SOCIETY OF CRITICAL CARE ANESTHESIOLOGISTS
SOCCA

INTERCHANGE

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President's Message

Mark E. Nunnally, MD, FCCM
President, SOCCA
New York University Langone Medical Center
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Hello SOCCA and happy summer!

It was great to see so many of you at the 2024 Annual Meeting, presented by IARS and SOCCA, in my old hometown of Seattle. We presented what has to be the most extensive lineup of critical care content ever at a SOCCA meeting. Many thanks to Allison Dalton and Kunal Karamchandani for an excellent group of topics and speakers. Although the "feel" of the meeting is a little different, I hope you would agree the spirit is very much alive. IARS has been a gracious partner in supporting the meeting. The energy we bring to the meeting helps their own mission of education. We make a great partnership!

As your new President, I am eager to continue our path of engagement. Our robust committee and subcommittee structure is doing great things. There are no small plans for this incredible team. Jennifer Rzepka, our Executive Director from the Association Resource Center (ARC), has been a tireless champion of the Society, and our transition to ARC management has been very smooth. I'll also give a shout-out to Andrew Bronson and the rest of the ARC team, who have done a terrific amount of work behind the scenes to keep up our communications and presence on the internet and social media. Great job and great energy!

Critical care practice faces special challenges currently. One particularly important one is the Medicare Critical Care Payment Policy, and the time criteria for 99292 (critical care, subsequent 30 minutes). Current policy requires physicians to provide 104 minutes of critical care service before they can bill 99292, a change from a requirement of 74 minutes previously. Our partners in the ASA, in collaboration with multiple societies, sent a letter to the Centers for Medicare & Medicaid Services (CMS), asking to return to the former requirement.

It should be a very exciting year. Stay tuned and stay engaged!

Click here to view or print the SOCCA INTERCHANGE newsletter.

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Clinical Practice Committee Update

Bridging Expertise: The Dynamic Role of SOCCA's Clinical Practice Committee (CPC)

The Clinical Practice Committee (CPC) of the Society of Critical Care Anesthesiologists (SOCCA) was created to foster collaboration across subspecialties and enhance engagement among SOCCA members. Established as an ad-hoc committee, the CPC aims to integrate various subspecialties into joint projects with SOCCA, thereby broadening the scope of expertise and enriching the collective knowledge within the society.

Gozde Demiralp, as the Chair of CPC, along with Alok Gupta as the Vice Chair, will continue to expand and develop the robust structure of CPC. Currently, we have established six specialized workgroups. Each workgroup aims to focus on a subspecialty or necessity within the scope of a critical care anesthesiologist. The purpose is to see if these workgroups can sustain interest and expand into a committee structure or if they will be time-limited for a specific purpose and rest after achieving a particular goal. We will all wait and see!

We would like to briefly introduce these workgroups to you:

The *"Quality and Patient Safety Workgroup"* aims to advance perioperative patient safety for all critically ill patients. It plans to bring ICU professionals interested in this arena together to share resources for quality improvement (QI) projects and QI research and, hopefully, create a QI library to be the network for QI and safety protocols for all critical care providers. Somnath Bose leads this workgroup as Chair, and Joy Chen is Vice Chair.

The *"MCS/ECMO/CTICU Workgroup"* of CPC/SOCCA is uniquely positioned to spearhead the development of a comprehensive educational framework and curriculum for managing mechanical circulatory support (MCS) within critical care and perioperative medicine. The first primary focus of this workgroup will be to create an educational curriculum for mechanical circulatory support management for critical care medicine fellows and intensivists eager to gain expertise. The plan is to collaborate with ELSO in creating many workshops, courses, and training modules that target current or future critical care physicians and are accessible to all CCM fellowship program sizes and locations. By establishing this, they hope to contribute to a standardized education to ensure that all CCM fellowship graduates achieve competency in MCS management. This workgroup is chaired by Lovkesh Arora, accompanied by Laura Sutherland as Vice Chair.

The *"Neurocritical Care Workgroup"* is dedicated to targeting an audience of specialists who primarily care for critically ill patients with acute neurological conditions. They will be seeking collaboration with the Society of Neuroscience in Anesthesiology and Critical Care (SNACC). The aim is to learn from each other's practice models and present a SWOT analysis report to a larger interest group. Discovering neurologist-neurosurgeon-anesthesia intensivist ratios within fellowship programs is another interesting topic in which this workgroup would like to invest. This workgroup is being developed by Ozan Akca (Chair) and Elizabeth Mahanna (Vice Chair).

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Chair, SOCCA Clinical Practice Committee
University of Wisconsin-Madison
Madison, WI

Alok Gupta, MD
Assistant Professor
Northwestern University
Chicago, IL

Obstetrical emergencies are every intensivist's biggest scare. The *"Obstetric-Critical Care Workgroup"* will dedicate its effort to collaborating with the Society of Obstetric Anesthesia and Perinatology (SOAP) resources while concentrating on the unique challenges faced by pregnant patients in critical care settings. This group works on developing guidelines and best practices for managing severe obstetric complications, ensuring both maternal and fetal safety. Ioannis Angelidis (Chair) and Emily Naoum (Vice Chair) lead this group.

The *"Transplant Anesthesia Workgroup"* collaborates closely with the Society for the Advancement of Transplant Anesthesia (SATA) to develop educational materials and clinical practice guidelines. Their goal within 1-2 years will be to enhance professionals' knowledge base and clinical skills across the entire spectrum of transplant perioperative care. They aim to achieve this by creating comprehensive educational resources and establishing evidence-based guidelines to improve patient outcomes in all phases of transplant perioperative care. This workgroup is led by Dr. Ranjit Deshpande (Chair) and Megan Rashid (Vice Chair).

The *"Physiologically Difficult Airway Taskforce"* was created by Drs. Kunal Karamchandani and Craig Jabaley

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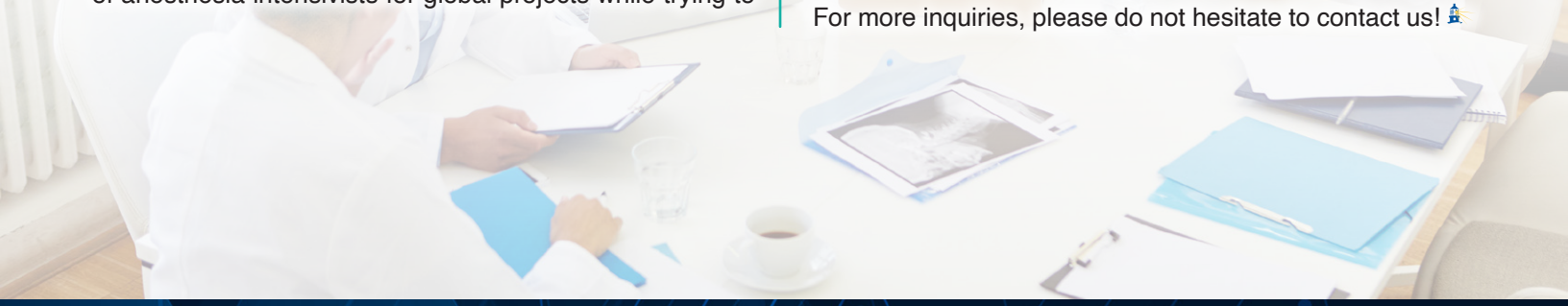
Clinical Practice Committee Update *continued from page 2*

and expanded into an international expert group. This phenomenal group is publishing its first consensus statement on airway management for critically ill patients. They also delivered a fantastic panel at the Annual Meeting in Seattle this year. At the 2024 Annual Meeting, this task force was requested to continue as a workgroup due to overwhelming interest and ongoing projects. Current chairs of the PDA Workgroup are Kunal Karamchandani and Craig Jabaley, along with Mary Jarzebowski as Vice Chair.

Lastly, the newest workgroup of CPC is the *"Global Critical Care Workgroup"*, which extends SOCCA's reach beyond national boundaries, addressing global disparities in critical care. The aim is to bring together an already enlarging group of anesthesia intensivists for global projects while trying to recruit more members. This group promotes international collaboration, resource sharing, and the development of universally applicable critical care practices, as well as creating awareness of increasing global fellowships. This group will be started by Vanessa Moll (Chair) and Ana Crawford (Vice Chair).

The CPC's efforts and output have the potential to play an instrumental role in advancing SOCCA's mission- Creating a more interconnected and engaged community of critical care anesthesiologists. Through its diverse workgroups, the CPC not only addresses current challenges in critical care anesthesiology but also anticipates future trends, ensuring that SOCCA members remain at the forefront of the field.

For more inquiries, please do not hesitate to contact us!



SOCCA drip

SOCCA Drip is a new online platform that offers member-generated content, spotlights member achievements, and delivers relevant news and updates from the broader critical care community—more frequently than ever before.

- **Our newsletter, SOCCA *Interchange*, will continue to highlight features from our members and news from within the organization.**
- **To reflect these changes, SOCCA's Main Menu has changed to include "Drip" under "News" on the main menu.**
- **All back issues of SOCCA *Interchange* are available here.**
- **To explore contribution opportunities or share relevant professional or programmatic accomplishments, please contact the office: info@socca.org**

Communications Committee Update

It was great reconnecting with our members at the Annual Meeting in Seattle. We had a productive meeting and shared ideas to further enhance our community and outreach efforts. I am excited to announce the long-anticipated expansion of our social media presence. In addition to our existing presence on Twitter, we plan to connect with our members on LinkedIn and Facebook. This expansion marks a significant step forward in our efforts to engage with you across multiple platforms. In this initial phase, we will focus on establishing communities on these platforms. To streamline our efforts, content curated by our dedicated social media volunteers and our management company's social media team will be seamlessly distributed across all platforms using Buffer, our social media account manager. Buffer allows the content created by our team to be amplified on multiple platforms simultaneously without added work. Looking ahead, we're excited about the possibilities for further expansion. We envision exploring additional platforms to ensure we reach all our members wherever they may be.

As we work on this new chapter, we're also exploring innovative approaches to content creation. One exciting idea that emerged from our discussions is introducing more video-based content. For instance, we're exploring the concept of a "Member Spotlight" video series to showcase the outstanding contributions of our board of directors, committee leaders, and volunteers. Additionally, we will collaborate with the Women in Critical Care Workgroup; together, we aim to produce compelling video content that offers insights into women's daily lives in Anesthesiology Critical Care, demonstrating how they navigate the balance between personal and professional aspirations.

Madiha Syed, MD
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Cleveland, OH

In this issue of the Interchange, we have articles focused on the vital role critical care anesthesiologists play outside the operating room, the role of coaching and mentoring in anesthesiology critical care, a message from our new SOCCA President Dr.Nunnally and much more. We hope you continue to share any projects and perspectives with SOCCA. Your participation is invaluable to the continued success of SOCCA, and we look forward to welcoming new voices and perspectives. Please follow us on X @SOCCA_CritCare and follow our new accounts on Facebook and LinkedIn.

Education Committee Update

I thoroughly enjoyed the opportunity to see so many of you in Seattle for the IARS/SOCCA Annual Meeting last month. This year's meeting was a bit different from previous years, with the addition of a three-day critical care tract of panels, a SOCCA co-sponsored panel in the non-critical care tract, and an ultrasound workshop presented by our SOCCA members.

The critical care track commenced with a fantastic panel moderated by Dr. Miko Enomoto in which Dr. Matthias Merkel, Dr. Liza Weavind, Dr. Audrey Spelde, and Dr. Christina Boncyk discussed ways to ensure patients receive critical care services even outside the bounds of the typical Intensive Care Unit. They discussed how mobile ECMO, critical care outreach teams, regionalization of services, and Post-Intensive Care Syndrome (PICS) clinics can allow us to better serve our patients.

Dr. Miriam Treggiari moderated a panel in which Dr. Vijay Krishnamoorthy, Dr. Emily Vail, Dr. Karthik Raghunathan, and Dr. Marcos Lopez evaluated strategies for improving RCT design for critical care patient populations. Large database research has emerged as an alternative approach to assessing large populations of patients. In a panel moderated by Dr. Allison Dalton, Dr. Hannah Wunsch discussed the nuances of using large databases for research. In contrast, Dr. Piyush Mathur discussed how to use AI and machine learning to optimize its utility. Dr. Rahul Kashyap presented his experience with the SCCM VIRUS (COVID-19) registry and how this database allowed for the rapid organization and dissemination of knowledge regarding COVID-19.

We had multiple panels discussing the use of ECMO, CPR, and eCPR. Dr. Marc Dickstein, along with Dr. Vivek Moitra, Dr. Lauren Sutherland, and Dr. Robert Sladen, described the hemodynamic changes associated with mechanical circulatory support, including changes in pulsatility, oxygen delivery, and myocardial work. In a panel moderated by Dr. Matthew Wiepking, Dr. Leon Eydelman, Dr. Christopher Ortiz, and Dr. Maxwell Hockstein presented current evidence, workflows, and outcomes related to eCPR. In a separate panel moderated by Dr. Matthias Riess, Dr. Matthew Barajas, Dr. Johanna Moore, and Dr. Jason Bartos explained the use of different tools to enhance CPR, including mechanical devices, head and chest elevation, and eCPR.

Allison Dalton, MD
Chair, SOCCA Committee on Education
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Intubation of a physiologically difficult airway may result in hemodynamic or respiratory compromise. Dr. Carlee Clark moderated a panel in which Dr. Kunal Karamchandani, Dr. Craig Jabaley, Dr. Mary Jarzebowski, and Dr. Alok Gupta reviewed the risks for intubation in this subset of patients and discussed mitigation factors for optimization in the peri-intubation period.

Communication failures may result in increased adverse events and medical errors. Dr. Kunal Karamchandani moderated a panel on improving patient care handoffs. Dr. Aalok Agarwala and Dr. Christopher Potestio presented the importance of structured handoffs while Dr. Andrea Vannucci discussed how the EMR can be used to improve handoffs in the perioperative period.

Over the last several years, the number of anesthesia residents pursuing fellowships has decreased. Drs. Craig Jabaley, Brigid Flynn, Erin Hennessey, and Vivek Moitra highlighted the recruitment data and provided insights on developing workforce pipelines, changing organizational practice, and enhancing professional and career development.

In addition to the panels on the critical care track, this year's annual meeting highlighted a SOCCA-sponsored panel that featured the interplay of vasopressor/inotropes, organ protection, and prediction of patient deterioration across the care continuum. This panel brought together Dr. Ashish Khanna, Dr. Michael Mathis, Dr. Matthieu Legrand, and Dr. Allison Janda to discuss using vasopressors in cardiac operating rooms, general operating rooms, and intensive care units.

At the conclusion of the annual meeting, we presented a half-day SOCCA Spotlight, which allowed for additional education sessions, including a panel discussion on global critical care presented by Drs. Vanessa Moll, Didi Odinkemelu, and Nicole Arkin. The educational program finished with a review of recent, relevant articles from the subspecialty literature: a panel moderated by Dr. Erin Hennessey with subspecialty reviews by Drs. Ameeka Pannu (NeuroICU), Dragos Galusca (Liver Transplant),

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Eduacation Committee Update *continued from page 5*

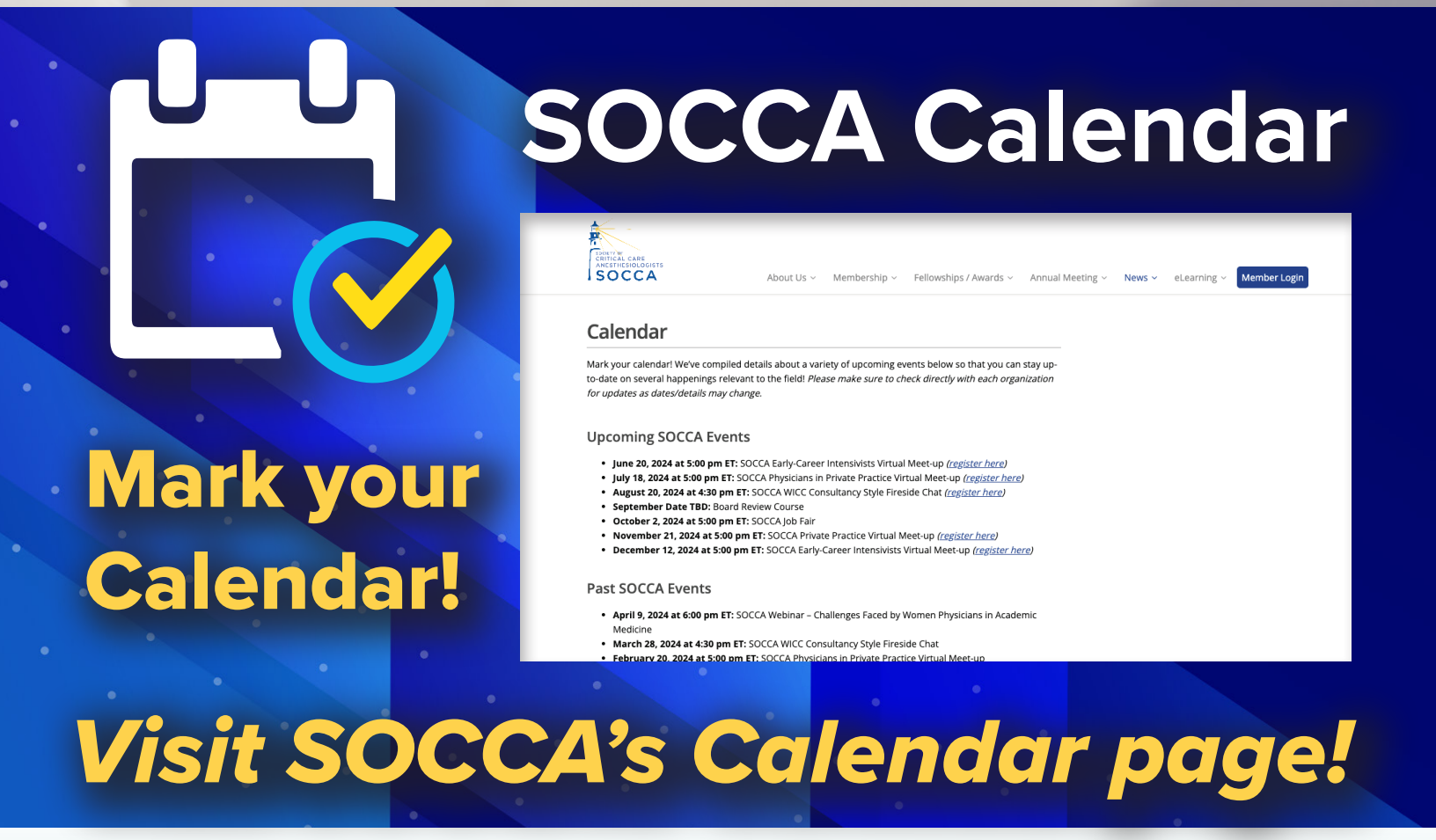
Nazish Hashmi (CV ICU), and Matthew Wiepking (Obstetrical Critical Care).

In addition to the educational panels, members of SOCCA developed a Point of Care Ultrasound (POCUS) workshop specifically designed for use in the peri-resuscitative period or during medical emergencies. This workshop was ticketed and very well attended. Furthermore, multiple critical care oral abstracts and visual abstracts were presented throughout the conference. Thank you to all our presenters and panelists for making the Annual Meeting a tremendous success!

SOCCA presented two awards to its members at the annual meeting. Theresa Tenge was presented with the 2024 Young Investigator Award for her work entitled "Early detection of palliative care need in intensive care unit patients – development and cross-validation of the PC-ICU score." The Burchardi Award, co-sponsored by SOCCA and SCCM, is awarded to a leader in anesthesia critical care defined by "competence, humility, humanity, and a sense of humor." Dr. Rebekah Aslakson was the 2024 awardee of the Burchardi Award. Congratulations to Dr. Tenge and Dr. Aslakson!

The education committee is excited about returning and new educational offerings for 2024 and beyond. The SOCCA webinar series will continue with virtual lectures in the fall and winter. The Board Review course will return in September 2024 as a comprehensive review for our fellows and junior faculty in preparation for the critical care board exam in October. We also anticipate new opportunities, including a journal club for fellows, developing an anesthesia critical care-specific question bank, and cultivating critical care resources for trainees through Open Anesthesia, Anesthesia Toolbox, and the SOCCA ICU resident guide. Thank you to our education committee members for all of your contributions.

Finally, I am happy to announce the new chair of the SOCCA education committee. Dr. Kunal Karamchandani is an associate professor in the Department of Anesthesiology and Pain Medicine at the University of Texas Southwestern Medical Center. He has been the vice-chair of the education committee for the last two years and has been instrumental in developing the SOCCA annual meeting since 2020. The education committee will flourish under his leadership!



Membership Committee Update

SOCCA membership continues to grow, so it is an exciting time to be on the membership committee! The committee met at the annual meeting in Seattle in May and had extensive discussions about how best to continue to serve our members. We also had an in-person meet-up co-sponsored by Women in Critical Care (WICC) and Early Career Intensivists (ECI) workgroups, which was well attended by conference attendees. Given the success of this event, we will make arrangements to do something similar at the ASA and SCCM annually. We want to continue providing virtual meet-up opportunities throughout the year to supplement all the educational offerings from the Education committee. We are planning to have quarterly meetups for the Physicians in Private Practice group (PPP), the Early Career Intensivists (ECI), and Women in Critical Care (WICC). The calendar for these events can be found on the SOCCA website. We also look forward to hosting our annual Job Fair in the fall, on October 2, 2024.

This summer, we are looking forward to welcoming new members to our committee. We are eager to revamp our mentorship program and reconnect with former members. But most importantly, we want to hear from you! Your ideas and suggestions are invaluable to us. If you have any thoughts that the membership team can assist with, please don't hesitate to share. We are committed to ensuring that our members derive maximum value from their memberships.

Alisha Sachdev, MD
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Women in Critical Care Update

In keeping with our mission of offering mentorship and an opportunity to build a community, WICC presented a new format on March 28th, the Fireside Consultancy. This Fireside Consultancy was led by Dr. Hua, Co-Chair of WICC where 4 WICC participants presented focused issues that they were facing. The consultancy uses a structured format where individuals present a problem they are experiencing to the group at large. Group members provide feedback and support, and the individual with the query is given a chance to reflect. This session was well attended and received encouraging feedback. We hope to continue this with a second session in August.

WICC also held a meeting at the Annual Meeting in Seattle which was attended by several BOD members as well as other members. Dr. Siddiqui (Co-Chair WICC) presented an update on WICC activities and suggestions were made by participants for future plans. This was followed by a joint get-together with the Early Career Intensivists group. This event was also very well attended and provided participants with an opportunity to network and build new friendships.

We will see you all at the next Fireside Consultancy and at the ASA!

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Coaching and Mentoring - Underutilized Resources for an ICU Fellow

Coaching and mentoring are valuable tools in a physician's professional development. They serve similar goals but have unique roles and boundaries. A mentor tells you how, but a coach asks you why.

Mentoring is a seasoned colleague directing a junior colleague on how to succeed from a vantage point of the mentor's experience. By sharing knowledge, advice, and insights from their career, they help the mentee avoid pitfalls and can open doors for them. It often is a longer-term relationship aimed at development and career advancement[1]. Coaching focuses on specific goals or outcomes [2]. It is led by a trained coach who asks probing questions, offers feedback, and provides support to help clients unlock their potential and achieve the desired results [3]. Coaching tends to be more short-term and task-oriented. Both are beneficial for professional development.

Professional coaching for client physicians offers numerous benefits, contributing to individual and organizational success[2]. A coach will provoke answers from the client to help them achieve their goals. Every physician has a unique career path and confronts challenges, but they also possess specific strengths and talents a coach can help them realize about themselves. Professional coaches tailor their approach to the client to foster a supportive environment where physicians can explore their objectives, concerns, and aspirations in a confidential setting[3]. Coaches assist in identifying career aspirations, creating actionable plans, and navigating career transitions. Whether a physician aims for a leadership position in research or education, coaching unlocks the answers from the coach with the guidance and support needed to achieve these goals.

One obvious advantage is the development of leadership skills. Physicians often find themselves in leadership roles, whether leading medical teams or managing administrative projects, sometimes out of the physician's comfort zone. Coaches work with physicians to find their personal way to strengthen their teamwork, conflict resolution, and interpersonal skills, creating a more productive and efficient working environment. Coaches facilitate transformative dialogues that can find hidden strengths to be used as tools and strategies to lead[4].

Professional coaching also promotes physician well-being and prevents burnout. As healthcare organizations increasingly recognize the importance of supporting their staff's mental and emotional health, coaching offers a proactive and individualized solution. Professional coaching provokes self-reflection, leading to new personal insights. Through guided introspection, physicians can discover their values, priorities, and motivations, aligning their work with their inherent purpose[5]. This way, physicians can find their passion and focus on what matters most.

The benefits of professional coaching for physicians are multifaceted. From leadership development and stress management to career advancement and improved communication, coaching contributes significantly to individual and organizational success in healthcare. Sometimes, as a younger physician, you may need to figure out what questions to ask, what direction to take, or where to focus your energy. Mentoring can more directly help with that. As the medical profession becomes more challenging, embracing coaching as a valuable tool can lead to more fulfilled, resilient, and effective physicians.

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The theory of mentorship is simple - guidance, direction, and influence provided by someone more senior and experienced [6]. The practice of mentorship is more nuanced. The mentor's goal is to develop a trainee professionally; however, effective mentorship encompasses more of a spectrum besides career growth. Mentors offer insights from their experiences, helping mentees develop critical skills, expand their networks, and confidently navigate career challenges. Through mentorship, mentees gain access to valuable advice, constructive feedback, and tailored guidance, accelerating their learning curve and avoiding common pitfalls. A mentor-mentee relationship encourages and fosters emotional and psychological support, and the mentor must be prepared for support in areas outside of work[6,7]. Because of this, the most influential mentors are often those with similar interests, personalities, and values that foster a relationship of trust and integrity. A good mentorship will often naturally develop into a relationship that is, in essence, a friendship. Deciding to be a mentor has the natural tendency and responsibility to be long-lasting, as any strong friendship[6]. Furthermore, mentorship will evolve as the mentee progresses through their career[6,8].

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Physicians should strive to obtain a spectrum of mentors as they progress through various stages of life and career[8,9]. There may be a point where a mentee has met their goals with a mentor and seeks new mentorship as mastery within an area is achieved. In addition, sometimes goals change, or the mentee needs mentorship in a different aspect of life outside clinical practice, including research[8]. Having various mentors increases the breadth of experience and knowledge that can be gained, broadens the mentee's skills, and adds quality relationships to enhance the person's life. A good mentor should always be present along the mentee's journey, no matter where life takes them[6]. It is notable to mention that as a mentee progresses through life, they may, in turn, become a mentor[9]. It brings up the point that mentorship is a continuous cycle as experiences and guidance are shared amongst individuals; as the mentee enters their mentorship cycle, they will pass on all the guidance they have acquired[8] and pay it forward. It is also important to remember that as individuals progress to the mentor stage, they remain close to their mentors to continue their growth and maintain those meaningful relationships[6,9].

There are traits that great mentors and coaches both share. Both coaching and mentoring strive to get the most out of their collaborative partner, and both push their collaborative partners beyond their comfort level so that they can grow. Mentorship is a more experienced colleague providing the mentee structure, framework, and instruction[6,9]. Coaching involves outlining goals and providing a safe space for the coached through guided self-discovery to find answers to achieve those goals. While mentorship should also have defined goals, mentorship is different because the solutions come from the mentor[6,9]. Mentorship is a symbiotic relationship. In the mentor role, the mentor must be encouraging, open about their experiences, and lead by example. Sometimes, that involves sharing mistakes and how they grew from them. This should come naturally as the mentor and mentee share similar attributes[9]. Coaching is more directly focused on the person being coached, where the coach is merely the guide.

How could this benefit our ICU fellow trainees? Only a few studies have been done to answer this question, but we may get some insight from other fields of medicine and how they have utilized coaching and mentoring. Utilizing a mentoring program within an ICU as part of the THRIVE model (threat, harm risk investigation, and engagement) translated to a benefit to the follow-up of patients and families in post-ICU care settings[10]. Mentoring as a part of trainee education in regard to advanced care planning (ACP) precipitated increases in ACP documentation, more prompt communication, and improvements in ICU quality measures[11]. Mentorship and coaching from large mature ICUs to more rural and newer ICUs improved the clinical care[12]. Surgeons who function at the highest levels receive coaching to keep their heads in the game and grow their excitement for performance improvement[13]. Professional development for ICU pharmacists to become better equipped as young professionals for research and to improve leadership skills was beneficial to the pharmacist and the institution in which they practiced[14]. The common thread is that coaching and mentoring benefit providers and patients.

Mentoring and coaching are distinct approaches to professional development, each with its unique focus and methodology. With engaged coaches and mentors, trainees could benefit in their professional development.

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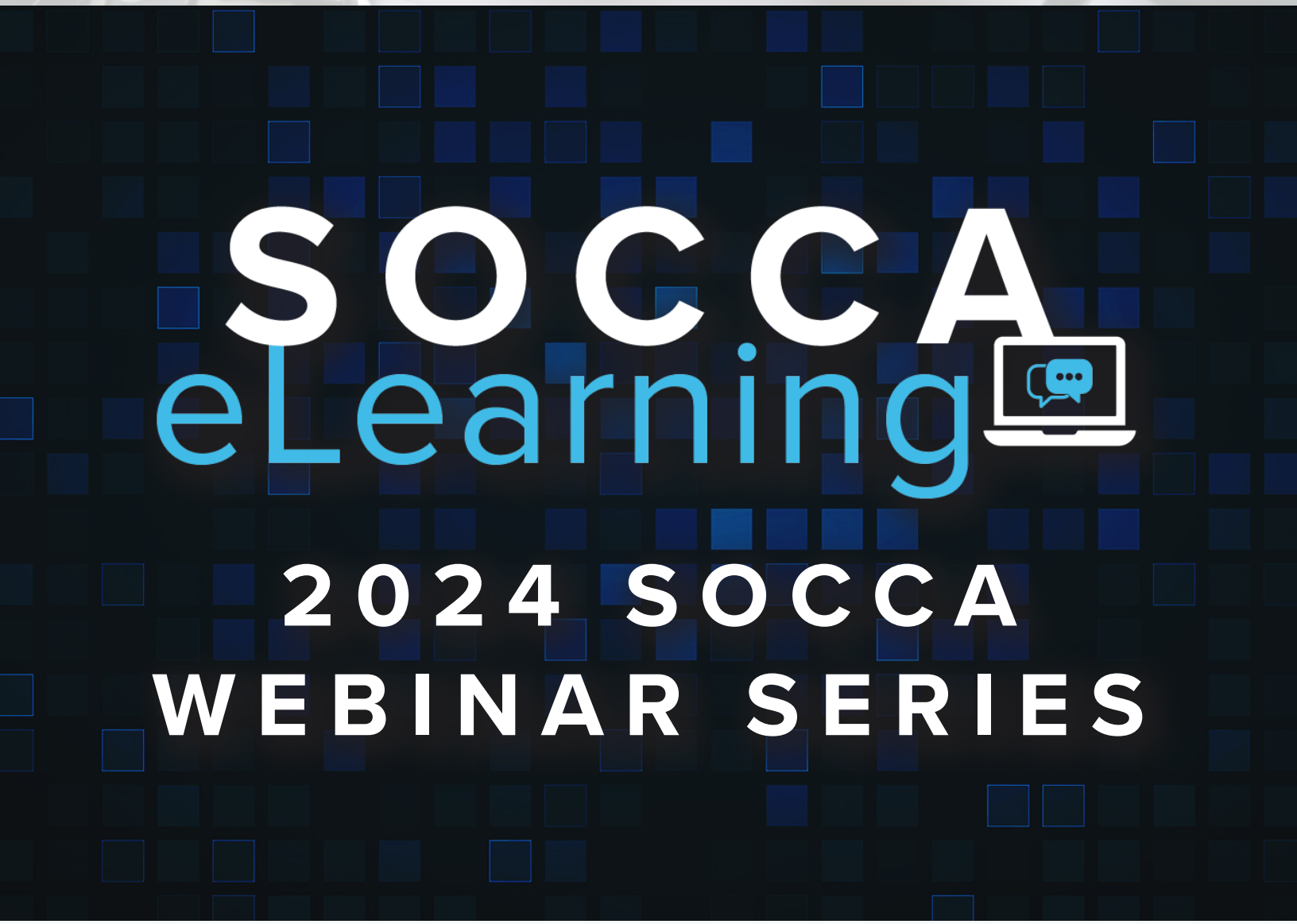

Artificial Intelligence in Neuro-Critical Care Settings

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Introduction:

Neuro-critical care constitutes a demanding, high-alert setting that requires expeditious decision-making by critical care teams in response to patient health status. The resource-intensive nature of neuro-critical care settings results in a substantial financial burden. As of 2016, the Centers for Disease Control and Prevention (CDC) reported an annual national healthcare spending cost of $40.6 billion for non-fatal Traumatic Brain Injuries (TBI), with Medicare-insured patients contributing more than 50% of this figure.[1] Integrating artificial intelligence (AI) into medical applications has witnessed exponential growth, assisting with clinical decision-making. This article highlights the basis of AI learning and its integration into neuro-critical care settings and discusses potential AI applications within the neuro-critical care environment.

Artificial intelligence:

Artificial intelligence (AI) is the simulation of human intelligence processes by machines, especially computer systems. In the medical field, the use of AI has become more prevalent, and it has evolved to revolutionize diagnosis, treatment plan, and patient care through the analysis of vast amounts of data to assist healthcare professionals in making more accurate and efficient decisions, ultimately leading to improved patient care and outcomes.

AI learning is the process by which the machines analyze data, identify patterns, and adapt their algorithms to improve performance without explicit programming. AI learning is broadly categorized into two schools of thought: supervised and unsupervised learning.

Supervised learning relies on manually inserted or "labeled" information and specific criteria to create an algorithm that produces the output from the available data. The output in supervised learning is pre-determined, and the algorithms are responsible for rapidly categorizing and streamlining the data to one of the desired outputs. In a medical context, a supervised learning algorithm is analogous to the patient interviewing and medical decision-making process. The "inputs" are the symptoms, pertinent history, or exam findings, and the outputs can range from a broad differential to precise diagnoses.[2] This medical decision-making process mirrors the function of a random forest and decision tree analysis algorithm (further explained in *Figure 1*).[3] For example: a woman wants to run outside, but she does not want to run if the ground is wet from a recent storm or if the temperature is freezing cold. The algorithm here would process each criterion as individual decisions. The last storm was 24 hours ago, and the ground appears dry, so the algorithm could set a threshold of "12 hours since previous storm" to approximate if the ground will be wet. Thus, the algorithm gives "true" as its output and proceeds to the next decision. If the threshold was instead set at "48 hours since the previous storm", the output would be "False," and the algorithm would default to the woman 'not running.' Supervised learning estimates only what it

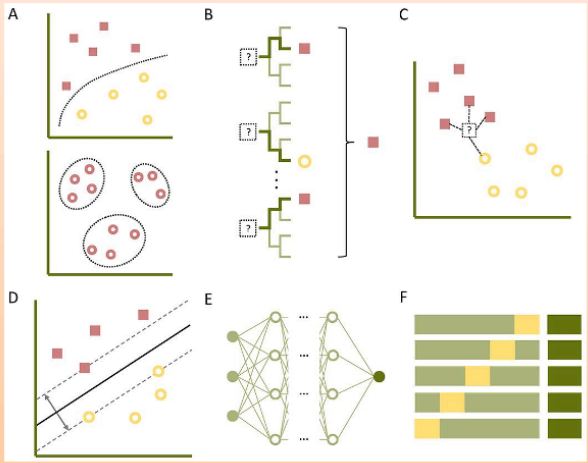

Figure 1: Supervised learning (top) and Unsupervised learning (bottom) algorithm visual representations. (A) Linear Regression plot. (B). Random Forest into Decision Tree. (C). k-nearest neighbor algorithm. (D). Support Vector. (E). Artificial Neural Networks. (F). Cross Validation.

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is trained to do based on clearly defined thresholds and outputs.

In contrast, unsupervised learning has unique outputs, thus allowing the algorithm to generate responses not explicitly programmed during its training. Artificial neural networks, one of the most common subtypes of unsupervised algorithms, are designed with multiple layers of interconnecting data nodes that interact, like the numerous layers of interconnecting neurons in the nervous system. The activation of nodes in hidden layers is determined by threshold values, which can fluctuate depending on how frequently a specific connection is activated or bypassed.[4] The addition of variables, such as environmental conditions, creates additional nodes that can broaden the number of potential outputs and potential connections within the algorithm. *Figure 1* depicts the variety of supervised and unsupervised algorithms with brief explanations of each function.

Integration of AI in Neurocritical Care:

Example 1: AI and ICP management

The integration of AI applications within neurocritical care can provide substantial benefits. The time-sensitive nature of the neurocritical care environment necessitates continuous surveillance using a diverse number of data-gathering equipment. Intracranial Pressure (ICP) is one such variable. ICP requires paramount supervision due to its robust predictive value for mortality.[6] Elevated ICP can rapidly lead to cerebral hypoperfusion and herniation if not treated or if it doesn't respond quickly to medical management. ICP is an invaluable variable for Multi-Modality Monitoring (MMM).[2] MMM entails recruiting and combining data for similar variables from multiple measurement devices to improve monitoring precision and aid in promptly detecting fluctuations in clinical conditions to perform medical decision-making.[5]

Traditionally, the gold standard for ICP measurement is intraparenchymal strain gauges or fiber-optic monitors. Other modalities include ultrasound measurements of optic nerve sheath diameter (ONSD) or ventricular diameter, but neither has demonstrated accuracy for clinical decision-making.[6] The true potential of AI algorithms in ICP monitoring lies in their capacity to predict impending changes. Notably, Zweifel et al. delved into the application of the Cerebrovascular Reactivity Index (CRI) to assess the brain's autoregulatory function in response to variations in cerebral blood pressure.[7] In normal circumstances, cerebral arterioles vasoconstrict in reaction to elevated blood pressure, thus reducing excessive cerebral perfusion and increasing ICP. Consequently, decreased perfusion leads to reduced ICP, establishing an inverse relationship between ICP and arterial pressure. In cases of impaired cerebral reactivity, as observed in traumatic brain injuries (TBI), this relationship becomes direct, meaning any rise in blood pressure may result in a subsequent increase in ICP.[7] Figure 2 portrays pulse waveforms illustrating normal and impaired cerebral reactivity, with CRI calculated as the correlation coefficient at 8-10 second intervals. In this study and in the clinical setting, measuring ICP with an intraparenchymal gauge allows frequent measurements and easy trending of data points. Intraparenchymal measurements also provide

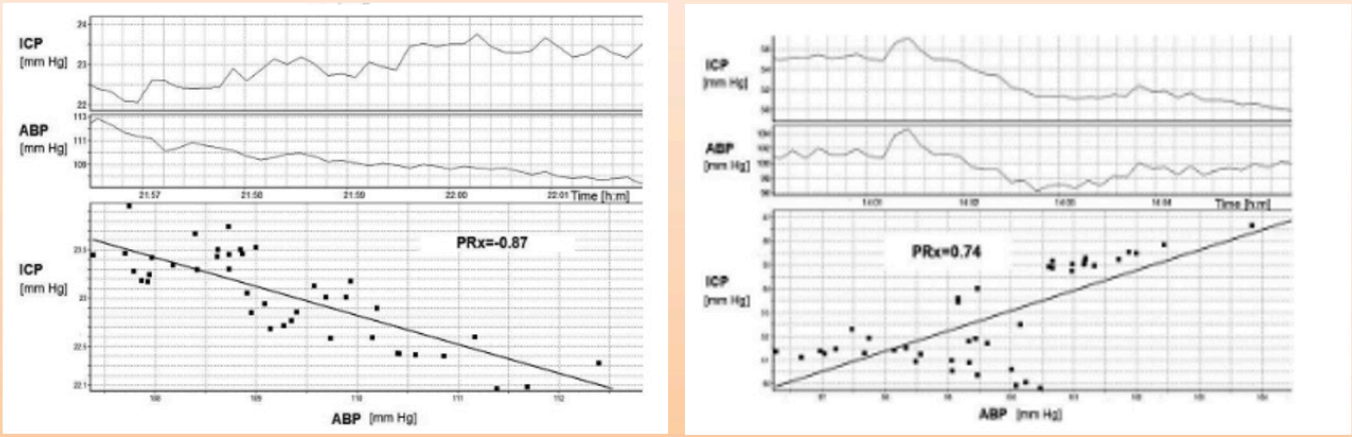

Figure 2: Comparison of normal and abnormal cerebral blood flow (CBF) via MAP (ABP)vs ICP changes. Figure 2a: Normal Waveform with appropriate cerebral reactivity in which ICP decreases with increasing MAP. Figure2b: Abnormal Waveform with impaired cerebral reactivity in which ICP increases with increasing MAP [7]. ¶

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global information instead of local cerebral ICP data, which is a limitation of arterial Doppler analysis.[6] However, the scope of AI integration in ICP monitoring extends beyond trend analysis. An unsupervised algorithm utilizing CRI can track ICP variability, alerting when there is a high probability of surpassing the critical threshold of 20 mmHg. An algorithm could also take an active role in the immediate treatment, such that it can be programmed to trigger immediate interventions such as elevating the head of the bed to a minimum of 30 degrees, adjusting the ventilation rate on the nearby ventilator to induce hypocarbia, or administering a measured dose of mannitol. The implementation of a swift and automated response has the potential to forestall further decompensation, affording the critical care team additional time for nuanced decision-making beyond the algorithm's preprogrammed responses.[2]

Example 2: AI and EEG management

In addition to ICP, seizures contribute to the complexity and demands of neurocritical care due to numerous interventions and complications related to the event. The resource-intensive nature of seizure monitoring presents a compelling opportunity for the integration of machine learning algorithms. Presently, Electroencephalograms (EEGs) are applied to patients and continuously observed by trained technicians, who relay suspicious findings to the critical care team when epileptiform activity is seen on EEG recordings. Prompt diagnosis is essential for preventing substantial clinical deterioration, especially given the diverse etiologies that can precipitate seizures. One study found that some patients who presented with altered mental status were subsequently diagnosed with nonconvulsive status epilepticus (SE), a scenario where EEG remains the gold standard diagnostic tool capable of accurate diagnosis.[8] AI holds the potential to streamline EEG interpretation for critical care teams, particularly in settings with limited resources or personnel.[9] Chavakula et al. devised an algorithm for objectively quantifying interictal spikes in raw EEG samples. The algorithm, depicted in *Figure 3,* comprised a 5-stage design before entering a classification program that accurately discerned the lateralization of interictal spikes in single and multiple-channel EEGs across various stages of the sleep-wake cycle. The algorithm identifies a "wavelet" on an EEG strip and demonstrated a sensitivity of approximately 77.6% and specificity of approximately 87.6% when compared to spike quantification conducted by two board-certified clinical neurophysiologists.[10] This study underscores the potential of machine learning in aiding the early detection of epileptic activity.

Although primarily applied for epileptiform monitoring purposes, the utility of EEG can extend into other variable monitoring such as ICP monitoring. Connoly et al. explored the correlation between EEG signal changes and ICP in two patients at the UCLA neurocritical care unit undergoing burst suppression with phenobarbital.[11] ICP was measured through an extraventricular drain catheter, and depth EEG waveforms were assessed using a 6-electrode strip placed adjacent to the catheter. The study found that approximately 79.6% of bursts in EEG were followed by a transient increase in ICP. Moreover, Spearman correlation analysis revealed a significant association between the amplitude of ICP changes and the duration of bursts on EEG.[11] Despite the small sample size of this study, it unveils the potential contributions of EEG in neurocritical care settings. While AI algorithms designed for ICP management can be adapted even when EEG monitoring is the primary measurement driver, current research primarily assesses directional ICP fluctuations correlated with EEG changes. A future avenue could involve investigating EEG readings at critical ICP levels, specifically those exceeding 20 mmHg, considering potential risks of cerebral ischemia, which may display generalized slowing of waveforms. This approach necessitates trend interpretation rather than the EEG providing a distinct, recognizable pattern at predefined ICP thresholds.

Concerns regarding use of AI:

AI is an exciting tool that is rapidly expanding. However, emerging technology brings emerging concerns. An international survey in 2023 amongst 650 surgeons in 71 countries considered AI to be a last resort among other resources such as guidelines, training programs, and second opinions.[12] One thought is that information and education regarding AI is limited, and not enough clinicians understand how AI could help in clinical settings. In the same survey results, emergency and trauma surgeons expressed the need for sound decision aids.[13] The above-mentioned examples comprise only a small percentage of all the AI projects ongoing to organize and analyze big data. The need to prepare and educate medical teams on how AI can serve their medical decision-making needs should be as paramount as programming algorithms.

Patient autonomy, confidentiality, justice, and protection are also decisive concerns with AI. AI regulation and oversight systems will be required as AI software is progressively included in routine medical care. Many large tech corporations like Google and Microsoft are developing their own AI systems for big data collection in healthcare and personalized health information, either from smart watches or other innovative devices.[14] Patient competency with medical decision-making can fluctuate in neurocritical care settings, yet patient autonomy must be maintained. However, will vulnerable patients have the capacity to consent to AI's role in their healthcare, especially if AI grows the ability to administer medicines automatically? A survey study in 2021 asked physicians and patients who they

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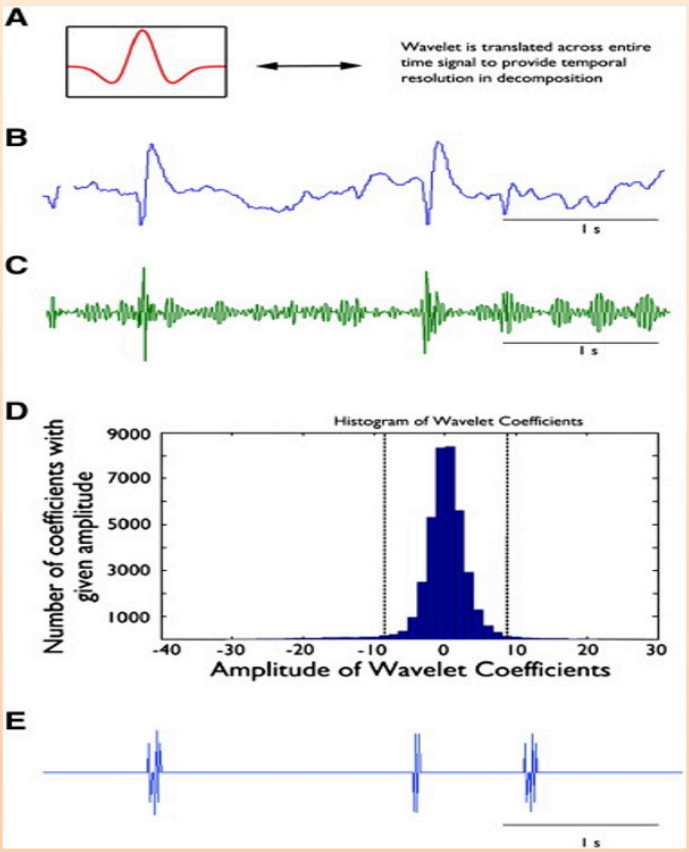

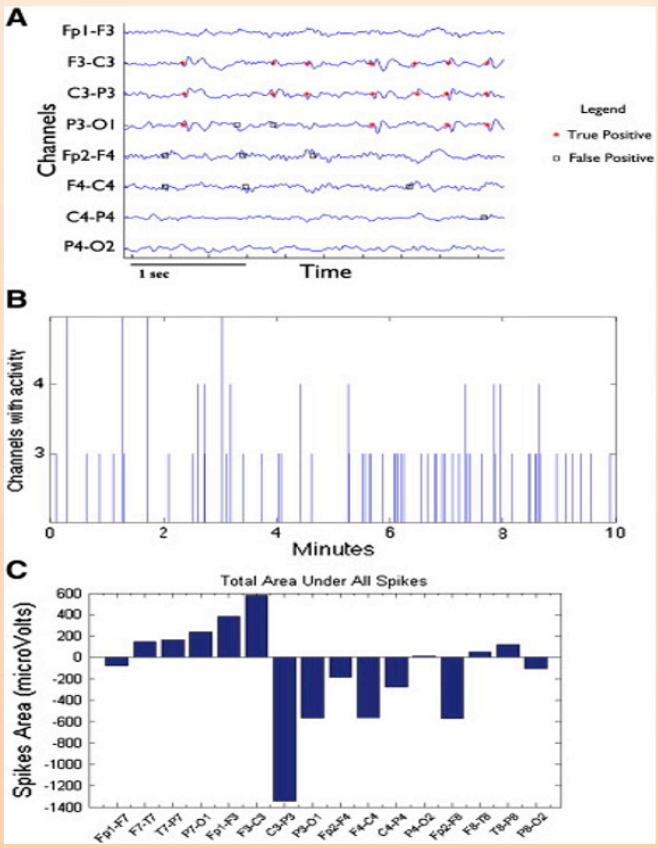

Figure 3-1 and 3-2. Chavakula et al 5-stage interictal spike detection algorithm. (1A) A wavelet signal with finite length is the basic unit of the EEG recording (1B). The algorithm determines a threshold for the summated magnitude of wavelets (1C) before assigning a wavelet coefficient (1D) to further characterize a signal by including 95% of the wavelet values in an EEG spike before reconstructing values back to the original signal (1E). This algorithm was expanded to include multichannel EEG readings (2A). Deflections only appearing in one channel or simultaneously in all channels were considered artifact and not spikes. The algorithm then measured a spike area that is defined as the sum of the wavelet amplitudes [10].

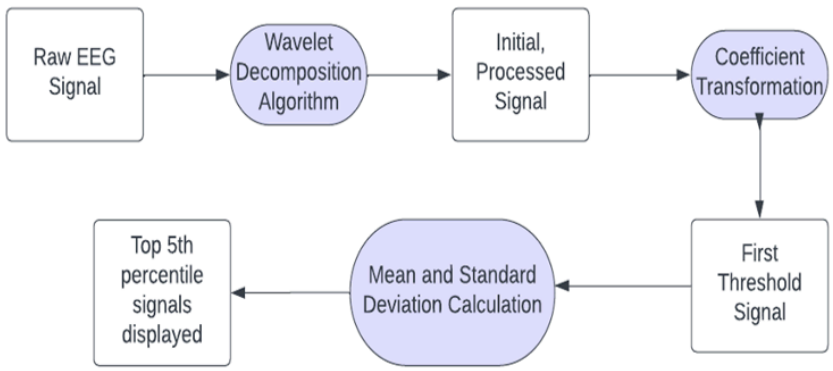

Figure 4. Flow Chart outlining Chavakula et al 5-stage interictal spike detection algorithm pathway. Square Symbols: explicit input or resulting output data. Oval Symbol: programmed filters and code algorithms utilized to transform data.

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thought would be responsible if an adverse effect occurred with direct AI involvement.[13] Figure 4 shows the bar graph from the study, noting that most respondents (patients and physicians) thought physicians should carry liability for AI. These questions will likely be answered as new legislation comes in and AI becomes the standard of care in the future. With that being said, the safety and autonomy of individuals must always take priority.

Conclusion:

AI is gradually bridging the gap between data collection and analysis and can serve as a key contribution to improving neurocritical care. ICP and Epilepsy-related algorithms are a few of the many disciplines that are working to elevate neurocritical care. Hospitals and clinics with limited access to resources and staffing are most likely to witness the benefits of integrating AI first. The limiting factors for further integration of AI into neurocritical care are a lack of provider education and the ethical dilemmas surrounding patient autonomy and justice. More studies are needed to look at the efficiency and reliability of AI in healthcare settings.

We have no conflicts of interest to disclose.

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Large Language Models Take Center Stage: Potential for Critical Care Applications

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INTRODUCTION

In 2022, the medical community was introduced to the capabilities of ChatGPT – a popular large language model (LLM) that performed exceptionally well in medical problem solving, scoring above 85% on both USMLE Step 1 and Step 2. ChatGPT is a chatbot composed of an advanced language model from the family of Generative Pretrained Transformer (GPT) models designed by OpenAI (San Francisco, California) in 2018. It is currently the largest publicly available LLM.[1] ChatGPT was not specifically designed for a medical interface, yet it accomplished this task by instantaneously analyzing vast amounts of real-time data. It autonomously builds on previous functions, continuously improving its capabilities.[2] LLMs are a subset of artificial intelligence (AI) designed to mimic human text and language processing abilities. LLMs utilize deep-learning algorithms, such as neural nets, to learn from text-based datasets. Vast amounts of datasets allow the LLM to analyze patterns and context of the text, learning statistical correlations between relative words and their position. This enables the LLM to predict which words are most likely to follow when presented in a given phrase.

ChatGPT's popularity and utility have increased exponentially in recent months, as it demonstrates value and efficiency across a wide variety of tasks. Numerous competitors have also entered the field, including Google's Bard, Meta's Llama, X's (formerly Twitter) Grok, and Anthropic's Claude to name a few. Also, many LLMs trained on healthcare data, including electronic healthcare record data, have been developed since then.[3] The ushering in of LLMs for application in virtually every industry begs the question – how can we leverage LLMs in the intensive care unit (ICU) to improve patient outcomes and enhance the workflow of clinicians? (Figure 1)

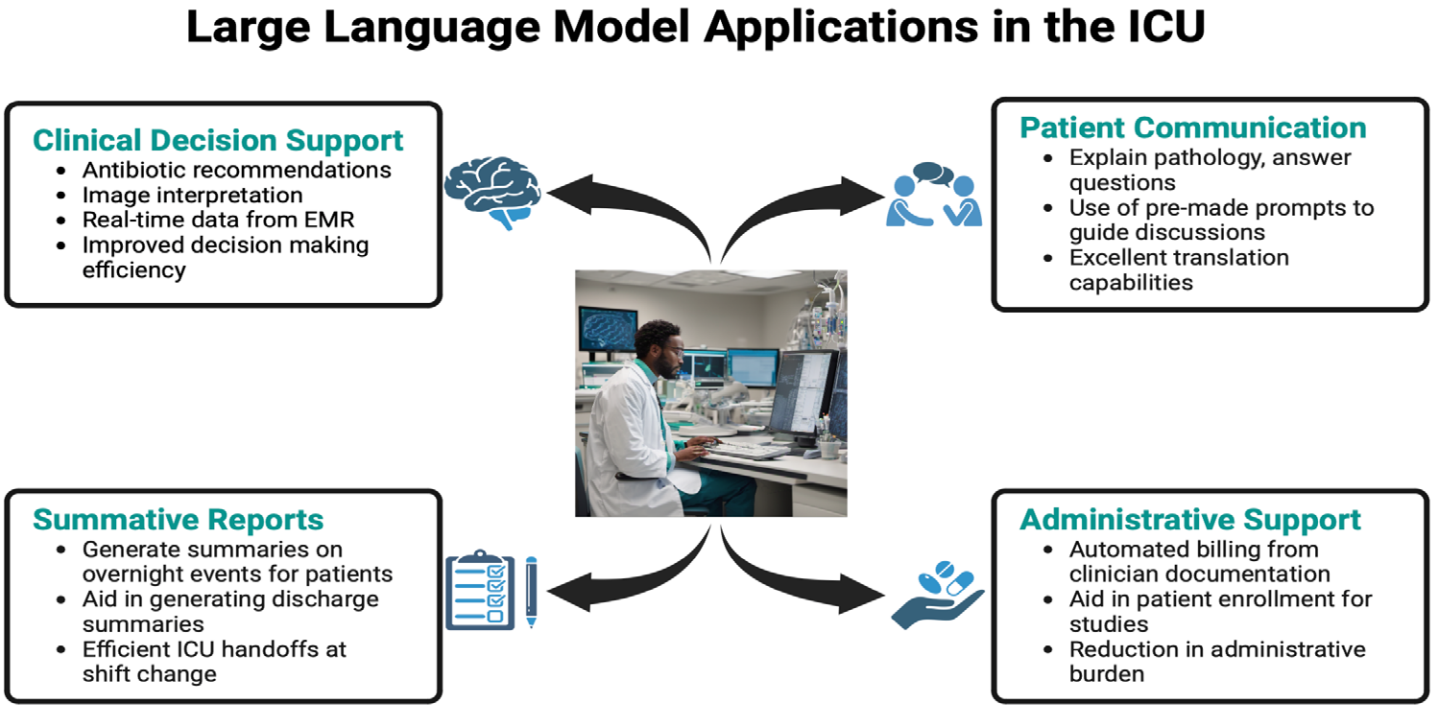

***Figure 1**. Potential applications of large language models (LLMs) in Critical Care*

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OPPORTUNITIES

Clinical Decision Support

Within the ICU, chatbot-based LLMs can serve as an extension of the intensivist and a decision support tool for clinicians. In this context, LLMs would be most effectively utilized if they were developed "in house" for use in a specific hospital system with their electronic medical record (EMR). This would ensure compliance with standard operating procedures, chatbot recommendations tailored to community antibiograms, hospital pharmacy formularies, and real-time data pulled in from the EMR to aid in decision support. Imagine a scenario where a patient is admitted to the ICU in septic shock, and a LLM is able to make recommendations for pressors (while citing sources) based on bedside hemodynamic data, suggests initial antibiotics based on blood cultures or disease pathology, and is able to interpret initial radiographic imaging. In this hypothetical scenario, the added value in speed of decision-making and cognitive offloading to the intensivist presents a use case for LLMs in the ICU as they are further honed for the medical community.

Patient Communication

Conversations with patients and family members can often be challenging to navigate in the ICU. LLMs can help improve these communications with grace and compassion.[4] Additionally, chatbot-based LLMs are highly valuable as a tool for patient communication to explain pathology and prognosis and answer patient questions on their own time. Patients and families can be given a QR code, email, or EMR message that generates a pre-determined prompt that can be copied into LLM-based chatbots. This prompt primes the AI model for its role and guides the conversation on the patient's own level of understanding.[5] Finally, LLM's abilities to surpass language barriers offers tremendous value at the bedside. LLMs can be programmed to understand and respond in multiple languages with the click of a button, thereby providing an effective means of constant communication with patients who speak another language.

Summative Reports

One of the primary roles of LLMs in any setting is to sift through large amounts of available data and generate summary statements for the end user. The ICU presents a perfect environment to leverage this feature, as vast amounts of data are generated for each patient. LLMs can generate summative reports for patients on the unit overnight where notable events, abnormal lab results, imaging results, blood product transfusions, etc are pulled from the EMR and detailed in a concise report for sign-out to the day team. Such a use case would improve ICU efficiency and workflow organization with sign-outs at shift change. These capabilities can also be used for communications to generate discharge summaries in formats that are meaningful to the patients and their families.[5]

Administrative support

One of the promises LLMs hold in healthcare is their ability to help with documentation in the electronic health record (EHR). Clinician's note documentation in EHR has been noted to be one of the key reasons for burnout. Relieving clinicians of this stress while caring for critically ill patients is likely to be immensely beneficial. Billing derived from clinician documentation and its automation is another potential use case where LLMs have the potential to reduce clinicians' administrative burden.[6] LLMs also hold the promise to support research by making the process of patient enrollment and measuring treatment effects easier.[7] Lastly, for quality improvement, providing summarized insights of collected data in an efficient and effective manner is likely to improve the continuous improvement process in healthcare.

Education

With the infodemic in healthcare research and publications, LLMs can help provide curated information efficiently.[8] LLMs can also help curate the information into formats such as presentations and documents, which are more effective. Assistance with curriculum design, filtering through trainee applications, and assistance with letters of recommendation are just some of the additional tasks LLMs are currently being evaluated for.[9]

CHALLENGES

Despite the potential benefits of LLMs in critical care medicine, there are significant challenges that must be addressed before widespread implementation can occur. One of the primary challenges is data privacy. Patient data are sensitive and must be protected from unauthorized access. Healthcare data are especially sensitive due to the risk of discrimination if wrongfully disclosed. The use of LLMs requires the collection and storage of large amounts of patient data, which further undermines public confidence in AI, given the general increase in the frequency of data breaches and inappropriate data use.[10]

Moreover, AI models face the notorious "black box" problem. Although these models can solve complex critical thinking problems, they are not always able to produce an explanation for a given response or solution.[11] Additionally, a chatbot's responses become tailored to the user as the algorithm refines responses based on user preferences. This can limit patients' awareness of alternatives and gradually diminish their role in the patient-physician relationship.[11] While users can train the chatbot simply by using it, the training data from which the chatbot structures its in-

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telligence and responses can be inherently biased if it does not accurately represent the people it serves.[12]

These limitations can be mitigated by continuously training AI models with updated standards of medical care, incorporating medical knowledge explicitly within the training data, and promoting diversity in the field of AI.

CONCLUSIONS

LLMs have the potential to revolutionize healthcare by serving as an adjunct to the tools physicians use to improve patient care. The newer multimodal models, which can use various modalities of data, including text, variables, and images, to deliver multimodal responses, are likely to bring in even more enhanced capabilities in the near future.[13] Within the field of critical care, LLM-based chatbots can aid in clinical decision support, help with goals of care discussions, and summarize the large data sets generated by patients in the ICU. Although measures must be in place to ensure the protection of patient data and minimize model bias, the integration of AI into the workflow of the ICU has the potential to improve patient outcomes and overall satisfaction with the delivery of care.

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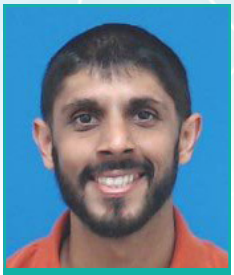
Critical Care Anesthesiologists: Their Expanding Role Outside the ICU

The first public demonstration of an ether anesthetic in 1846 marked a turning point in our ability to provide safe and effective medical care. It birthed the specialty of anesthesiology as we know it today.1 While the footprint of anesthesiology has classically centered around the operating room, its practitioners quickly began bringing the expertise gained therein to other settings such as obstetrics, pain management, and critical care. Today, we are seeing a similar burgeoning of the depth and scope of the practice of critical care anesthesiologists (CCAs) beyond their traditional roles in the intensive care unit (ICU).

CCAs bring many skills and experiences that can help bridge perioperative medicine with broader areas of patient care. Our background in anesthesiology already positions us as expert consultants in patients' medical and logistical needs across the continuum of preoperative, intraoperative, and immediate postoperative care. In the ICU, we gain the perspective of providing longer-term care for the critically ill, patients on the floor and in the emergency room, those ready for discharge or transfer to the floor, or those moving to skilled nursing care or rehabilitation facilities. We bring firsthand knowledge of multiple distinct but interconnected systems beyond the operating room and ICU, including resource management, care coordination, discharge planning, social work, billing, insurance, and more. Let us consider several examples.

The perioperative surgical home (PSH) was introduced as a concept by the American Society of Anesthesiologists (ASA) in 2011 as a patient-centered, continuity-focused model of care intended to bridge the preoperative, intraoperative, and postoperative needs of surgical patients.[2] This model is increasingly being utilized everywhere, from tertiary care centers to community hospitals, as our aging population brings with it a higher incidence of medically challenging patients presenting for surgery.[3] With this comes an increasing need for physicians skilled in managing highly comorbid patients. CCAs are often tasked with caring for such patients in the operating room and serving as their care providers in the ICU. We can leverage this expertise to predict complications and optimize care in ways ranging from preoperative adjustments of medications, nutrition, and conditioning to invasive intraoperative cardiac monitoring to postoperative ventilator management, all while maintaining greater continuity of care than might otherwise be impossible.

A 2019 study estimated that nearly 300,000 in-hospital cardiac arrests occur annually in the United States.[4] Multiple national and international committees have suggested Rapid Response Systems (RRS) as a means of improving outcomes following in-hospital cardiac arrest.[5] The involvement of intensivists in such teams has been shown to have beneficial effects on several post-arrest metrics.[6] CCAs may aid in the success of these teams by (1) helping identify patients early in the course of their deterioration, (2) offering immediate recommendations on early intervention, and (3) assuming care either in the ICU or until definitive disposition is available. The involvement of CCAs in such teams may be particularly valuable in rural communities or developing nations. By acting as a singular source of hemodynamic, airway, sedation, and vascular access expertise, we can help overcome the limited availability of all these modalities in under-resourced settings.



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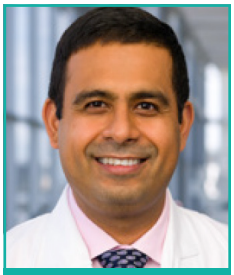

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For patients failing to respond to maximal medical therapy during cardiovascular collapse, initiation of extracorporeal membrane oxygenation (ECMO) may be a crucial bridge to definitive treatment. While the operating room of a tertiary care center is the optimal environment for such placement, ECMO is increasingly being initiated in the ICU, on the floor, and even at smaller regional and local hospitals before transport to a referral center. The International ECMO Network recommends the development of mobile teams to help coordinate such processes and, if necessary, provide on-site support and transport back to an experienced ECMO unit.[7] To safely implement ECMO in such a broad context requires not just skilled proceduralists but knowledgeable consultants advising on the candidacy of individual patients and optimization before, during, and after cannulation. While this has classically fallen to cardiothoracic surgeons, CCAs are increasingly being called upon to fill this role.[8]

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Our understanding of cardiovascular and respiratory failure, skills with echocardiography, and vascular access expertise position us to quickly identify patients likely to benefit from ECMO, locate and cannulate target vessels, and continue management throughout transport and in the ICU.

CCAs can also help guide decision-making in the realm of palliative care and when high-intensity care would prove futile and, in turn, increase patient suffering. Staying in an ICU during the last 30 days of life and death in an acute care setting are considered negative prognosticators of the quality of end-of-life care.[9] Patients nearing the end of life frequently have complex medical histories, significant analgesic requirements, and complicated family/surrogate needs, and the availability of dedicated palliative care services is often limited.[10] But this is precisely the population CCAs are best trained to serve. A 2018 randomized control trial showed that ICU-led family support interventions with patients nearing end-of-life and their surrogates resulted in improved quality of communication ratings and reduced ICU length of stay.[11] Our expertise with sedation and analgesia management, patient and family communication, and interdisciplinary coordination can be readily extended beyond the ICU to dedicated in-patient hospice units, palliative care consult services, home hospice, and outpatient hospice facilities.

The utility of CCAs is not limited to improving clinical outcomes. Modern hospitals range from small community institutions to multi-billion-dollar enterprises employing tens of thousands. Their operations require leadership with expertise in emotional intelligence, team building, conflict resolution, and time-critical situational leadership; all key parts of the training and daily practice of the CCA. Hospitals at the top of US News and World Reports "Best Hospitals" list are more likely to be run by physicians.[12] Those physicians require an understanding of how organizations operate from different perspectives. As intensivists from an anesthesia background, we understand the realities of shifting perspectives. Going from our "team of one" behind the curtain to rounding with a large group in the ICU. Single handedly managing mechanical ventilation, medications, and fluids for a single patient on a given day in the operating room, to delegating protocols to teams of respiratory therapists, pharmacists, and nurses for an entire service on another day.

The consequences of critical illness on long-term mortality risk are well documented, but information sharing between acute care and primary care settings is often incomplete and insufficient.[13] Many primary care practitioners have limited direct access to medical records at larger hospital systems. For them, a patient's ICU stay may become a black box filled with crucial but inaccessible information that will significantly impact the resumption of that patient's care. As physicians whose practice ranges from the ambulatory to the ICU setting, we have a unique vantage point that can be used to institute programs connecting the entire spectrum of patient care. Information-sharing programs between intensivists and primary care providers have been shown to be a possible tool for improving numerous post-ICU outcomes.[14] Such programs would allow easier transition back to the community and more targeted post-discharge care. These are likely to not only make life better for our patients but improve metrics tied to reimbursement, such as patient satisfaction, readmission rates, and referral numbers.

Academic production is another arena in which CCAs continue to make significant contributions. Those of us who enter critical care medicine tend to do so out of an innate curiosity for how the body is affected by the most severe physiologic insults. This is reflected in trends in publication patterns by CCAs. A recent review found that anesthesiology-trained authors outnumbered those from all other primary specialties in 3 of the 4 top critical care journals.[15] Given the expanding need for ICU-level care, the need and opportunity for cutting-edge research led by ICU physicians will only grow.

Critical care emerged as a concept from the 1952 Copenhagen polio epidemic.[16] Since then, it has become a distinct, well-defined avenue of practice approachable from multiple specialties. The modern CCA is well poised to serve as a liaison between every part of the healthcare enterprise, including the operating room, wards, ICU, C-suite, and the community at large.

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