential to increase demand for prehospital services and facilitate improvements in their quality and accessibility.

In LMICs, while the prehospital system faces numerous challenges, there are also promising opportunities for enhancement. Collaborative efforts among government agencies, healthcare providers, civil society organizations, and international partners can leverage expertise, resources, and networks to enhance prehospital care in resource-constrained settings. Several studies have highlighted the significant role of community members and non-medical first responders in delivering prehospital care. By involving and empowering communities, there is potential to increase demand for prehospital services and facilitate improvements in their quality and accessibility.[6]

Dr. Morel is privileged to work in one of the Dominican Republic's most advanced healthcare facilities. However, despite this privilege, there remains a pervasive concern about the significant delays in accessing medical care for oneself or loved ones during emergencies. The reality remains that the actions taken in the initial moments following a TBI are arguably the most critical aspect of the treatment process. Future research will need to focus on adapting rural trauma team training to LMIC settings, aiming to equip traffic law enforcement and medical trainees with essential skills that could establish a new standard for trauma care and educational frameworks in these regions. We are optimistic that the MOTOR trial will illuminate a path forward. ●

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World Coma Day 2024: Spotlight on the NCS Asia Oceania Chapter

By Gentle S. Shrestha, MD, FACC, EDIC, FCCP, FRCP (Edin), FSNCC (Hon), FNCS; Hemanshu Prabhakar, MD, PhD; Kapil Zirpe, MD, FICCM, FSNCC; Jo Ann Soliven, MD, FPNA, FNCS, FPSCCM; Saurabh Anand, MBBS, MD; Masao Nagayama, MD, PhD, FAAN, FACP, FNCS; Yu-Lin Wong, MBBS, MD; DaiWai Olson, PhD, RN; Claude Hemphill, MD, MAS

Figure 1. *Flyer for the Asia Regional Chapter's World Coma Day webinar.*

The fourth World Coma Day took place on March 22, 2024, and shined a spotlight on the NCS Asia Oceania chapter. The region had its own dedicated online webinar which was organized and supported by NCS, with focused discussions on unique challenges and opportunities for successful implementation of the Curing Coma Campaign (CCC) in low- and middle-income countries (LMICs) (**Figure 1**).

The webinar started with a welcome address by Dr. Hemanshu Prabhakar from India, which was followed by a talk from Dr. Kapil Zirpe from India, the current chair of the region. Dr. Zirpe highlighted perspectives from developing nations, including their understanding of coma and issues related to implementing the CCC, the unique challenges inherent to LMICs, and possible solutions and associated opportunities.

The following session included a panel discussion moderated by Dr. Gentle S. Shrestha from Nepal, who is the immediate past chair of the NCS Asia Oceania chapter. This discussion involved panelists from multiple nations from the region as well as members of NCS leadership. Among the panelists, Dr. Jo Ann Soliven represented the Philippines, Dr. Saurabh Anand represented India, Dr. Masao Nagayama represented Japan, and Dr. Yu-Lin Wong represented Singapore. CCC co-chairs Dr.

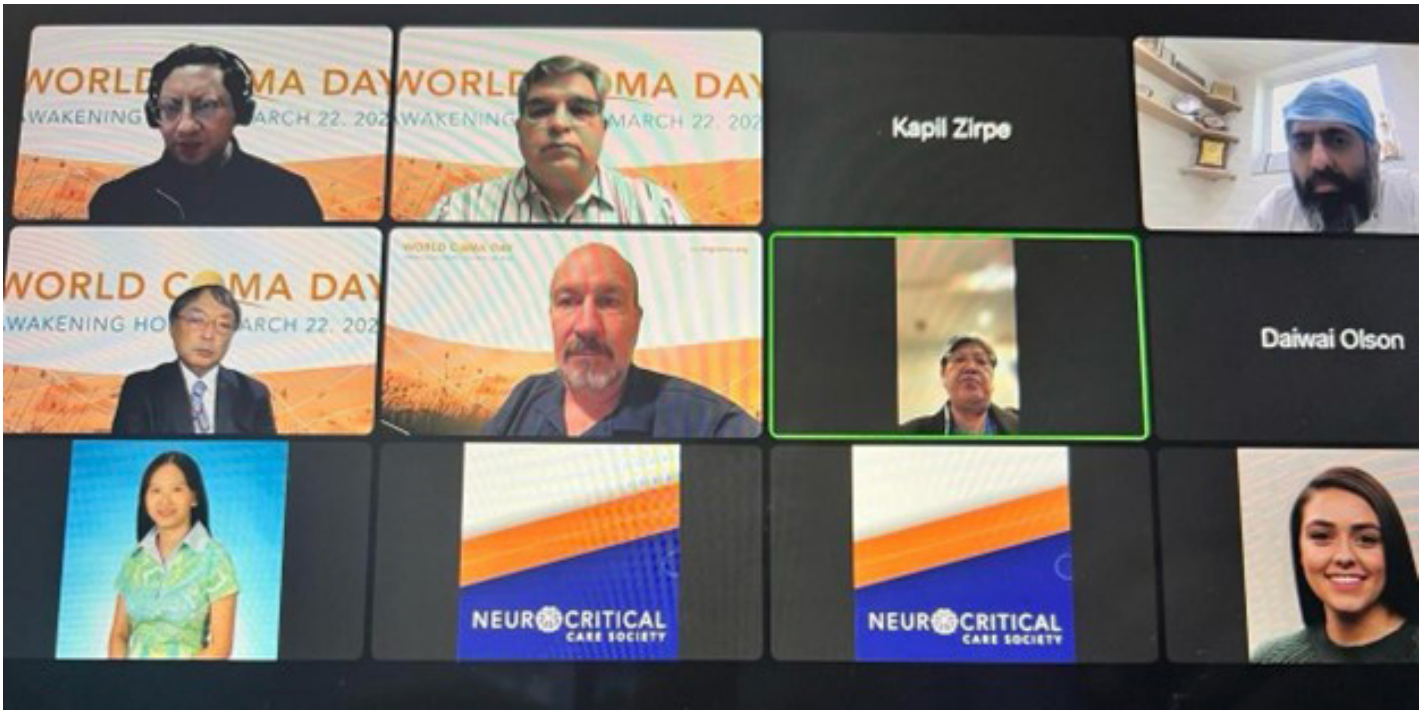

Figure 2. *The discussion panel*

Claude Hemphill and Dr. DaiWai Olson also participated in the panel discussion, representing NCS leadership (**Figure 2**).

Dr. Hemphill elaborated on the CCC's major ongoing projects and activities, as well as its vision for the future. Meanwhile, the other expert panelists underscored how many LMICs were in the region, and that the unique perspectives of these nations need to be considered. The panelists discussed regional challenges related to coma diagnosis and management such as primitive pre-hospital transportation, a high disease burden, poor insurance coverage and reimbursement of healthcare costs, limited resources, clinician nihilism, and an overall lack of awareness about coma. The panel also discussed the need to strengthen preventive measures to minimize the burden of coma, promote cost effective interventions, and enhance management strategies for common causes of coma like traumatic brain injury and stroke. The panel emphasized the value of raising awareness among both healthcare workers and the public, while also expressing a need for high quality epidemiological data and collaborative efforts for enhancing coma care and coma research. Dr. Nagayama added that education about coma, including risks, crisis management, and related issues, was an urgent need in every country. In response, Dr. Hemphill expressed his and NCS' eagerness to support coma-related activities in the region and proposed that the region formulate its own roadmap for coma care that would be achievable and realistic.

> "Education about coma, including risks, crisis management, and related issues, [is] an urgent need in every country."

In summary, the NCS Asia Oceania chapter marked World Coma Day 2024 with a lively online panel discussion that focused on the challenges and opportunities for the CCC in the region. Hopefully, this kind of discussion can help bridge the numerous gaps in coma care in LMICs and be a step toward enhanced care in the future. ●

Medical Futility: An Ongoing and Evolving Challenge

By Vishal N. Patel, MD; Krista Lim-Hing, MD; Richard K. Choi, DO; Matthew N. Jaffa, DO




Case Presentation

A 78-year-old woman has been admitted to the Neurocritical Care Unit. She arrived following a cardiac arrest in the setting of a Hunt and Hess 5 subarachnoid hemorrhage due to a ruptured basilar artery aneurysm. She has remained comatose despite cerebrospinal fluid diversion and ongoing aggressive care. Unfortunately, her course has also been complicated by diffuse bilateral infarcts from delayed cerebral ischemia related to severe vasospasm noted on brain MRI. She is now developing worsening renal function and will likely require hemodialysis soon.

On exam she is comatose, GCS score is 3T, pupils are nonresponsive, oculocephalic reflex is absent, there is no blink to threat, cough reflex is present and gag reflex is present but weak. There is no noted grimace nor motor response to pain.

The family is requesting that all medical measures be continued and are requesting tracheostomy, PEG tube and, if necessary, CPR. The caring team has expressed concerns with continuing restorative care for this patient and are requesting invocation of the hospital's "medical futility" policy.

Futility

Futility, as related to medical care, remains a vague and often legally and ethically ill-defined concept — something we frequently discuss on rounds or during multidisciplinary team conferences but rarely at a systemic or societal level.

While terms such as "potentially inappropriate care" or "non-beneficial" care have been introduced as a means to soften the language, all commonly refer to a medical prognostication that a patient's condition will not improve due to permanent illness or injury, and as such, further therapies that will not improve said condition should not be attempted, such as in the case described above. This definition, however, is not consistently used, and the term has also been associated with other meanings, such as a physician's prognostication that a therapy may produce no physiological effect; a physician's prognostication that a therapy may produce a physiological effect, but the effect will provide no medical benefit to the patient; and, in a self-serving manner, used to pronounce a proposed therapy as ineffective because they do not wish to prescribe it.[1]

Several major aspects of futility of care discussions surround the need to make value-based judgements about what is beneficial or meaningful to individuals for whom we might apply this term, the unconscious biases we bring to the table as clinicians having these conversations, and the inexact science of prognostication. As medical technologies continue to become more advanced, life-sustaining measures improve, and advancements in neuroscience continue, healthcare professionals anticipate an indeterminacy in the resolution of these ethical dilemmas.[2]

Our aim here is to promote individual exploration of this meaningful but often difficult topic for families, clinicians, and society.

Futility in the Literature, the Law, and Hospital Policy

Meta-analysis studies in the literature reveal a diverse and often conflicted view of futility of care. Indeed, individual states and hospital systems approach futility of care differently, and some

> "Individual states and hospital systems approach futility of care differently, and some may not address futility of care at all in their hospital policies."

"The concept of medical futility is inherently a deeply personal assessment of meaningful benefit, and yet one that is ensconced in societal and cultural norms."

may not address futility of care at all in their hospital policies.[2] Many hospitals have opted to create policies with few specifics. For instance, in one of our hospitals there is an approved policy for addressing concerns of "potentially inappropriate medical care," though it ultimately provides limited guidance as to what might constitute futile care and instead directs the invoking medical team to obtain an ethics consult with potential for further discussions with hospital leadership and legal counsel.

Requests for resuscitation against medical recommendation and clinician directed code-status changes (also referred to as "unilateral DNR") are the most commonly addressed areas of futile care. It is the societal norm in the United States to perform CPR on all patients admitted to the hospital unless a "Do Not Resuscitate" (DNR) order has been discussed and signed, though each state has different requirements for initiation of DNR for patients without legal surrogates. In Georgia, for example, "unbefriended" patients—that is, those without legal surrogates—require two physicians to agree that the patient is a candidate for non-resuscitation in the setting of cardiac arrest. The two physicians must agree that one of the following applies:

- The patient has a medical condition that can reasonably be expected to result in their death; OR
- The patient is in a comatose state with no reasonable possibility of regaining cognitive functions; OR
- The patient is someone for whom cardiopulmonary resuscitation would be medically futile in that such resuscitation will likely be unsuccessful in restoring cardiac and respiratory function or will only restore cardiac and respiratory function for a brief period of time, so that the patient will likely experience repeated need for cardiopulmonary resuscitation over a short period of time.

In many states, the order of surrogate decision maker stops after adult sibling, while in Maryland a "friend or other relative" who presents an affidavit to the clinical team documenting a maintained close relationship with the patient will suffice, enabling them to make decisions regarding code status. However, this example is very limited in scope as many discussions related to futility of care do not necessarily focus purely on code status or resuscitation.

The concept of medical futility is inherently a deeply personal assessment of meaningful benefit, and yet one that is ensconced in societal and cultural norms. Concerns that performing CPR despite the belief that it is futile in certain patients has been noted as a driver of moral distress among healthcare workers in the US, whereas in the United Kingdom guidance on enacting DNR orders is bound by that which is known to be medically feasible.[3]

Regional Differences in Perception of Medical Futility

The term "persistent therapy," used primarily in Poland and some other Eastern European cultures in lieu of "medical futility," is defined as "the use of medical procedures to maintain life function of the terminally ill in a way that prolongs their dying, introduces excessive suffering, or violates their dignity".[4] While this term may convey the concept of "medical futility," it can be confusing as "dignity" varies from individual to individual.

Others have advocated a focus on education, healing, and understanding when addressing goals of care. In the Middle East, the terms "Sabr" and "Shukr" – "Patience and Thankfulness" – are emphasized in discussions between healthcare providers and patients and their families. This concept values patients' and families' principles, and reinforces education, understanding, and appreciation for the heroic efforts towards preservation of life, while also underscoring the severity of illness.[5]

Cultural viewpoints greatly influence regional views on the concept of medical futility. Regional differences exist across the United States. For example, healthcare teams in the southeastern United States must contend with the dark history of the Tuskegee Syphilis Study. This has led to a legacy of inherent distrust of healthcare amongst many patients and families. Medical literacy and socioeconomic factors also influence how a patient's family may view conversations regarding goals of care. Healthcare systems and physicians have to adapt and recognize regional and historical influences when discussing patient care.

Conversation Goals for Clinicians, Patients and Families

It is important to be cognizant that different people may interpret the term "medical futility" differently. These differences often emerge as conflicting views between members of the healthcare team, patients, and their families.

Patient autonomy as a pillar of medical ethics may sometimes challenge the personal beliefs and biases of the healthcare team

when balancing viewpoints. It is important to recognize that everyone involved may need some level of support.[6] Pragmatism and dogmatism often must be put aside.

As clinicians and healers, we must remember that acceptable, or meaningful, clinical benefit is a "moving target" and defined differently for every individual and their family. Healing for a patient or family may mean more time. A compassionate viewpoint and discussion go a long way in the healing process.

When the care of a patient has ultimately reached the point where the team is discussing medical futility, it is important to note that communications have often broken down, and that the patient or family may feel mistrust toward the caring team. It will be essential to attempt to restore this trust to open the two-way communications that are necessary for successful navigation of patient autonomy.

Practically, when meeting with patients and their families to discuss care that is viewed by the medical team as futile, it is often simplest to return to the basic tenets of shared decision making: identifying the patient's and family's values and goals for medical care, acknowledging their expertise in understanding these values, and providing our expertise in the realm of medical possibilities. Every patient and family are unique and we as healthcare providers must tailor our discussions to each situation.[6] Framing conversations in terms of goals and goal concordant care often obviates the confusion that a focus on providing or stopping an intervention can create.[7]

In some clinical scenarios there may also be differences of opinion amongst the healthcare team. Here, as in conversations with family, the focus should remain on respectful dialogue, an understanding of each other's views, and ultimately providing goal concordant care for the individual we are all treating. When the impasse is too wide to cross, hospital ethics committees may provide a forum for conflicting viewpoints to be equally shared, respected, and discussed while recognizing that ultimately the guiding principles of ethics, hospital policy, and legal precedent will determine the final decision for how care is provided.

In the case above, more detailed conversations led us to learn that the patient had previously expressed that her goal was to spend more time on this plane of existence, no matter the cost, but family also expressed significant concern with mistrust, stating that "different providers said different things." Conversations were ultimately not able to reach a consensus, and the caring team requested a unilateral DNR. The patient underwent tracheostomy and PEG tube placement and was discharged to a subacute rehabilitation facility.

Summary

Our chosen specialty of neurocritical care finds itself at a crossroads where emerging technologies and the evolution of our understanding of consciousness offer unbounded possibilities for the care we provide to those faced with severe acute brain injury. The concept of medical futility remains dynamic and evolving, leading to frequent experiences where what can be done "to" a person and what might be done "for" that person must be sorted out. During that process, we ought to remain realistic, humane, and supportive of our patients, their families, and ourselves. ●

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Point-of-Care Ultrasound Education in Neurocritical Care: A Call to Action

By Thanujaa Subramaniam, MD; Toufic Chaaban, MD; Judy Ch'ang, MD; Aarti Sarwal, MD; Atul Kalanuria, MD, FACP, MHCI





Introduction

Point-of-care ultrasound (POCUS) is increasingly being recognized as an essential skill for critical care providers, intended to enhance clinical assessments to improve patient care. Beyond its adoption for procedural guidance, bedside ultrasound assessments can provide critical diagnostic information in a timely manner to guide real-time decision making for the acutely ill patient. An accumulating body of evidence has shown that POCUS can improve clinical outcomes and lower medical costs.

Over the past decade, there has been widespread adoption of bedside ultrasonography by various critical care specialties, with respective governing societies issuing guidelines and position statements encouraging the use of POCUS. However, the field of neurocritical care has yet to fully embrace this innovative field, and neurocritical care training programs vary in their efforts to provide accessible, well-structured educational programs for trainees.

Application in Neurocritical Care

Patients with acute brain injury are predisposed to multiple cardiopulmonary complications, and knowledge and competency in POCUS has particularly advantageous applications in neurocritical care. POCUS might help in identifying the underlying etiology or comorbid conditions in patients with acute ischemic stroke, such as intracardiac thrombus or heart failure. In patients with subarachnoid hemorrhage and traumatic brain injury, stress cardiomyopathy is common and volume status is of paramount importance. Bedside ultrasonography can be used to differentiate etiologies of hypotension, guide volume resuscitation, and provide serial hemodynamic assessments for nuanced treatment strategies. Acute respiratory failure, commonly encountered in neurocritical care patients, can be effectively assessed and managed with basic lung ultrasonography skills. More advanced applications such as evaluation of diaphragmatic function can be useful in predicting readiness for extubation in patients with neuromuscular respiratory dysfunction.

Aside from general ultrasound applications, the field of bedside neuro-ultrasonography has also undergone an important transformation in recent years. Important applications of neuro-POCUS include assessments of cerebral blood flow and velocities, signs of raised intracranial pressure, and diagnosis of intracranial mass lesions or midline shifts. Transcranial doppler POCUS assessments can be used to serially monitor evolving vasospasm in subarachnoid hemorrhage patients or evolving cerebral perfusion patterns in patients with acute brain injury of various etiologies. This can be used to guide therapy initiation and determine treatment effect.

Current State of Point of Care Ultrasound in Neurocritical Care

POCUS adoption amongst neurocritical care providers is thought to be highly variable. Data on POCUS use and competency across neurocritical care programs is lacking; a recently concluded nationwide survey of POCUS skills and utilization by neurocritical care practitioners will likely provide some valuable insights. In addition to the overall dearth of neurocritical care literature on POCUS, most publications are primarily focused on the neuro-ultrasound specific applications, with little on body ultrasound applications in the neuro-critically ill population.

Notably, there is also an absence of professional society issued guidelines or position statements on bedside ultrasonography for neurocritical care practitioners. In contrast, societies such as Society of Critical Care Medicine (SCCM), American College of Emergency Physicians (ACEP), and the American College of Chest Physicians (ACCP) have provided detailed guidelines with guidance regarding scope of practice and recommendations regarding training and defining competency.

Perhaps unsurprisingly, POCUS is not universally taught across neurocritical care fellowships nationwide. When training is provided, there is typically no standardized curriculum or competency evaluation. Conspicuously, the neurocritical care Accreditation Council for Graduate Medical Education (ACGME) common programs requirement makes no mention of POCUS.

In comparison, ACGME common program requirements for critical care medicine designated POCUS as a core knowledge area, and surgical critical care ACGME program requirements emphasize knowledge of cardiac ultrasound in the critical care setting. ACGME program requirements for POCUS in acute care residencies such as emergency medicine and anesthesiology are robust and detailed.

Challenges and Proposed Solutions

The barriers to universal neurocritical care oriented POCUS training are multifold. Many fellowship programs lack sufficient presence of ultrasound competent faculty with time and funding to successfully develop and implement an ultrasound curriculum. In addition, many institutions have limited access to ultrasound machines and lack archival and image review software that enables a formal process of skill assessment with quality assurance of providers acquiring ultrasound images.

One approach to addressing institutional limitations involves leveraging national workshops and courses backed by professional societies such as SCCM and ACEP to build early critical care ultrasonography skills. However, the high cost of a national course may prohibit many from accessing this resource. In such cases, regional collaborative efforts bringing together POCUS experts from multiple institutions to teach in a workshop setting may be a good alternative. Additionally, a multidisciplinary approach in collaboration with other specialties with established POCUS programs (e.g., emergency medicine physicians and other critical care specialists) within single institutions may prove beneficial in the initial stages of designing a curriculum. Institution-wide efforts to encourage POCUS utilization include integrating POCUS imaging and documentation into Electronic Medical Record (EMR) systems and incorporating billing protocols into the workflow, which can improve documentation as well as provide a revenue stream to fund ultrasound programs.

Ultimately, achieving widespread POCUS adoption requires support and guidance from professional bodies. Guidelines issued should affirm the practice of ultrasound for neurocritical care, in addition to defining appropriate scope of practice, and make recommendations for training necessary to achieve competence. Further, it would be prudent to form a task force comprised of neurointensivists along with experts from other critical care specialties to formally design the outline of a neurocritical care-oriented POCUS curriculum and oversee its implementation.

Current Efforts

NCS hosts an Ultrasound Section that has been instrumental in bringing together POCUS enthusiasts to foster academic collaborations and drive educational efforts within the neurocritical care community. In addition to monthly meetings, Ultrasound section members leverage social media via X (formerly known as Twitter) and TikTok to educate and disseminate information.

Notable efforts by this group include the POCUS webinar series. The webinar recordings from the first series, designed to teach basic bedside ultrasound skills in a neurocritical care setting, are currently accessible to members as a free educational resource on the NCS website. The recently commenced second webinar series is targeted towards providers who are interested in more advanced bedside ultrasound applications. The Ultrasound section also organizes a TCD workshop as well as a POCUS and body ultrasound workshop at the NCS annual meeting, geared towards beginners who are intent on hands-on training. Lastly, section leadership supports recurring publications of POCUS case studies in *Currents* to increase awareness and education within the neurocritical care community.

> "Given its proven clinical utility, it is hoped that more neurocritical care programs will begin to formally implement POCUS training and education."

Conclusion

Modern intensive care practice necessitates the incorporation of bedside ultrasonography. Given its proven clinical utility, it is hoped that more neurocritical care programs will begin to formally implement POCUS training and education, along with the development of a dedicated curriculum by professional organizations. Collaborative efforts to gather data on POCUS application and its impact on neurocritical care patients will enable bedside ultrasound to become a standard tool in providing high quality neurocritical care. ●

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Role of Point-of-Care Ultrasound in Lumbar Puncture

By Earllondra Brooks, MD; Izn Shahab, MD; Gary Hunter, MD; Erika Sigman, MD




Introduction

Despite major advances in neuroimaging, lumbar puncture (LP) remains a necessary diagnostic and therapeutic procedure for a variety of neurologic disorders. LPs aid in the diagnosis of central nervous system infection, subarachnoid hemorrhage, and many other disorders that can present as neurologic emergencies. As such, a delay in diagnosis caused by failed LP attempts may result in major morbidity or mortality.

Traditionally, LPs have been performed at the bedside without imaging guidance. However, many LPs are now being performed fluoroscopically in radiology departments due to an increasing shift toward more procedures performed by radiologists. In contrast, LPs performed by neurologists and neurosurgeons have significantly declined (by 74% and 83%, respectively).[1] The most frequently described barriers to a successful bedside LP are age and body mass index (BMI). Older age is associated with an increased risk of degenerative disease and spinal surgeries which lead to more challenging anatomy, while higher BMI has been associated with increased difficulty in identifying the proper intervertebral space.[2-5] The ICU setting also poses its own challenges, as patients are critically ill, may be attached to a ventilator or other devices, and are often difficult to position.

Given the anatomical challenges associated with LPs, point-of-care ultrasound (POCUS) can serve as a helpful tool to improve success rates with bedside attempts.

Clinical Case

A 77-year-old male was transferred to the intensive care unit from a rural hospital after he developed acute-onset confusion and abnormal behavior. He subsequently suffered a cardiac arrest in hospital with return of spontaneous circulation after resuscitation, then had a seizure. CT brain and basic work-up did not reveal a cause of his encephalopathy.

Cerebrospinal fluid sampling was sought as part of his evaluation. Positioning and landmark identification were challenging given the patient's anatomy and intubated status. An LP was performed with ultrasound guidance to address these challenges. The static technique was used to identify landmarks for the procedure. A linear probe was used in the transverse orientation to locate a spinous process (**Figure 1**). Acoustic shadowing was identified, corresponding to the location of a spinous process (**Figure 2**). To demonstrate the differences between the two probes, a longitudinal view was subsequently

***Figure 1**. Linear probe in transverse orientation with mark on patient's skin to denote spinous process (red arrow).*

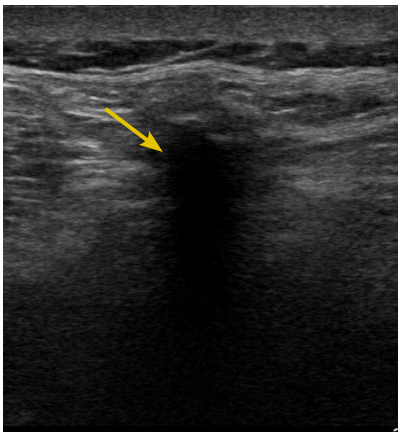


***Figure 2**. Linear probe demonstrating acoustic shadowing from a spinous process (yellow arrow).*

***Figure 3**. Curvilinear probe in longitudinal orientation.*

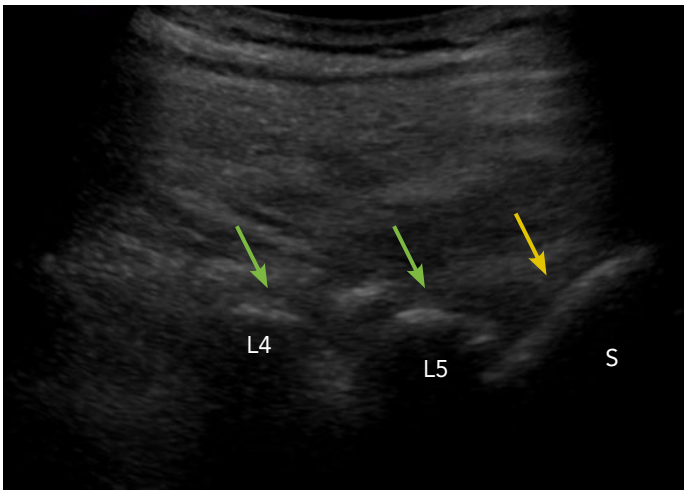


***Figure 4**. Longitudinal view with curvilinear probe demonstrating hyperechoic curved structures with acoustic shadowing, which are L4 and L5 (green arrows) and the sacrum (S) (yellow arrow).*

obtained using a curvilinear probe (**Figure 3**). The spinous processes of L4 and L5 were identified, along with the sacrum (**Figure 4**).

A surgical marker was used on the patient's skin to denote pertinent landmarks. These marks were then connected, with the point of intersection being identified as the optimal site for needle insertion. Basic cerebrospinal fluid parameters were within normal limits. Gram stain, culture and VZV/HSV PCR were negative as well. The patient was successfully extubated but suffered ongoing cognitive deficits. A subsequent MRI showed signs of hypoxic ischemic injury and an echocardiogram demonstrated signs of ischemic heart disease, which may have been the cause for his delirium and cardiac arrest.

> "Ultrasound-guided LPs can be performed by a static or dynamic technique, with most comparative studies in the literature evaluating a static approach."

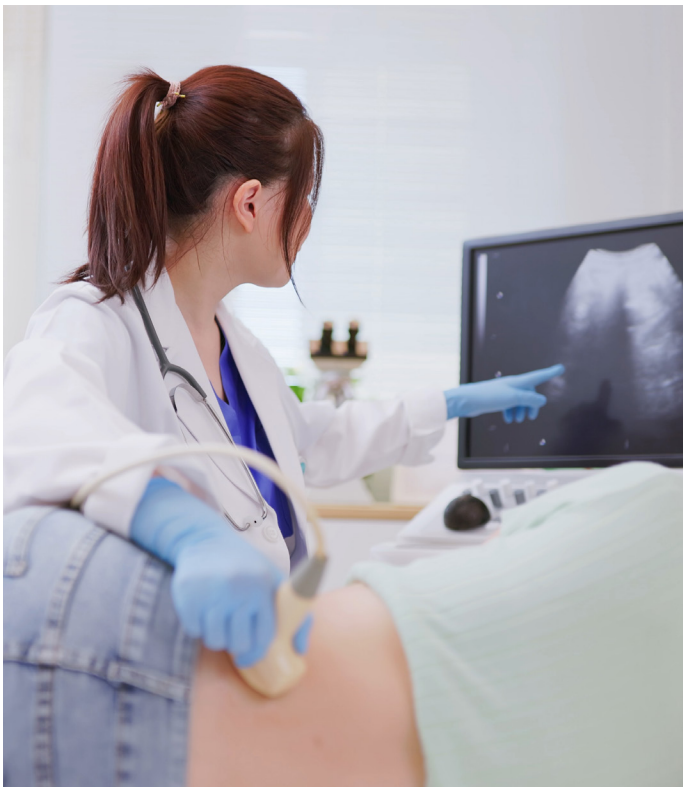
Discussion

In patients with difficult to palpate bony landmarks or unsuccessful initial attempts, POCUS-guided LP can be a useful tool to delineate patient anatomy and increase one's chances of success at the bedside. A 2013 meta-analysis of 14 randomized controlled trials (RCTs) compared ultrasound-assisted LPs and epidural catheterizations with those performed using a traditional palpation landmark-based approach. This meta-analysis demonstrated a decreased risk of failed and traumatic LPs and epidural catheterizations when using ultrasound imaging.[6] Although this study evaluated both LPs and epidurals, similar results were seen in a 2018 meta-analysis which only included RCTs involving LPs, and also demonstrated fewer traumatic LPs, decreased procedure duration and lower patient pain scores.[7] A more recent large retrospective cohort study in 2023 also showed that ultrasound-assisted LPs were associated with increased success rates and a lower risk of traumatic LP.[8] Note, however, that the incidence of side effects after POCUS-guided LP such as post-LP headache, infection, or epidural bleeding have not yet been studied.

Ultrasound-guided LPs can be performed by a static or dynamic technique, with most comparative studies in the literature evaluating a static approach.[9-10] A dynamic, or real-time, ultrasound-guided LP is performed using a longitudinal (in-plane) or paramedian approach, and tracking the needle tip with insertion. A static-ultrasound-assisted LP (SULP) involves using the ultrasound to identify the bony landmarks to determine the ideal points of needle entry, and then proceeding with needle puncture without the ultrasound in hand. This can be performed with the patient in the sitting or lateral decubitus position.

The linear or curvilinear probe may be used for ultrasound-assisted LPs. The curvilinear probe may be preferred for patients with a higher BMI or larger body habitus for greater depth and increased field of view (**Figure 3**). The transverse view

> In patients with difficult to palpate bony landmarks or unsuccessful initial LP attempts, ultrasound can be a helpful tool to better delineate patient anatomy and improve one's chances of success at the bedside.



can be used to confirm and mark the midline (**Figure 1**). The longitudinal view, which can be obtained by rotating the probe 90 degrees, can be used to mark spinous processes and identify the interspinous/intervertebral spaces (**Figures 3 & 4**).

Conclusion

Lumbar punctures remain an important diagnostic and therapeutic tool for a variety of neurologic disorders. In patients with difficult to palpate bony landmarks or unsuccessful initial LP attempts, ultrasound can be a helpful tool to better delineate patient anatomy and improve one's chances of success at the bedside. ●

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Cefepime's Double-Edged Sword: Neurotoxicity in Critically Ill Patients

By Michelle Payne, PharmD, BCCCP

As a fourth-generation anti-Pseudomonal cephalosporin, cefepime is one of the first-line antimicrobials used to treat various hospital-associated bacterial infections. Similar to other beta-lactams, it is generally well-tolerated. In the setting of critical illness, cefepime is recommended to be dosed at 2 g every 8 hours to optimize pharmacodynamic target attainment (time over minimum inhibitory concentration, MIC), particularly in infections caused by organisms with higher MIC.[1] Cefepime extended infusions are recommended to overcome variable serum concentrations in patients with obesity[2] or augmented renal clearance[3], such as those of younger age, post-trauma or burn, or with sepsis, and have become increasingly popular for use in other critically ill patients as well. As cefepime is primarily excreted via the urine as unchanged drug, it requires renal dose adjustments in patients with renal insufficiency, particularly in elderly patients (**Table 1**). These occur at relatively higher thresholds than other beta-lactams, requiring adjustment once creatinine clearance falls below 60 mL/min, which is not uncommon in acute kidney injury or older age.

Failure to dose reduce in renal insufficiency can result in encephalopathy, myoclonus, and seizures.[4] Cefepime-induced neurotoxicity is associated with increased morbidity and mortality, though its correlation with in-hospital mortality is difficult to separate from other causes in critical illness.[5] In 2012, the U.S. Food and Drug Administration released a warning following the report of several cases of non-convulsive status epilepticus associated with cefepime.[6]

Table 1. Cefepime renal dose adjustments recommended by manufacturer.[4]

Creatinine Clearance (mL/min)	Manufacturer Recommended Maintenance Schedule[a]
Greater than 60 (Normal recommended dosing)	2 g every 8 hours
30 to 60	2 g every 12 hours
11 to 29	2 g every 24 hours
Less than 11	1 g every 24 hours
Hemodialysis[b]	1 g every 24 hours

[a] Maintenance regimens for cefepime extended infusions utilize the same dosing adjustments, infused over 4 hours with a bolus loading dose.

[b] Administer following hemodialysis on hemodialysis days.

Incidence of cefepime-induced neurotoxicity varies widely, ranging from 1% to up to 24% of ICU patients.[5,7-9, 11] Cases are predominantly reported in patients who are elderly, have renal dysfunction, and/or require intensive care.[5,9-12] In the ACORN trial — the only randomized trial to evaluate cefepime-induced neurotoxicity to date — cefepime was associated with higher rates of encephalopathy, with 21% fewer delirium- and coma-free days compared to piperacillin-tazobactam in ED and medical ICU patients.[11] Although the incidence is higher in patients who did not receive appropriate renal dose reductions, Fugate et al. reported that 29% of ICU patients still experienced neurotoxicity despite receiving dosing appropriate for their renal function.[7] Similarly, Payne et al. reported that over a quarter of patients with cefepime-induced neurotoxicity received appropriate dosing for their renal function; however, serum concentrations obtained in seven of these patients were elevated (≥20 mg/L).[10] It is important to note that although 44% of the patients evaluated in this study were identified to be critically ill at the time of cefepime administration, it is unclear if the patients developing neurotoxicity at renally-appropriate doses were those in the ICU.

Risk of cefepime-induced neurotoxicity in patients receiving cefepime extended infusion remains largely unknown. A retrospective study by Venugopalan et al. found no significant difference in the incidence of neurotoxicity in 70 patients who received cefepime extended infusions.[5]

Patients with pre-existing neurological or neurovascular conditions—particularly those in the neurocritical care unit—are not well represented in the existing literature that evaluates cefepime-induced neurotoxicity. Most studies do not elucidate if the patients were located in the neurocritical care unit when receiving cefepime. Case reports primarily describe patients in the ICU for septic shock or post-operatively, though Fugate et al. identified one patient in the neuroscience ICU.[7] Less than 20% of patients reported with neurotoxicity are described to have pre-existing CNS disease, including cerebrovascular disease, seizures,

intracranial hemorrhage, encephalopathy, encephalitis, cerebral palsy, or dementia.[5,9,10] However, in the few cases described among patients with stroke or pre-existing seizures, there was no significant difference in the incidence of neurotoxicity.[5]

Cefepime-induced neurotoxicity typically presents as confusion, diminished level of consciousness, and other symptoms of encephalopathy.[8-13] Less commonly, patients demonstrate agitation and aphasia. Symptoms may progress to myoclonus and seizures, with non-convulsive seizures being more common than generalized convulsions.[5,12] Typical EEG findings of cefepime-related encephalopathy show diffuse background slowing in the delta and theta ranges and generalized periodic triphasic discharges.[5,14-15] Symptom onset is generally reported between 2 to 6 days following the start of drug therapy, although there is a considerable time lag between onset and diagnosis of cefepime-induced neurotoxicity. Most patients have partial to complete resolution of symptoms approximately 24 to 48 hours after cefepime discontinuation.

The exact mechanism of cefepime-induced neurotoxicity is not fully understood. Cefepime has been demonstrated to cross the blood brain barrier in the setting of inflammation, reaching CSF concentrations of 5 to 58% of serum concentrations.[16] Active transport of cefepime out of the CSF to the blood may be impaired in renal dysfunction and critical illness due to the accumulation of toxic organic acids and decreased protein binding.[10,14-15] The commonly accepted mechanism is that cefepime inhibits GABA-related inhibitory activity through competitive antagonism at GABA-A receptors in a concentration-dependent fashion, thus resulting in central excitotoxicity.[5,8,10,17] Fernández-Fernández and Ameneiros-Lago proposed an additional mechanism through cefepime-related hypocarnitinemia, due to cefepime's inhibition of OCTN2-mediated carnitine transport resulting in urinary loss of carnitine.[18] Since hypocarnitinemia results in impaired mitochondrial fatty acid oxidation and has been implicated in neurotoxicity secondary to valproic acid toxicity, the authors hypothesized the potential contribution of carnitine deficiency in the setting of cefepime-induced neurotoxicity.

Management of Cefepime-Induced Neurotoxicity

Management of cefepime-induced neurotoxicity primarily consists of prevention, rapid recognition and diagnosis, and withdrawal of the offending agent. As cefepime-induced neurotoxicity is primarily reported in patients with renal insufficiency or age-related changes in renal function, emphasis is placed on dose reductions based on the patient's estimated renal function. However, highly variable renal function and frequent concurrent nephrotoxic medications, particularly in critically ill patients, often results in the inability to detect renal insufficiency in a timely fashion. Dosing recommendations rely on creatinine clearance estimates, which may be delayed when creatinine-based equations are used in the setting of acute changes in renal function.[10] In patients with advanced chronic kidney disease, serum creatinine and estimated creatinine clearance do not always correlate with true renal function.[7] As such, these patients may receive doses adjusted for their calculated creatinine clearance, but not appropriate for their true renal function, as demonstrated by serum cefepime levels obtained in Payne et al.[10]

Cystatin C has been proposed as an alternative marker for renal function as it is not affected by muscle mass and has been found to have a stronger association with estimated glomerular filtration rate.[19] KDIGO recommends the use of equations that combine both creatinine and cystatin C when available for drug-related decision making in patients with chronic kidney disease[20]; however, there is limited data on the use of cystatin C to guide renal dose adjustment of cefepime. Kim et al. found that cystatin C-guided dose adjustment was associated with an 89% decreased risk of cefepime-induced encephalopathy compared to dose adjustments based on serum creatinine.[21]

Furthermore, cefepime-induced neurotoxicity has been reported despite concurrent hemodialysis, even with appropriate dose adjustments.[7,9] Cefepime dosing in continuous renal replacement therapy (CRRT) highlights the difficult balance between adequate doses for antimicrobial effects and avoiding elevated serum concentrations placing patients at risk of cefepime-induced neurotoxicity. Recommended dose adjustment for cefepime in CRRT equates doses used in patients with creatinine clearance of approximately 30 to 60 mL/min (e.g., 2 g every 12 hours for Pseudomonal infections). Venugopalan et al. found that CRRT was independently associated with development of cefepime-induced neurotoxicity.[5] In contrast, Honore and Spapen recommend against overly cautious dose reductions as patients receiving recommended CRRT dosing only obtain approximately 90% coverage of organisms with minimum inhibitory concentrations ≤2 μg/mL.[22]

Therapeutic drug monitoring (TDM) has been explored as a tool for identifying patients receiving supratherapeutic concentrations and at risk of adverse events. While TDM has been widely used for antimicrobials medications with narrow therapeutic windows, namely vancomycin and aminoglycosides, its use in cephalosporins is still limited. Widespread adoption has been limited by the assays' unavailability, as well as the lack of well-defined therapeutic thresholds. Several retrospective studies evaluating TDM for other beta-lactams have found poor correlation between high serum concentrations and rates of various toxicities.[23] Similarly, the exact concentration threshold for neurotoxicity has not been well elucidated.[5] Boschung-Pasquier et al. found that a median trough concentration of 21.6 mg/L (IQR 17.0-28.6 mg/L) was associated with neurotoxicity.[13] In contrast, Huwyler et al. and Venugopalan et al. found toxicity to be associated with much higher troughs, averaging 52.2 mg/L and 61.8 mg/L, respectively.[5,24]

Since cefepime-induced neurotoxicity is highly reversible, timely recognition and withdrawal of cefepime is important in reducing morbidity. Continuous EEG monitoring in patients with altered mental status and encephalopathy can be useful in providing diagnostic clarity and identifying non-convulsive status epilepticus.[17] However, this degree of monitoring is not often available or feasible for most patients without other neurological conditions, even at resource-rich institutions. In addition, some providers argue that EEG abnormalities may not be specific to cefepime-induced neurotoxicity and instead reflect underlying metabolic changes, such as the triphasic waves seen in uremic or hepatic encephalopathy.[17] In patients found to be in non-convulsive status epilepticus, treatment can include administration of anti-seizure medications. Since cefepime-related neurotoxicity

typically resolves with simple cessation of the drug, these patients are unlikely to need long-term anti-seizure medications.[8,17]

In my practice, providers in the neurocritical care unit generally avoid the use of cefepime due to the paucity of literature in this population. For empiric or targeted coverage of Pseudomonas spp., alternative agents such as piperacillin-tazobactam and meropenem are considered, balancing the poor CNS penetration of the former antimicrobial with stewardship of the latter. I encourage deeper discussions of the risks of neurotoxicity in patients with multidrug-resistant Pseudomonas, noting that cefepime remains an optimal antimicrobial when resistance mechanisms to meropenem — primarily through drug efflux via porins — are present. Furthermore, alternative antimicrobials such as ceftazidime, piperacillin-tazobactam, carbapenems, and fluoroquinolones are each associated with their own risk of neurotoxicity, including seizures, with limited data comparing the rates of neurotoxicity with cefepime. In contrast, providers in our medical, surgical, and cardiac ICUs continue to use cefepime as a first-line agent with careful and frequent monitoring of and dose adjustments for renal function. Cefepime-induced neurotoxicity is often hard to identify in practice, due to the many confounding causes of altered mental status. However, if neurotoxicity is suspected, cefepime is immediately changed to an alternative antimicrobial.

Given the frequent use of cefepime for healthcare-associated infections, it is vital that clinicians are mindful of cefepime-induced neurotoxicity. Cautious and frequent dosing adjustments should be prioritized in renal insufficiency to mitigate the risk. The use of TDM should be further investigated to determine optimal therapeutic windows to ensure adequate exposure while minimizing toxicity. While it is not necessary to avoid the use of cefepime entirely, there are select patient populations – for example, elderly patients and those with renal dysfunction – in which cefepime should be considered with caution and alternative antimicrobial options considered. ●

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Understanding Risk Adjustment Factor (RAF) Scores and Their Impact on Reimbursement

By Ryan Hakimi, DO, MS, NVS, RPNI, CPB, FNCS, FCCM, FAAN

In an earlier article in this series, I discussed the importance of provider documentation in the H&P, especially the documentation of Hierarchical Code Conditions (HCCs) tied to payments.

https://currents.neurocriticalcare.org/Leading-Insights/Article/the-business-of-neurocritical-care-how-your-docume

Recently, the Centers for Medicare and Medicaid Services (CMS) launched Version 28 of its HCCs when it published the "2024 Advance Notice with Proposed Payment Updates for the Medicare Advantage and Part D Prescription Drug Programs." This version is based on claims data from 2016-2019 and is felt to be more accurate for current practice. It will have significant changes for the CMS-HCC Risk Adjustment Model for Contract Year 2024 which has already begun. Of note, the payment-related HCCs (those that are tied to reimbursement) increased from 86 to 115.

For 2023-2025, a blend of this new version (V28) and the prior version (V24) will be included in the models incorporating HCCs into the calculation of each patient's RAF Score. However, before we jump into the important factors relevant to neurocritical care providers, let us define the elements of the RAF score.

Comparison of V24 and V28 HCC Models

	V24	V28
	2020 CMS-HCC Model	2024 CMS-HCC Model
FY22/23 ICD-10 codes - total	73,926*	73,926*
FY22/23 ICD-10 codes mapped to payment HCCs	9,797 (13.3%)	7,770 (10.5%)
FY22/23 ICD-10 codes mapped to non-payment HCCs	64,129 (86.7%)	66,156 (89.5%)
Added		209
No longer mapped in the 2024 CMS-HCC Model		2,236
No longer mapped – ICD-10 clinical updates		2,161 (96.6%)
No longer mapped – Principle-10 focused updates		75 (3.4%)
HCCs - total	204	266
HCCs – payment	86 (42.2%)	115 (43.2%)
HCCs – non-payment	118 (57.8%)	151 (56.8%)

* The total number of ICD-10 diagnosis codes varies by fiscal year.

Slide modified from AAPC Webinar on Risk Assessment Ask the Experts, accessed 7/1/23.

What Is a RAF Score?

RAF scores are used by CMS to estimate the cost of healthcare for a Medicare Advantage plan beneficiary for the upcoming year. It determines the monthly payment made by CMS to the health plan for a given beneficiary during the following year, also known as a contract year (CY). As such, the health plan will be paid at a higher rate for older patients with multiple medical conditions and with conditions of greater severity as the anticipated cost of care for the given patient will be higher.[1] Risk adjustments were designed only for Medicare Advantage Plans, but their use is expanding as many healthcare systems are changing to value-based care (i.e., pay for performance).

How Are RAF Scores Calculated?

RAF scores incorporate demographic data and disease risk scores. Demographic data include age, sex, location of residence (home, skilled nursing facility, etc.) and disability status. Disease risk scores are determined from physical exam findings and diagnoses listed in provider documentation during face-to-face patient encounters (including synchronous telehealth encounters) and their associated HCCs. The lower the HCC number, the higher its contribution to the RAF score.

A RAF score of 1.00 means that the patient will have an average expected cost of care in the upcoming year. A score greater than 1.00 reflects a patient with a higher severity of illness while those below 1.00 are considered "healthier". Given that the RAF score is greatly determined by provider documentation, it is imperative that the patient's RAF score truly match the patient's severity of illness as it will impact provider and organizational payments in the following year. In other words, the patient must look as sick on paper as they do in person in order for organizations and providers to be fairly reimbursed.

- Although the EHR has created efficiencies for providers such as auto-populated histories, problem lists, and diagnostic study results, it is important to note that none of these contribute to the RAF score as they do not count as being documented by the provider.

V24 HCC Model	V28 HCC Models
Spinal Disease Group: 3 HCCs • HCC 70 *(Quadriplegia)* • HCC 71 *(Paraplegia)* • HCC 72 *(Spinal Cord Disorders/Injuries)*	**Spinal Disease Group: 3 HCCs** • HCC 180 *(Quadriplegia)* • HCC 181 *(Paraplegia)* • HCC 182 *(Spinal Cord Disorders/Injuries)*

Slide modified from AAPC Webinar on Risk Assessment Ask the Experts, accessed 7/1/23.

> "The patient must look as sick on paper as they do in person in order for organizations and providers to be fairly reimbursed."

For example, if an auto-populated head CT report documents that the patient has a new large acute intraparenchymal hemorrhage, but the provider does not list it in their assessment and have a plan for it using at least one of the MEAT criteria (Monitor, Evaluate, Assess, Treat), it will not count as a diagnosis.

- It is best practice for providers to document each Diagnosis + Status + Treatment (plan) + Thought Process/Associated risk and conditions to enable coders to correctly capture the HCC and thus calculate a correct RAF score.[2]

The second key principle of coding, as discussed in the previous article, is that coders cannot infer anything that is not documented by a provider (especially from the history, medication list, problem list, diagnostic test results, or operative reports) unless discussed elsewhere in the physical exam or assessment/plan. For example, if the patient has a documented hemoglobin A1C of 12 in the lab section of the note and the medication list indicates that the patient is on an insulin infusion, coders cannot assume that this patient has uncontrolled Type II diabetes mellitus with hyperglycemia unless the provider uses those words as an assessment and documents a plan for it, such as "continue insulin infusion for now due to fluctuant glucose levels."

Here I highlight certain changes that are germane to neurocritical providers. Of note, all sequelae codes were removed from the methodology, including spinal cord injuries. Therefore, one must document the functional state of the patient as a surrogate for the sequelae as shown below:

HCCs Related to Neurological Diseases

2020 model (V24)	Changes in V28 (2024)
HCC 73 (Amyotrophic Lateral Sclerosis and Other Motor Neuron Disease) HCC 74 (Cerebral Palsy) HCC 75 (Myasthenia Gravis/Myoneural Disorders and Guillain-Barre Syndrome/Inflammatory and Toxic Neuropathy) HCC 76 (Muscular Dystrophy) HCC 77 (Multiple Sclerosis) HCC 78 (Parkinson's and Huntington's Diseases) HCC 79 (Seizure Disorders and Convulsions) HCC 80 (Coma, Brain Compression/Anoxic Damage)	HCC 190 (Amyotrophic Lateral Sclerosis and Other Motor Neuron Disease, Spinal Muscular Atrophy) HCC 191 (Quadriplegic Cerebral Palsy) HCC 192 (Cerebral Palsy, Except Quadriplegic) HCC 193 (Chronic Inflammatory Demyelinating Polyneuritis and Multifocal Motor Neuropathy) HCC 195 (Myasthenia Gravis with (Acute) Exacerbation) HCC 196 (Myasthenia Gravis without (Acute) Exacerbation and Other Myoneural Disorders) HCC 197 (Muscular Dystrophy) HCC 198 (Multiple Sclerosis) HCC 199 (Parkinson and Other Degenerative Disease of Basal Ganglia) HCC 200 (Friedreich and Other Hereditary Ataxias; Huntington Disease) HCC 201 (Seizure Disorders and Convulsions) HCC 202 (Coma, Brain Compression/Anoxic Damage)

2020 model (V24)	Changes in V28 (2024)
HCC 51 (Dementia With Complications) HCC 52 (Dementia Without Complication)	HCC 125 (Dementia, Severe) HCC 126 (Dementia, Moderate) HCC 127 (Dementia, Mild or Unspecified)

2020 model (V24)	Changes in V28 (2024)
HCC 99 (Intracranial Hemorrhage) HCC 100 (Ischemic or Unspecified Stroke) HCC 103 (Hemiplegia/Hemiparesis) HCC 104 (Monoplegia, Other Paralytic Syndromes)	HCC 248 (Intracranial Hemorrhage) HCC 249 (Ischemic or Unspecified Stroke) HCC 253 (Hemiplegia/Hemiparesis) HCC 254 (Monoplegia, Other Paralytic Syndromes)

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Transplant Related HCCs

2020 model (V24)	Changes in V28 (2024)
HCC 186 (Major Organ Transplant or Replacement Status)	HCC 454 (Stem Cell, Including Bone Marrow, Transplant Status/Complications)

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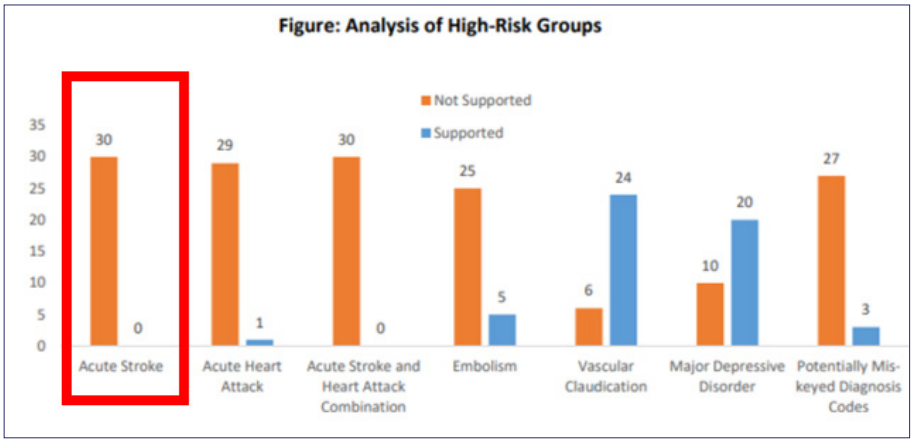

- Medicare Advantage Compliance Audit of Specific Diagnosis Codes That Humana Choice (H6609). CMS (A-05-19-00013)

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Documentation of dementia became much simpler, although the reimbursement decreased. Other common neurological conditions remained essentially unchanged with the exception of renumbering of the HCC (note that higher numbers mean lower reimbursement).

Certain conditions, although common to neurocritical care and clearly associated with high illness severity, were rarely documented overall and as such have been removed from the methodology. These include Guillain-Barre Syndrome, critical illness polyneuropathy, flexor posturing as best motor response in a comatose patient, and injury codes associated with sequelae of concussions. In addition, given the fact that the process is expected to reward high quality care, surgical complications such as intraoperative cerebrovascular infarction during surgery and post-procedural cerebrovascular infarction following cardiac surgery were removed from the HCC list.

Three new additions relevant to NCC providers include diagnoses associated with liver disease (alcoholic hepatitis with or without ascites, toxic liver disease with chronic hepatitis, malignant ascites, etc.), any lower extremity amputation except toe amputations, and malignant pleural effusions. Also emphasized in V28 are the documentation of any type of transplant (including hematologic), as post-transplant states are clearly associated with greater cost.

The importance of correct documentation related to NCC is best illustrated in a recent Humana Insurance audit of a particular health system. In a review of 30 charts in which acute ischemic stroke was coded, there were zero that supported the diagnosis and thus the health system had to repay (with penalty) the money they had received as shown above.

Although the details of this case are not known, it is possible that the patients identified in the audit may indeed have had acute ischemic strokes, but the provider may have used auto-populated radiology documentation (for example) to document the condition, which would not have been in compliance. Alternatively, perhaps they did not have an associated treatment plan documented.

Overall, as organizations shift towards value-based care and dig deeper into informatics to quantitate the cost of care provided, providers need to know that there is a possibility that their compensation may become individualized. For example, an NCC provider who documents well and captures the maximal amount of appropriate reimbursement for their health organizations may receive a higher salary than another NCC provider who takes care of a similar patient with the same length of stay and the same outcome, simply because of their documentation. ●

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Nurse Staffing: A Public Health Crisis in the Making

By Jordan Yakoby, EdDc, DNP, MBA, ACNP-BC, CCRN, CNE, FCCM

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> "Lower nurse-to-patient ratios result in decreased patient mortality, shorter lengths of stay, and decreased cost … [yet] we are still having conversations about improving nurse staffing."

The pandemic has finally been declared 'over,' though COVID-19 continues to linger. The phenomenon of burnout has been well documented pre-pandemic, in many cases due to understaffing. This was exacerbated by the severe strain of COVID-19 placed on the healthcare system, with nurses leaving in droves post-pandemic. While nursing professional organizations and unions have long advocated for formalized standards around nurse staffing in a variety of care settings, there has traditionally been stiff opposition, particularly from hospitals, nursing homes, and certain healthcare associations.

California has long led the way on nurse staffing, with specific staffing requirements across various care settings, viz., a 1:1 nurse-to-patient ratio in the operating room, 1:2 in intensive care units, labor and delivery care areas, and critical care patients holding in the emergency department, 1:3 in stepdown units, and 1:4 in emergency departments, telemetry, and ante/postpartum care areas. This has resulted in lower mortality and failure-to-rescue rates in California hospitals compared with other states (Lasater et al., 2021). However, it should be noted that there are circumstances in which a 1:1 ratio may be necessary. The Neurocritical Care Society recommends not only 1:2 staffing ratio, but also 1:1 staffing in particularly high acuity situations (Moheet et al., 2018).

This year, New York became the first state in the post-pandemic era to legislate on the issue of nurse staffing. However, as has traditionally been the case, key groups expressed strong opposition to the legislation, resulting in a watered-down version of the law that is restricted to staffing in the critical care environment. This version requires a 1:2 registered nurse-to-patient ratio in critical care areas. Outside of critical care, the law merely requires an internal committee to handle staffing in these areas, the composition of which must be 50% nurses and 50% hospital administrators.

It is a welcome change to finally codify the requirements that have long been known to be best practice regarding staffing in ICUs. The legislation will certainly introduce much needed accountability for hospitals to provide appropriate nursing care for critical care patients. Civil fines will ensue for hospitals failing to meet these requirements after submission of a corrective action plan. While this is a victory for critical care professionals, we cannot be insular in nature. A key tenet of critical care – neurocritical care being no exception – is to prevent critical illness and reduce admission and readmission rates as much as possible. For this reason, we must be equally concerned with nurse staffing in medical-surgical units and other patient care areas inside and outside the hospital. Therefore, the remaining aspects of this law likely fall short of its aim to police nursing staffing ratios and adhere to best practice. Even with a committee with half its composition including nurses, the law provides that the other half of the committee be composed of hospital administrators.

The law does not give the nursing members of the committee any real power or other tools to enforce recommendations, rendering this provision of the law a toothless tiger. Furthermore, the reality of the power differential between hospital administrators

and nurses on the committee, particularly in non-union environments, can easily give rise to situations where nurses are pressured or intimidated into not speaking freely regarding staffing issues or giving in to less-than-ideal staffing decisions emanating from this committee. This is yet another instance of politically active, well-funded, and powerful interest groups successfully opposing the implementation of safety-based measures in service to the almighty dollar.

It has been demonstrated that lower nurse-to-patient ratios result in decreased patient mortality, shorter lengths of stay, and decreased cost (Lasater et al., 2021; Musy et al., 2021; Rae et al., 2021). Yet even in this technologically advanced era, we are still having conversations about improving nurse staffing. Hospitals do not understand that lower ratios result in more individualized nursing care and long-term cost reductions, even after increased staffing is factored into the cost equation. For example, how many of us in the neuro ICU have avoided transferring a complex patient to the floor, for fear of the lack of attention the patient will receive on the medical ward? I, for one, have held onto several patients without critical care needs, but who did have a need for careful secretion management, including suction, chest physiotherapy, and other interventions that could be handled on the medical floor if it were not for staffing issues. Medical-surgical floors in several hospitals in the New York area, where I am based, have ratios in excess of 1:6, and in some cases up to 1:10, which even led to a recent New York City-wide nursing strike earlier this year.

This represents an increased ICU length of stay and increased costs associated with the hospitalization. It also represents fewer ICU beds available for other patients. This is intricately connected with the concept of "missed care," which is nursing care left undone due to lack of time to implement all the necessary aspects of nursing care. Missed care is largely due to staffing issues, with nurses forced to triage which aspects of patient care are most critical while deferring the rest (Gehri et al., 2023). Few states across the nation have implemented any sort of legislation or regulation addressing the issue of nurse staffing. As the recent pandemic showed us, the American healthcare system is in crisis. In truth, the pandemic was merely another data point telling us what has already been long known, namely that patient harm can and does occur due to inadequate staffing decisions made only to benefit hospitals' bottom lines.

Nurses are becoming burned out. With an entire generation of nurses on the brink of retirement and a looming shortage, the lack of adequate staffing will only exacerbate the issue. Over the years it has become clearer that hospitals nationwide are unwilling to implement industry-recommended staffing ratios across all care areas. It is time for state and federal legislators and regulators to step in and mandate staffing ratios for all areas of the hospital. This should be done with nurses at the table. I would remind policymakers that a conversation about nursing without nurses at the table is not a conversation about nursing. Now is the time to take up this vital issue to prevent future harm. We can do better. We must do better. ●

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Patient Care in an Era of Drug Shortages

By Peter Papadakos, MD, FCCM, FAARC, FCCP, FNIV

One of the latest issues affecting our daily care of patients in the neurological intensive care unit is an ever-growing list of critical medications and intravenous solutions on shortage. Tragically, patients are being subjected to ongoing critical shortages of almost every class of medications used in our daily practice. This may lead to a major decline in how we are able to handle both routine and emergency care of our patients both in the outpatient and hospital settings. Drug shortages not only affect individual patients but also impact the entire health system, both in costs and flow of care.

Many classes of medications have been affected — from drugs used to treat seizures, hypertension, cardiac arrhythmias, sedatives, and cancer medications — and virtually no drug class has been spared. The latest shortages of drugs used to treat heart arrhythmias (adenosine, amiodarone) and bradycardia (atropine) are of major concern to emergency departments and ICUs, as are the shortages of important common sedatives such as lorazepam, which are especially critical for patients with seizures, withdrawal, agitation, and intractable nausea.

Of further relevance for neurocritical care, the FDA shortage database and the University of Utah drug information website[1,2] reported a national shortage of many antiseizure medications often used in the management of status epilepticus, including rectal diazepam, oral clonazepam, and intravenous preparations of lorazepam, midazolam, and valproic acid. Between 2019 and 2020, there were 97 reported shortages among sponsor-reported antiseizure medications, of which 93% were common generic brands.[3] This affects the entire neurocritical care team, as antiseizure medications are a mainstay of our daily practice. Our skilled pharmacists are now working overtime to find supplies, replace medications, and educate us about contingency plans and next steps. It now feels like a daily event for pharmacists to inform us of shortages and whether there are alternatives available for that day or week. The landscape of what is in short supply on any given day is ever-changing.[4]

There are a multitude of factors contributing to the ongoing medication shortages, the most important of which is the loss of our nation's ability to manufacture medications domestically. By moving production facilities abroad, we have been witness to increasing issues with existing supply chains. Offshore manufacturing has also led to other important issues such as quality, sterility, and potency of these medications. There have even been disturbing reports of counterfeit medications entering both the hospital and retail markets in both the lay press and in peer-reviewed papers, including a report in our journal.[5]

As frontline neurocritical care providers, how do we address these issues of drug shortages and inconsistent quality? To begin with, we must join forces with our patients and the general public along with political leadership to pressure the pharmaceutical industry to address this crisis. One of the simplest ways to address this issue would be a simple common sense solution: bring drug manufacturing and supply chains back to North America. This would ensure that our supply chain is simplified and truncated, enhancing our ability to safeguard medications and security via our robust regulatory framework. In this way, medications would be under the watchful eye of federal and state agencies in order to guarantee purity and safety. National databases would also allow increased adaptability in addressing local and regional shortages with real time data that can facilitate more rapid responses in the manufacturing sector. Our modern health system cannot reach its full potential without the drugs we need to care for our patients, and we all need to advocate that this crisis be addressed. ●

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