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CANADIAN ASSOCIATION OF CRITICAL CARE NURSES

Canadian Association of Critical Care Nurses

Vision statement

All critical care nurses provide the highest standard of patient- and family-centred care through an engaging, vibrant, educated and research-driven specialized community.

Mission statement

We engage and inform Canadian critical care nurses through scholarship, education, and networking providing a strong unified national identity.

Values and beliefs statement

Our core values and beliefs:

- Excellence and Leadership
  - Collaboration and partnership
  - Pursuing excellence in education, research, and practice
- Dignity and Humanity
  - Respectful, healing, and humane critical care environments
  - Combining compassion and technology to advocate and promote excellence
- Integrity and Honesty
  - Accountability and the courage to speak up for our beliefs
  - Promoting open and honest relationships

Pathways to success

1. **Leadership:**
   - Lead collaborative teams in critical care interprofessional initiatives
   - Develop, revise, and evaluate CACCN Standards of Care and Position Statements
   - Develop a political advocacy plan



2. **Education:**
   - Provision of excellence in education
   - Advocate for critical care certification
3. **Communication and Partnership:**
   - Networking with our critical care colleagues
   - Enhancement and expansion of communication with our members
4. **Research:**
   - Encouraging, supporting, facilitating to advance the field of critical care
5. **Membership:**
   - Strive for a steady and continued increase in CACCN membership

Letter from the Editor

In this final issue of the Canadian Journal of Critical Care Nursing (CJCCN) for 2026, the manuscripts explore themes of complexity and comprehensive care in critical care nursing. These contributions remind us of the intricate and often demanding nature of our practice, where clinical expertise, sound judgment, and collaboration are essential to delivering safe and compassionate care.

Teamwork is fundamental to critical care nursing. In complex, rapidly changing clinical environments, we depend on one another for physical, intellectual, and emotional support. Each member brings unique knowledge, experience, and perspectives that strengthen the team. Supporting one another, recognizing individual contributions, and working toward shared goals are essential to our professional practice.

These same principles extend beyond the bedside to the professional organizations and individuals who support and advance critical care nursing.

As we close the final issue of 2026, I would like to express my sincere gratitude to Christine Halfkenny-Zellas, outgoing Chief Operating Officer of the Canadian Association of Critical Care Nurses (CACCN). Throughout her years of service, Christine has been an integral part of CACCN and the CJCCN. Her dedication, leadership, and commitment to supporting critical care nurses have made a lasting contribution to our professional community.

On a personal note, Christine has been instrumental in supporting my role as Chief Editor of CJCCN. Her institutional knowledge, thoughtful guidance, and exceptional organizational skills have provided continuity and support throughout my editorial responsibilities. I have greatly appreciated her professionalism, generosity, and willingness to share her expertise.

As critical care nurses, we recognize that the strength of any team lies not only in the work we accomplish together but also in the ways we support and influence one another. Christine exemplifies this commitment, and her contributions will continue to be felt well beyond her departure.

Christine, thank you for your dedication to CACCN, CJCCN, and the broader critical care nursing community. I wish you continued success and fulfillment in your next chapter.

All my best,
Kara Sealock, EdD, MEd, RN, CNCC(C), CCNE

Nursing Perception of Barriers to Cardiogenic Shock Program Implementation and Sustainability: A Qualitative Study at a Canadian Heart Centre

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Abstract

Background & Purpose: *Cardiogenic shock (CS) is associated with high mortality despite advances in acute cardiac care. Structured CS programs have demonstrated improved patient outcomes; however, their long-term sustainability remains a significant challenge, especially in resource constrained settings. This study aimed to explore nurses' perceptions of barriers to CS program implementation and sustainability at a Canadian heart centre.*

Methods & Procedures: *A qualitative study was conducted using a participatory design framework and included a survey, two focus group discussions and one workshop. Reporting was guided by the Consolidated Criteria for Reporting Qualitative Research (COREQ) framework. Participants included a multidisciplinary group comprising coronary care unit (CCU) nurses, administrators, physicians, researchers, and a patient partner. Thematic analysis was applied to transcribed session data to identify key perceived barriers.*

Results: *Three major themes emerged: inefficiency, culture, and knowledge. Participants identified systemic inefficiencies, such as inconsistent documentation, outdated technology, and unclear communication pathways. Cultural resistance, professional silos, and hierarchical structures impeded collaboration. Knowledge gaps related to CS protocols and limited interprofessional education further hindered implementation and long-term adherence.*

Discussion: *Nurses are central to the success and sustainability of CS programs. The barriers identified reflect broader organizational and educational challenges within critical care environments. Enhancing communication, empowering nursing leadership, and fostering interprofessional collaboration may support better program outcomes.*

Conclusion: *Addressing structural inefficiencies, improving access to CS-specific education, and including nurses in protocol development and decision-making is critical for improving adherence and ensuring long-term sustainability of cardiogenic shock programs.*

Keywords: cardiogenic shock; coronary care unit, implementation, and outcomes

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Implications for Nurses

1. Empowerment in Protocol Development: Nurses should be actively included in the creation and revision of cardiogenic shock (CS) protocols. Their frontline perspective can help ensure that protocols are both practical and patient-centred, ultimately improving adherence and outcomes.
2. Leadership in Interprofessional Collaboration: Nurses are well positioned to break down professional silos by advocating for and facilitating interprofessional communication. Promoting shared decision-making and collaboration can reduce cultural resistance and strengthen team-based care in critical settings.
3. Advocacy for System Improvements: Given their direct exposure to workflow inefficiencies and outdated systems, nurses can play a key role in identifying and advocating for improvements in documentation practices, communication tools, and technology use.
4. Championing CS Specific Education: Ongoing education and training related to CS management should be prioritized for nursing staff. Nurses can also lead or support the delivery of interprofessional education sessions to address knowledge gaps across disciplines.
5. Support for Sustainable Program Models: Nurses must be supported by attending physicians and administrators to take on roles that contribute to the long-term sustainability of CS programs, including quality improvement initiatives, program evaluation, and research participation.

Introduction

Cardiogenic shock (CS) is characterized by low cardiac output, hypotension, and end-organ hypoperfusion (Anderson et al., 2018). Although mostly associated with acute myocardial infarction (AMI), the etiology of CS can include other comorbid conditions, such as heart failure,

myocarditis, cardiomyopathy, or valvular disease (Jones et al., 2019). Cardiogenic shock mortality remains high (>30%) despite standard treatments (Rathod et al., 2018). Until recently, the only intervention that conferred a survival benefit for CS patients was early revascularization, which was limited to AMI (Hochman et al., 1999). Yet, implementation of a modern CS program that includes mandatory standardized bedside screening, hub and spoke systems of care, and multi-disciplinary management (a "shock team") has led to improved outcomes in CS patients (Lee et al., 2020; Moghaddam et al., 2021; Papolos et al., 2021; Taleb et al., 2019; Tehrani et al., 2019).

Despite advocacy from cardiovascular societies and mounting evidence for the role of a CS program approach, many centres have encountered challenges translating this evidence into implementation and sustained adherence (Yau et al., 2024). This included our own centre, the New Brunswick Heart Centre (NBHC), a tertiary cardiac care centre serving residents across New Brunswick, Canada. While a CS program was implemented in 2019 as part of a research study, it faced barriers in maintaining post-study adherence. In the absence of a researcher-driven focus, critical aspects of the program reverted to historical patterns that overly relied on clinical judgment of frontline staff for identification and management of CS.

Recent guidelines have highlighted processes to implement and sustain a CS program. While buy in from both clinicians and administration is highlighted as a key step, the role of nurses in the development and operationalization of CS programs remains less well characterized.

Nurses are centrally involved in CS management through bedside screening, acute care delivery, coordination with shock teams, data documentation, and early detection and escalation of clinical deterioration. However, the introduction of standardized CS protocols may add to existing nursing responsibilities, which is important to consider in the context of high patient acuity, staffing constraints, and workload pressures.

Given these realities, nurses may hold important perspectives on practical challenges encountered during CS program implementation that are not fully captured in existing guidance. Accordingly, researchers of this study, sought to explore, from the nursing perspective, perceived barriers to adherence and implementation of a CS program.

Methods

Study Design

Guided by a participatory design framework (Duea et al., 2022), this qualitative study consisted of a survey, two focus group sessions and one workshop. The study was reported in accordance with the Consolidated Criteria for Reporting Qualitative Research (COREQ; Tong et al., 2007). As part of an internal quality assurance and program evaluation initiative within the department, informed consent by participants and approval from a health research ethics board (REB) were not required. The study took place at the NBHC, located at the Saint John Regional Hospital, which is the sole tertiary cardiac care provider for the province of New Brunswick, Canada, serving a referent population of nearly 1 million people.

A participatory design approach was used to engage frontline staff, administrative personnel, and a patient partner in a collaborative discussion. Conducting the sessions in a shared setting facilitated the exchange of diverse perspectives and supported a more comprehensive understanding of stakeholder needs and priorities.

A new standard process for screening and management of CS in the cardiac care unit (CCU) was implemented in 2019 as an initial research study. This standard process was developed after a series of meetings with stakeholders involved in all aspects of cardiac care at the NBHC, including nursing. Following consensus and the creation of the CODE SHOCK algorithm, a comprehensive educational strategy was deployed for all CCU staff, incorporating classroom-based teaching sessions and the placement of educational posters and placards throughout the unit. To ensure sustained competency and adherence to the protocol, ongoing training was provided through periodic refresher sessions, integration into staff orientation for new hires, and regular updates during team huddles and clinical rounds. This approach supported continuous reinforcement and consistency in the application of the CODE SHOCK algorithm.

As part of the initial research study, nurses were required to screen all patients for CS using a standardized case report form at the beginning of each 12-hour-shift, but this was outside of the usual documentation process (or standard). The severity of CS was defined by Society for Cardiovascular Angiography and Interventions (SCAI) classifications (Naidu et al., 2022). Patients at risk for or in CS were flagged by nurses to the CCU attending physician, who had sole discretion for care and management of that patient, including whether to activate the centre's shock-team (CCU attending physician and on-call cardiac surgeon and interventional cardiologist). Protocol compliance and data validity for the initial study were tracked for a period of 12-months from November 2019–2020. In brief, this study screening was documented in 1,160/1,562 (74%) of patients admitted to the CCU of patients developed CS 80/1,160 (6.9%; El-Mughayyar et al., 2024). In patients experiencing CS, activation of the CS team was limited to 35/90 (44%) of patients. Following study completion, engagement, and feedback regarding performance of the CS Team were deemed below guideline expectations for minimal care leading to the present study.

Participants

Purposive sampling was employed to identify CCU nurses who could provide valuable insights into the implementation and management of CS at the NBHC. Participants were initially identified through a survey developed by the research team and distributed to all CCU nurses at the NBHC. The survey was distributed in November 2022, approximately 2 years after completion of the initial research study. The survey aimed to gauge the nurses' experiences and comfort levels with CS management, as well as to assess their understanding of the CODE SHOCK algorithm. The survey included a mix of Likert scale questions, quantifiable items, and open-ended questions to allow for both structured responses and free text contributions.

The survey's distribution and return rate were tracked to ensure adequate representation, with a clear timeline provided for the data collection process.

While all survey respondents were invited to participate in the focus group, eight nurses (out of 62 nurses who responded to the survey) initially participated in the subsequent focus-groups and workshop. In addition to the nurses, targeted recruitment of individuals in leadership positions across clinical services (cardiac surgery), administration and research was undertaken to provide a more holistic view and understanding of the CS program. The patient partner was directly identified and recruited in collaboration with our physician participant using the following criteria: 1. recent and relevant lived experience of cardiac shock and subsequent treatment at our centre, 2. was lucid, able to describe their experiences from the inciting event to admission and discharge, and 3. was enthusiastic and willing to share experiences. Overall, two cardiac surgeons (out of 2), one administrator (out of 2), one patient partner, and three researchers (out of 4) participated in the focus groups and workshop sessions. These focus groups were designed to foster dialogue across various perspectives to better understand challenges encountered in the program's implementation.

Participation was voluntary, and nurses had the opportunity to self select for the focus group based on their interest and availability. One nurse and the patient partner were unable to participate after the first and second focus groups, respectively, due to work commitments. Despite this, the remaining nursing participants ($n = 7$) and overall participants ($n = 13$) were considered a representative sample for the study.

Data Collection and Analysis

Three sessions (120 minutes each) with two groups each were conducted in-person and online and were facilitated by researchers (KD [PhD], KB [PhD]) and led by clinicians with expertise in CS (CW [MD], JFL [MD]). The three sessions included two focus groups and one workshop. The objective of the first focus group (December 2022) was to inform participants about CS, present data from the initial CS research study, and conduct a discussion on how nurses perceived CS program implementation and management in the CCU. The second focus group (March–April 2023) was on patient journey mapping, where the journey of a CS patients was collaboratively mapped from admission to discharge. The third workshop (May 2023) reinforced discussion on previous potential barriers to the CS program implementation and developed a benefit cost matrix for future program sustainability. The semi-structured interview guide within each focus group was devised *a priori* (KD, KB) and involved discussion on a broad range of topics. This discussion was reviewed by JFL and modified based on familiarity with the CCU and institution of the CS program. As the interview guide was semi-structured and open ended, subsequent questions and discussion varied slightly between focus groups, but not markedly. All sessions were digitally recorded, transcribed verbatim and de-identified prior to analysis. Additional notes were made both during the focus groups and following review of the transcribed notes by KD, AB, and KB.

A thematic analysis was conducted by KD, who has course-based training in qualitative research, using NVivo 14 [Lumivero, March 2023]. Initial codes were then generated inductively and collated within NVivo. These codes were reviewed to identify patterns, which informed the development of preliminary themes and sub-themes. The themes were iteratively refined through discussions with the research team, ensuring coherence and alignment with the data. While preliminary findings and themes were shared with participants, transcripts were not returned to participants for feedback.

Reflexivity was actively considered throughout the analytic process. The lead analyst (KD) maintained a reflexive journal and engaged in regular peer debriefing with AB and KB to critically reflect on how personal perspectives and professional background might influence data interpretation. These steps were taken to enhance trustworthiness, mitigate potential bias, and maintain analytic rigour.

Results

Focus group and workshop composition:

Seven nurses initially participated in the subsequent focus groups and workshop. These nursing participants represented a broad range of experiences in terms of years worked and roles within the CCU. Two cardiac surgeons, one administrator, one patient partner, and three researchers additionally participated in the focus group sessions, aiming to provide a more holistic view and understanding of the CS program. The clinicians and administrator participants were all experienced professionals, who were instrumental in CS program conception and implementation at our centre and thus were able to contribute their expert perspectives on CS management and program implementation. The researchers chosen varied in experience and included individuals who designed and participated in the initial research study, current research leadership, a medical study trainee and those who could guide the sessions and analyze the data. The patient partner had recent lived experience and could describe their journey from admission to discharge.

Major themes:

Three major themes were identified as barriers to CS program implementation and sustainability: inefficiency, culture, and knowledge. Illustrative participant quotes for each theme are presented in Table 1. To enhance credibility, preliminary themes and interpretations were shared with a subset of participants (member checking) to ensure that the analysis accurately reflected their experiences. This process supported the trustworthiness through triangulation of the findings.

Theme 1: Inefficiency

The theme of inefficiency explored how inefficiencies manifested, their causes and its broader implication in CS program implementation and sustainability. Technological and structural factors were recognized as key drivers of inefficiency.

Technological issues identified by some participants focused on gaps or redundancies in tools and/or systems in the CCU. This included mode of entry (use of an electronic computer vs. paper documentation), with participants tending to favour one method or another, depending on circumstances. While

Table 1

Representative Quote Identified Within Each Major Theme

Theme	Quote
Inefficiency	'A lot of these times the reasons that we're not putting these vital signs in the electronic systems and doing all these things is because from a nursing practical standpoint, we are immediately seeing what is essential and what is not. So, to us our patient is our priority, and us double/triple documenting things in 10 different places is not efficient.' [Nurse]
	'The nurse at the bedside recognizes that there is a problem, its communicated, but there's not a clear process where that flag goes up. Ultimately, it's the physician who should be responsible but it's a little of a grey area. There should be a system where once it's flagged, it's identified, it's marked, and then there is an algorithm and/or order sets that can be implemented to then allow you to make decisions.' [Physician]
	'We're working in such an acute environment where patients' conditions are changing so often, and we're only filling out that assessment at the beginning of our shift whereas, you know, in the middle of our shift we could see drastic changes within our patient. So, a lot of times, we're not filling out a screening tool. It's just I've seen these changes in patients, and that may not necessarily be reflected with a screening tool of sorts.' [Nurse]
CCU culture	'That's the way things have run, and that's what they (senior nurses) know, and that's what they're comfortable with. With a newer nurse, you will go with the flow of how the units run.' [Nurse]
	'Once you say the words out loud, everybody looks at you and the Residents honestly don't know. To them, if it's late, it's calling to wake more people up. If the cardiologist on call isn't really on board, the Resident who sees the patient isn't likely to push the boundaries because the cardiologist doesn't think it is. I don't feel like they can push the cardiologist to activate a shock team.' [Nurse]
	'Just the importance of communicating even to the nursing staff, like understanding why the decisions that were made to not activate code shock, or not to consult so that we can just better understand and know at what point you want us to make you aware and what point are you wanting to start consulting? This would be appreciated by a lot of us.' [Nurse]
	'It's like a code blue. It can be a very well-run code and the patient still dies, but people feel better about the care they've provided compared to a successful resuscitation that was messy and unclear. It's a good outcome, but you still don't feel great about the care provided. That's where a lot of the frustrations come from with a code shock. We're kind of left in that lurch and think could we have done more?' [Nurse]
Knowledge	'I know just from my limited experience that even some of the attending positions aren't exactly sure what to do and how to activate code shock. I've seen some of the Residents go to the attending, and then the attending was like, 'Okay, well, how do we do this? What are we supposed to do?' [Nurse]
	'We are filling the sheets (documentation) out. But who is looking at them? It should be treated that the physician signs us off once they've looked at it.' [Nurse]
	'You have a really sick patient; trying to get them all bundled up and down to the cath lab to get lines in can sometimes be quite daunting. Sometimes, a patient isn't stable enough to get down there, but you also need these. You need a central line to start running your medications. It can be a lot of get patients there, where it would be much quicker and better for the patient and nursing staff to do it at the bedside.' [Physician]

concerted efforts were made to chart vital signs and CS assessments on electronic systems, participants often reverted to paper documentation in deteriorating patients, where the frequency of assessments made electronic systems documentation inefficient (distance from patient + rigid documentation constructs). Participants pointed to redundant, missing, or non essential inputs with the electronic medical records (EMR) system as barriers to using the electronic systems exclusively, despite recognizing that using a mixed mode of entry prevented effective tracking of key parameters of CS. The EMR system was also discussed as not being utilized to its full capacity; challenges included the lack of a flagging system for CS (like the Braden Scale or Fall Scores), not integrating screening documentation or flow sheets, or the ability to calculate SCAI scores directly from inputs, allowing for data visualization.

Structural factors identified by participants included workflows and organizational protocols. Workflows included a need for a standard order set for patients suspected of, or in CS—thereby lessening the need for clinical judgements and instituting more protocolized methods of data generation to inform clinical decision-making. Discussion focused on integrating a 'CS order set' with traditional admission order sets, and its value in generating an initial baseline of clinical data or flags. The intake reports from referring hospitals or from emergency room transfers were variable in the quality of information provided; while nurses were cognizant of key clinical

indicators of potential shock on reports (chest pain > 24 hours, receiving inotropes, grey skin colour), CS was not usually listed as a potential diagnosis. Secondarily, while participants saw the potential value in protocolized screening, adjustments, and co-design of new documentation forms with input from CCU was deemed essential.

Organization protocols referred to the frequency of protocolized screening (documentation) mandated with the CS program (once at the start of each 12-hour shift or twice/day). There was disagreement on how frequent protocolized screening needed to occur (i.e., 4–8 times/day) or whether screening should occur more often in all CCU patients or just suspected/actual CS patients. Participants were also cognizant of added workload on nurses if more frequent screening was mandated, whether requiring documentation to be filled in during time-critical scenarios was optimal and how overuse of the shock protocol may lead to burnout or resource overutilization.

Theme 2: Culture

The theme of culture highlighted how practices within the CCU could hinder implementation and sustainability of a CS program and included resistance, engagement, and communication. Participants pointed to routine inertia within the CCU, where there was a tendency to resist changes in how the unit operated, including modernizing to electronic systems only inputs, uptake of documentation, or changes in standardization to CS screening. The researchers felt the routine practice was limited to CCU specifically, and not other units, due to culture setting practices by senior nursing staff and significant variabilities in patient complexities and needs. Engagement from clinicians were also discussed as key to culture.

Regarding communication, nursing participants pointed to a culture of hesitancy, especially at night time, leading to a tendency to focus on actively monitoring CS patients until they self-resolved or deteriorated rather than activate the shock team. Nursing participants articulated that this hesitancy could be due to an inability to express divergent views or 'overstep their role/scope of practice' with attending/on-call physicians and was not just limited to themselves, but also medical learners (e.g. Residents). These instances were situational, tending to occur with newer nurses/residents and senior physicians (hierarchical barriers), but was most associated to night and weekend shifts. It was felt that regardless of how well a CS program was implemented, it would not matter 'if the culture within the CCU was to not to wake people up' [physician].

Theme 3: Knowledge

The theme of knowledge revealed how gaps in information prevented optimal implementation and quality assurance of the shock program.

Education referred to formal and informal practices to develop an understanding of CS itself; key manifestations, current guidelines, and Society for Cardiovascular Angiography and Interventions (SCAI) classifications. Participants pointed to variability in knowledge of CS and SCAI classifications amongst nurses and residents, which, when coupled with how uncommon CS is, led to delays in the identification and management of these patients. While physicians were knowledgeable about CS, there was more heterogeneity in their understanding of the shock protocols directly, including how to activate or initiate the shock team. Physician participants stated that there was significant variation in sub-specialty physician staffing the CCU including clinical cardiologists, electrophysiologists, and interventional cardiologists. Discussion focused on the need for continuing education on both CS and CS-based protocols, including case reviews, lunch and learns, or a repository of educational materials.

Participants discussed information gathering on several fronts and included documentation signoffs, line placements, non-invasive monitoring, and performance feedback. Despite filling out documentations and assessing shock status as mandated, participants did not feel like this information was utilized well by attending physicians. Rather, a system that required physician approval during rounds and a brief discussion of current SCAI shock status and patient trends was felt to be needed. Line placements (pulmonary artery [PA] catheter) were identified to be essential in obtaining proper data to reflect treatment and management strategies for CS patients but were logistically challenging to obtain consistently. Barriers identified included an inability for some medical practitioners to insert lines independently or the preference for certain attendings to not in put lines at the bedside.

Participants expressed that requiring patients to be sent to the cardiac catheterization lab for line placements was challenging, particularly for frail patients and at nighttime, which contributed to delays in obtaining key data for guiding decision-making. Trialing non-invasive cardiac output monitors within the CCU was also highlighted as an alternative route for information gathering without the need for a PA catheter. However, the group was unclear about the uptake of a new technology in the CCU or the means to request innovations in practice and technology implementation. Long-term capture of documentation (SCAI classifications, hemodynamic data, biomarkers, escalation, and deescalation of the type and timing of interventions, etc.) was deemed vital for the sustainability of the CS program as too was identification of gaps and deficiencies in screening; yet nursing, physician, administrator, and researcher participants stated that no system was in place for this level of data capture. The ability to link quantitative data derived from documentation (see above) to outcomes data in patients was particularly important for new initiatives (workflow or technological updates) and would allow for elevated discussion and justification to administration, informed by impact analysis.

Discussion

This focus group and workshop-based, qualitative study identified several interconnected barriers that a diverse set of participants (nurses, physicians, administrators, researchers, and a patient partner) perceive in implementing and sustaining a CS program at a Canadian heart centre. Our findings align with and extend the growing literature on multidisciplinary "shock team" models, which have shown improved patient outcomes but also identify significant challenges in practice (El-Mughayyar et al., 2024; Lee et al., 2020; Moghaddam et al.,

2021; Papolos et al., 2021; Yau et al., 2024). We identified major themes related to barriers: culture, knowledge, and inefficiency. The themes influence the implementation and sustainability of a CS program within a CCU.

Culture

Nurse participants consistently emphasized the importance of an inclusive, collaborative culture within the CS program. Nurses expressed a strong desire to be actively involved in interdisciplinary discussions, handovers, and family meetings, reflecting a need to move beyond hierarchical decision-making structures. This perspective aligns with prior qualitative work identifying multidisciplinary champions, including nursing leadership, as essential to successful CS programs (Yau et al., 2024). Inclusive communication structures, such as single call activation systems, have been shown to facilitate timely decision-making and reduce hierarchical barriers in shock teams (Senman et al., 2024).

Despite this, nurses described communication gaps and siloed workflows that limited real time alignment across specialties. Delays in obtaining attending physician input and limited feedback following shock team activations left many nurse participants feeling "out of the loop." These experiences mirror known challenges in multidisciplinary critical care, where fragmented communication can impede coordination across cardiology, intensive care, emergency medicine, and cardiac surgery services. Structured communication pathways and clear organizational frameworks are necessary to prevent fragmentation and improve team responsiveness (Senman et al., 2024). Consistent with this, our nurse participants voiced a strong desire (87%; unpublished results) to be involved in team discussions, handovers, and even family meetings.

Beyond communication, our nurse participants described the emotional and ethical burden associated with CS care. They reported feelings of moral distress when aggressive interventions failed to improve outcomes, particularly in end-of-life scenarios involving advanced mechanical circulatory support. Such distress has been documented in critical care settings, where ethical uncertainty and high mortality rates contribute to burnout (Hung et al., 2025). Participants identified a lack of preparation for end-of-life conversations and limited opportunities for debriefing as compounding factors. Prior studies suggest that early palliative care involvement, routine debriefing, and access to psychosocial support may help mitigate this burden and promote program sustainability (Bohula et al., 2025; Hung et al., 2025; Rubin et al., 2021).

Knowledge

A central barrier identified by our nurse participants was insufficient education and ongoing training related to CS management. They reported gaps in knowledge surrounding early shock recognition, hemodynamic monitoring (arterial lines), mechanical circulatory support devices, and protocol navigation. Limited exposure due to low case volumes in some centres was perceived as a challenge to maintaining clinical competency, a finding that is consistent with prior studies of emerging CS programs (Yau et al., 2024).

Additionally, nurses in our study valued receiving timely feedback on activation decisions – 90% wanted more debriefing and guidance from attendings. This mirrors recommendations that ongoing communication, including post-case reviews, is essential for team learning and alignment. These findings parallel those of the ESCAPE-CS focus group study, in which multidisciplinary clinicians emphasized the need for improved recognition of shock and timely response to patient deterioration (Ferguson et al., 2025). Participants in that study similarly highlighted the importance of structured education, simulation-based training, and skills reinforcement to support time critical decision-making.

Nurses in our study described standardized order sets, simplified algorithms, and pocket guides as tools that could reinforce learning at the point of care, particularly in high-acuity environments. Our nurse participants also emphasized the value of ongoing educational opportunities, such as annual competencies, in service training, and mentorship by unit-based nurse specialists or champions. These strategies have been recommended in the literature as mechanisms to sustain competency and build confidence among frontline staff (Ferguson et al., 2025). Participants reported enhanced education as foundational to empowering nurses to activate shock protocols and initiate critical interventions with confidence.

Inefficiency

Our nurse participants identified system level inefficiencies as significant impediments to effective CS program implementation. Inconsistent activation criteria, variability in treatment pathways, and lack of standardized documentation across providers and facilities were reported to create confusion and delays in care. Such variability reflects a well-documented challenge in CS management, where practice variation persists both within and across institutions (Yau et al., 2024).

The literature consistently identifies standardized protocols as a cornerstone of effective shock programs, with observational data suggesting improved outcomes when protocolized approaches, such as SCAI shock staging, are used to guide therapy (Yau et al., 2024). However, nurse participants emphasized that protocols must be simple, widely disseminated, and uniformly applied to be effective. Deviations from established pathways in our study echo prior findings that poorly integrated or inconsistently applied protocols undermine their intended benefits.

Our nurse participants described standardization as extending beyond clinical decision-making to include documentation and communication tools across units and referring sites, with the goal of establishing a shared language throughout the patient journey. This perspective aligns with prior research identifying practice variation as a persistent issue in CS care; however, evidence regarding whether documentation and communication standardization alone is sufficient to reduce variation remains mixed (Senman et al., 2024).

Resource constraints further compounded inefficiencies, particularly in the context of interfacility transfers. Nurses noted challenges related to staffing shortages, limited access

to advanced equipment at referring hospitals, and inconsistent processes during patient transfers. Geographic disparities between rural and urban sites were perceived as contributing to delays and coordination challenges, consistent with international findings highlighting resource variability as a barrier to quality shock care (Ferguson et al., 2025). Our nurse participants suggested that standardized interfacility transfer protocols and clearer regional coordination mechanisms could mitigate these inefficiencies.

Conclusion

Successful implementation of a CS program hinges not only on the availability of protocols but also on system level alignment across workflows, culture, and knowledge. Addressing the identified barriers with tailored, evidence-informed strategies may enhance patient safety, protocol adherence, and program sustainability in high acuity cardiac settings.

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Development and Evaluation of an EEG Curriculum for ICU Nurses to Facilitate Screening of Continuous EEG Data for Seizures in Critically Ill Adults

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Abstract

Background: *Seizures occur commonly in patients who are critically ill (i.e. 3%–44% prevalence of seizures in patients post-cardiac arrest) and may cause harm. Non-convulsive seizures (NCSz) have no overt physical manifestations, and thus electroencephalography (EEG) is required for diagnosis. Our objective was to design, implement, and evaluate an online curriculum to provide intensive care unit (ICU) Registered Nurses (RNs) with the skills required to screen raw continuous EEG (cEEG) for NCSz.*

Methods: *To help facilitate more timely diagnosis and management of NCSz in the ICU, we used Kern's six steps to design, implement, and evaluate an online spiral curriculum to teach ICU RNs the skills required to screen colour density spectral array (CDSA) followed by raw cEEG for NCSz.*

Results: *Ten ICU RNs completed the EEG curriculum. Post-curriculum sensitivity (98% vs 76%) and specificity (76% vs 48%) for NCSz increased compared to pre-curriculum. Intensive care unit RN performance relating to seizure identification significantly improved from pre- to post-curriculum (36% vs 81%, $p < 0.0001$) and confidence in all measured domains improved, although most significantly for seizure and EEG principles and seizure identification on CDSA.*

Conclusion: *Our curriculum was effective at improving ICU RNs' diagnostic accuracy for detection of NCSz with the goal of creating processes to facilitate more timely diagnosis and management of NCSz in patients who are critically ill.*

Keywords: nursing education, electroencephalography, critical care

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Implications for nurses

- Non-convulsive seizures (NCSz) commonly occur in patients who are critically ill, and are associated with increased mortality and morbidity.
- Non-convulsive seizures have no overt clinical manifestations. Diagnosis rests on detection with continuous electroencephalography (cEEG) to facilitate prompt treatment.
- Electroencephalography (EEG) curriculums can effectively improve critical care nurses' diagnostic accuracy when screening for NCSz.
- By supporting and developing critical care nurses' diagnostic accuracy and clinical expertise in screening for NCSz on EEG, we may aid in earlier detection of NCSz, which can lead to more timely treatment of potentially harmful seizures.

Background and Purpose

Seizures occur commonly in patients who are critically ill (i.e., 3%–44% prevalence of seizures reported in patients post-cardiac arrest) and mounting evidence suggests they are harmful (Bencsik et al, 2024). Most seizures in patients who are critically ill are non-convulsive or physical manifestations are confounded by sedatives and neuromuscular blockades. Non-convulsive seizures (NCSz) have no overt clinical manifestations and diagnosis rests on detection with continuous electroencephalography (cEEG), which facilitates prompt diagnosis and management.

Electroencephalography (EEG) is a safe, portable, and relatively accessible diagnostic tool that records electrical brain activity. Unlike cardiac telemetry, intensive care unit (ICU) nurses and other bedside providers are not routinely offered specialized training in cEEG interpretation, thus relying on the interpretation of vast quantities of raw cEEG data by an electroencephalographer, which is often delayed (Sutter et al., 2013). Strategies are needed to better integrate cEEG information into patient care and to bridge the gap between bedside providers and electroencephalographers, thereby ensuring that appropriate treatment for seizures is delivered in a timely manner (Kramer & Kromm, 2019).

Quantitative EEG (qEEG) consists of visually simplified, time compressed displays summarizing various elements of electrographic data (frequencies, amplitude, power, and rhythmicity). One form of qEEG is colour density spectral array (CDSA) that utilizes Fast Fourier Transform (an efficient algorithm that breaks down a signal into its constituent frequencies, revealing amplitudes and phases) of raw EEG data to display the power of each frequency (measuring how many times electrical inpulses repeat in one second, measured in Hertz [Hz]) at any moment

in time (Figure 1; Scheuer & Wilson, 2004). Since seizures often comprise an abrupt onset of rhythmic epileptiform activity (signifying cortical hyperexcitability, often indicating a high risk for seizures) that evolves in frequency, morphology, and location, these transient changes can be appreciated easily on CDSA as a flame shape (Figure 1).

It has been suggested that qEEG can be used by nonexperts to select cEEG epochs (extracted segment of a cEEG recording that is divided into smaller chunks, usually centred around a particular event) of interest for focused review by electroencephalographers (Dericioglu et al., 2015; Westhall et al., 2015; Williamson et al., 2014; Zhou et al., 2019). This results in reduced time burden with acceptable sensitivity, but a high false positive rate associated with EEG artifacts and other non-seizure abnormalities, which may be reduced with concurrent raw data interpretation. However, few robust curricula exist to train nonexperts to develop knowledge and skills in raw EEG (Figure 2) as a complement to qEEG interpretation. Therefore, we developed, implemented, and evaluated a cEEG curriculum to train critical care nurses on how to perform a two-step screen of quantitative CDSA followed by raw EEG for seizures.

Methods and Procedures

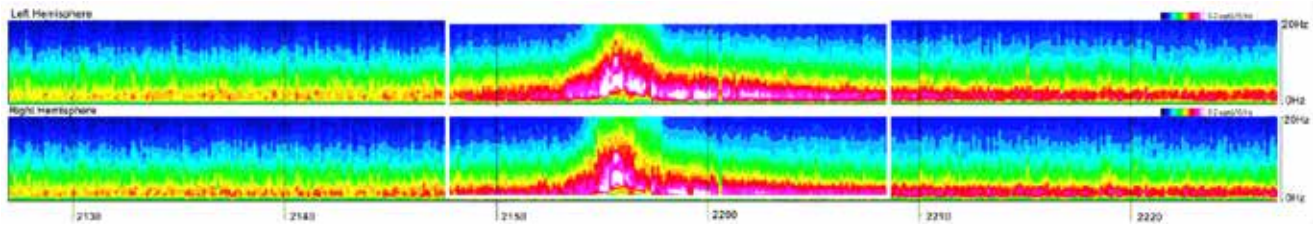
The study was approved by the Conjoint Health Research Ethics Board (CHREB). Kern's six-step approach to curriculum development, consisting of a general needs assessment, targeted needs assessment, outlining goals and objectives, creating content, implementing the curriculum, and evaluating the curriculum (Kern et al., 2009) was used to inform the creation of the EEG curriculum.

Needs Assessment

A general needs assessment was performed, in the form of a systematic review focusing on the structure and outcomes of educational programs for training non-electroencephalographers in performing and screening adult EEG, was conducted, and published (Kromm et al., 2021). Following this, critical care Registered Nurses (RNs) were identified as targeted learners for the curriculum, given their educational background, constant bedside presence, and experience with other physiologic monitoring for potential pathologies. A targeted needs assessment was conducted through a survey of 55 ICU RNs at a 36-bed general systems ICU at a Canadian academic medical centre (Foothills Medical Centre, Calgary, Alberta; Appendix).

Figure 1

EEG Colour Density Spectral Array



Two EEG Colour Density Spectral Arrays (CDSAs). Top – left hemisphere. Bottom – right hemisphere. Each trend comprises time on x axis, frequency on the y axis and power on the z axis portrayed via colours (cooler colours, such as blue/green, suggest low power while hotter colours, such as yellow/red/white, demonstrate high power). A possible seizure is shown (between the two white lines), comprising an increase in the power of faster frequencies over time followed by a decrease, creating a flame shape.

Figure 2

Raw Electroencephalography



Raw Electroencephalography (EEG) recording that depicts an electrographic seizure.

Questions pertaining to comfort and interest level focused on three main areas: 1) seizure principles, 2) EEG principles, and 3) EEG and CDSA interpretation. In addition to this survey, an audit of available learning resources pertinent to continuous EEG at this institution was conducted, revealing a brief document introducing the EEG machine and describing basic machine operations and electrode reapplication.

Objectives and Curriculum Development

The primary goals and objectives for the curriculum, based on the general and targeted needs assessment goals, were for RNs to acquire knowledge regarding basic seizure and EEG principles, as well as the necessary skills required to screen quantitative CDSA followed by raw cEEG for potential NCSz. A spiral curriculum, in which topics are revisited multiple times throughout a program increasing in complexity and depth with each encounter, of 15 tutorials was developed, detailing basic neuroanatomy, seizure, and EEG principles, as well as an approach to quantitative CDSA and raw EEG interpretation (Appendix). Each tutorial contained specific learning objectives, content presentations with visual aids, and additional resources. Corresponding practice modules were available consisting of theory-based questions and electroencephalographs to interpret. The curriculum was available online through www.teachingmedicine.com.

Participant Recruitment and Pilot Implementation

Following the survey, ICU RNs were invited to participate in the study. Participation was voluntary and RNs were randomly selected from those who expressed interest in participating. Participants received a $150 CAD honorarium upon completion of the EEG curriculum. Participants were given 3 months to complete the curriculum. For pilot curriculum implementation, participants registered through www.teachingmedicine.com/skills/neuro and completed 15 tutorials and 12 associated practice modules. Immediate feedback was provided during the practice modules, indicating whether responses were correct or incorrect and providing an explanatory rationale.

Evaluation and Feedback

(Appendix) The tests assessed participants' ability to perform EEG screening for seizures with a particular focus on raw EEG interpretation, including assessment of artifacts, and identification of seizures versus other EEG abnormalities, such as burst suppression, or rhythmic and periodic EEG patterns. The surveys assessed perceived confidence with specific knowledge and skills and sought feedback on various elements of the curriculum. Additionally, participant demographic information, including age, gender, nursing role, years of experience, and prior knowledge about seizures and EEG, was collected.

The primary outcome of interest was the participants' diagnostic accuracy of sensitivity and specificity, when screening for seizures. Secondary outcome measures were the time to complete the tutorials and practice modules, performance in artifact and seizure identification, confidence in seizures and EEG principles, artifact and seizure identification on EEG and CDSA. Performance was assessed using pre-and post-tests, while confidence was measured through pre- and post-curriculum surveys.

Data Collection and Statistical Analysis

Data was collected from the www.teachingmedicine.com/skills/neuro online modules. Upon participant completion, the data was de-identified and exported to comma separated variable (CSV) format. SAS software (Version 9.4, Cary, NC) was used for the statistical analysis. The accuracy of each question was summarized using univariate analysis. McNemar's tests were used to compare accuracy in recognition of EEG artifact and seizures before and after completion of the educational curriculum. The Mantel-Haenszel test was used to assess the overall impact of the curriculum across EEG categories. Generalized linear models were fit using generalized estimating equations (PROC GENMOD in SAS) to assess the effects of age, ICU experience, and nursing role on test performance. A p value of 0.05 or less was considered statistically significant.

Results

Needs Assessment

Fifty-five nurses completed the targeted needs assessment survey (100% response rate). Respondents' experience working in ICU ranged from 3 months to 22 years. The survey responses also revealed that 44%–88% and 30%–80% of RNs lacked confidence in their knowledge of basic seizure and EEG principles, respectively (Figure 3). Comfort in basic EEG and CDSA interpretation skills were reported as a deficit in 94% and 100% of the 55 respondent RNs, respectively. Post-curriculum responses indicated the interest in an EEG curriculum, and various methods of learning were favoured. The most requested method (76%) involved hands on practice (data not shown).

Pilot Curriculum Implementation and Evaluation

Demographics

From the original 55 respondents to the survey, 14 participants volunteered and consented to participate in the study. The median age of participants was 33 years [IQR 32–38], predominantly identified as female, and reported a median of 8 years of ICU nursing experience [IQR 4–9]. Ten participants completed the curriculum. One participant withdrew after being accepted into a master's program and no longer had sufficient time to participate. Reasons for non-completion were not obtained from the remaining three participants. Among those who completed the curriculum, one was an ICU nurse educator, three were nurse clinicians/charge nurses, and six were bedside RNs. Most participants reported 120 minutes or less of prior education related to seizures (72%) and EEG interpretation (93%; Table 1).

Engagement with Curriculum

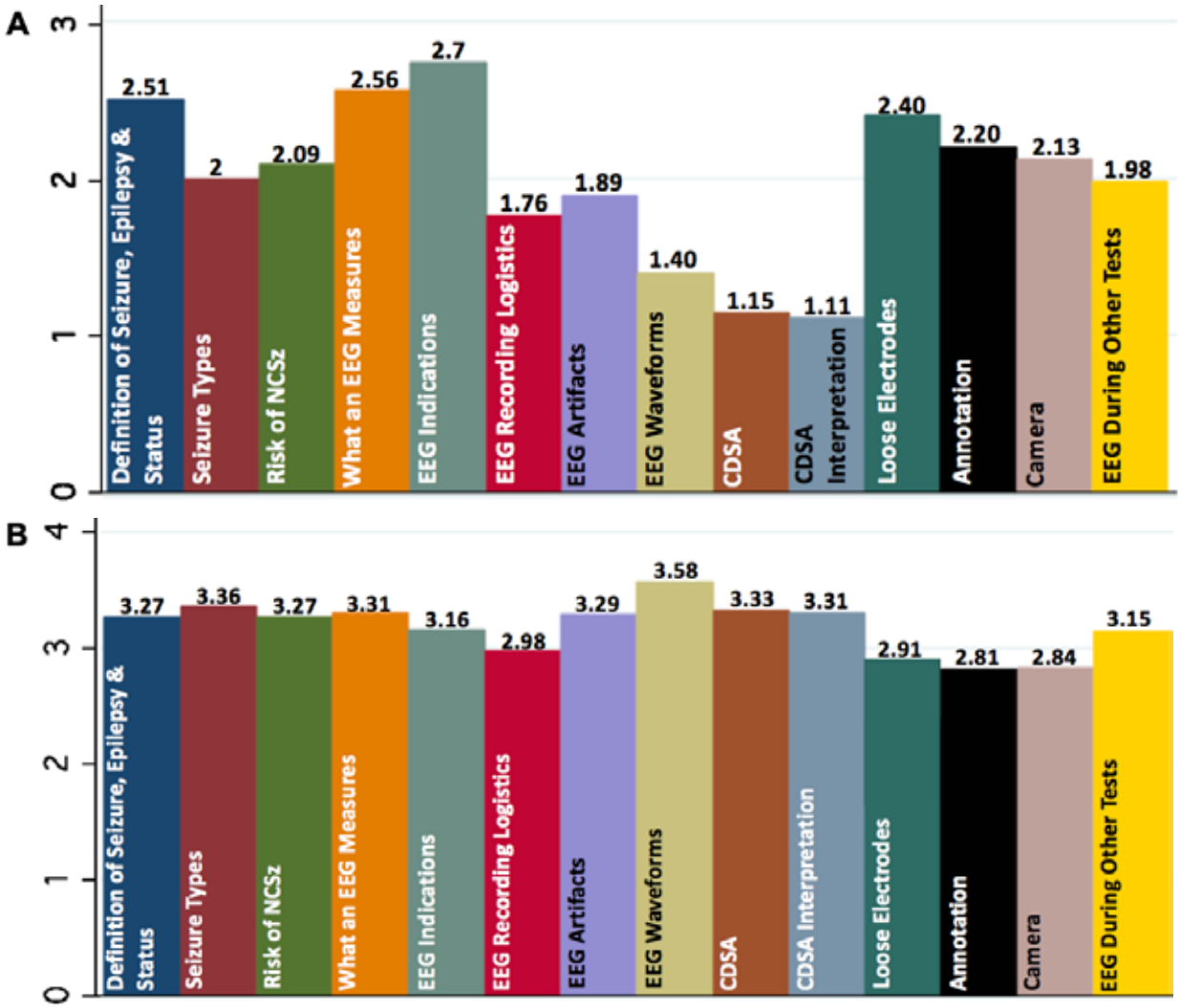
The total time spent on the 15 tutorials was 2 hours or less for all participants. Time spent on the practice modules ranged from 1–2 hours (20%), 2–4 hours (40%), and 5 hours or more (40%). The additional resources listed at the end of each tutorial for those requiring more teaching were only utilized by 40% of participants.

Curriculum Efficacy

The sensitivity and specificity for seizure identification in the post-curriculum test were 98% (95% CI, 90%–100%) and 76% (95% CI, 61%–88%), respectively. This was substantially

Figure 3

Needs Assessment Results



Pooled needs assessment results from 55 nurses showing A) mean comfort level of ICU nurses to seizure and EEG principles and skills [definitions of seizure, epilepsy, and status; seizure type; risk of NCSz; what an EEG measures; EEG indications; EEG recording logistics; EEG artifacts; EEG waveforms; CDSA; CDSA interpretation; loose electrodes; annotations; camera; EEG during other tests] (1, not comfortable at all, 2 somewhat comfortable, 3 comfortable, 4 very comfortable) and B) mean interest level of ICU nurses to seizure and EEG principles and skills [definitions of seizure, epilepsy, and status; seizure type; risk of NCSz; what an EEG measures; EEG indications; EEG recording logistics; EEG artifacts; EEG waveforms; CDSA; CDSA interpretation; loose electrodes; annotations; camera; EEG during other tests] (1 not interested, 2 somewhat interested, 3 interested, 4 very interested).

improved from the pre-curriculum test where sensitivity and specificity for seizure identification were 76% (95% CI, 61%–88%) and 48% (95% CI, 38%–59%), respectively (Figure 4). The most common EEG abnormalities to generate a false positive during raw EEG screening (in decreasing order) were sporadic epileptiform discharges, burst suppression, periodic discharges, and rhythmic delta activity (data not shown). Rarely were artifacts ever misinterpreted as seizure.

Participant performance relating to seizure identification significantly improved from pre- to post-curriculum (36% vs 81%, p <0.0001); however, artifact identification did not (70% vs 75%, p = 0.21; Figure 4). When modeled as a continuous variable, the improvement in test performance between pre- and post-curriculum was reduced in more experienced RNs (p = 0.04), but this effect did not persist when experience was dichotomized by those with the most vs. the least experience (p = 0.18). Improvement in performance was not modified by age (p = 0.27) or RN role (bedside RN vs nurse clinician/educator; p = 0.50).

Both before and after completion of the curriculum, participants rated their confidence with seizure and EEG principles, as well as identification of EEG artifacts and seizures (on raw EEG and CDSA) using a 5-point Likert scale of agreement/disagreement with statements of confidence relating to each topic (1 – strongly disagree, 2 – disagree, 3 – neutral, 4 – agree, 5 – strongly agree).

Table 1

Demographics and RN Baseline EEG Knowledge

	Total cohort (N = 14)	Those who completed the curriculum (N = 10)
Age, yr (median)	33	33
Sex (F:M)	13:1	9:1
ICU experience, yr (median)	7.5	8
Nursing Role		
Bedside RN	9	6
Permanent Charge RN	4	3
Nurse Educator	1	1
Time learning about seizures prior to curriculum, N (%)		
None	0 (0%)	0 (0%)
1–60 minutes	4 (29%)	3 (30%)
61–120 minutes	6 (43%)	3 (30%)
121–180 minutes	2 (14%)	2 (20%)
>180 minutes	2 (14%)	2 (20%)
Time learning about EEG prior to the curriculum, N (%)		
None	2 (14%)	1 (10%)
1–60 minutes	6 (43%	3 (30%)
61–120 minutes	5 (36%)	5 (50%)
121–180 minutes	1 (7%)	1 (10%)
>180 minutes	0 (0%)	0 (0%)

Before completing the curriculum, participants who reported confidence levels of agree or strongly agree were most confident in seizure principles (43%), EEG principles (36%), artifact identification (36%), and non seizure EEG abnormalities, such as burst suppression and rhythmic and periodic discharges (14%), or in seizure identification on raw EEG (14%). No participants reported confidence in seizure identification using CSDA (0%; Figure 4).

Following the curriculum, participants reported increased confidence in seizure identification (70%), EEG principles (100%), and seizure identification on CDSA (80%; Figure 4). Smaller improvements were observed in confidence related to artifact identification, recognition of non-seizure EEG abnormalities, and seizure identification on raw EEG (Figure 4).

Feedback

Post-curriculum responses indicated that 80% of participants thought the curriculum was efficient and 60% thought the curriculum was effective. The main themes identified included RNs wanting dedicated time and compensation to learn about neuromonitoring modalities, such as EEG, requests for various other teaching methods (including didactic teaching) and practical resources (such as a pocket manual), and the formation of an ICU RN super user group which would facilitate future peer teaching and support.

Discussion

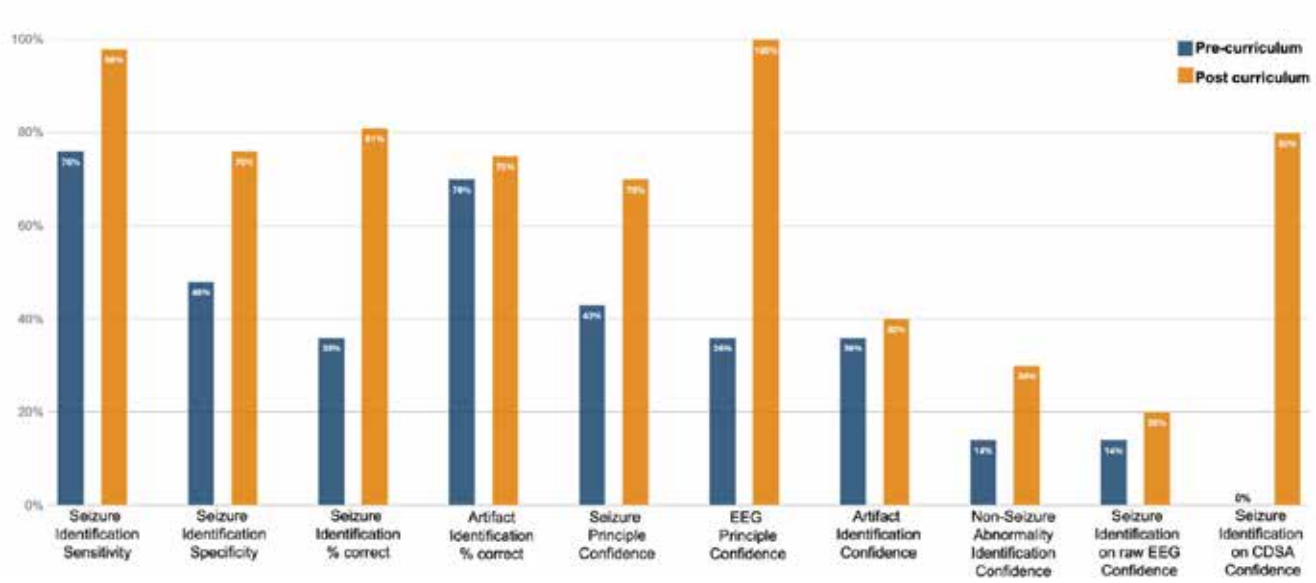
Via evidence-informed methods, we successfully designed, implemented, and evaluated a spiral curriculum comprised of electronic tutorials and practice modules designed to provide ICU RNs the necessary knowledge and skills to screen for NCSz. The curriculum was associated with improvements in participant performance and confidence across several domains, including increased sensitivity and specificity for identification of NCSz.

Non-convulsive seizures occur commonly in patients who are critically ill and have been associated with increased mortality, and worse functional outcomes (Payne et al., 2014). This is likely a result of secondary brain injury that has been associated with seizures, including metabolic crises, brain tissue hypoxia, elevated intracranial pressure, increased mass effect and midline shift, and hippocampal atrophy (Bencsik et al., 2024; Vespa et al., 2016; Vespa et al., 2007, 2010; Witsch et al., 2017). As such, rapid identification of harmful seizures via EEG and treatment are paramount and means to facilitate this are crucial.

Similarly to our study, several others have demonstrated effective educational strategies to improve detection of NCSz. While our study focused on educating ICU RNs, others have shown that many other "non-experts", including medical students, residents, fellows, and neurodiagnostic technicians, can be

Figure 4

Evaluation of Curriculum Efficacy



educated to perform and screen various formats of adult EEG, resulting in reduced delays in EEG completion and changes to management in 40%–50% of patients (Kromm et al., 2021). Several studies have focused on training non-experts to screen sonified EEG (converting EEG data to audible sound) and various forms of qEEG. The sensitivity of non-experts' screening of sonifed EEG and qEEG for NCSz has varied between 95%–100% and 40%–93% respectively (Kromm et al., 2021). Specificities have varied between 65%–85% for sonified EEG and 38%–95% for qEEG (Kromm et al., 2021).

Sonified and quantitative EEG offer the advantage of simplified and time-compressed EEG trends that can theoretically be screened relatively more easily and efficiently than raw EEG. However, when screening sonified or quantitative EEG, false negatives may occur with NCSz that are low in amplitude, low in frequency, focal, brief, or have characteristics that prevent them from standing out compared to the EEG background. False positives can arise from artifacts and other EEG patterns, as demonstrated in our study. Both may cause significant clinical consequences, including ongoing NCSz, neurophysiologic disturbances, mortality, complications, increased length of stay, and additional healthcare costs. While it is ideal to obtain confirmation by neurophysiologists of potential NCSz that have been identified by non-experts, high false positive rates would cause this approach to be arduous and non-sustainable. Reported false positive rates for NCSz within the acute care setting, which hypothetically could translate into neurophysiologist notifications, have ranged from 3.2/hr to 1/10hrs in studies (Kromm et al., 2021).

Raw cEEG can be difficult and time consuming to review for ICU bedside care providers who have other clinical responsibilities. However, when combined with qEEG, select epochs can be reviewed to confirm or refute potential NCSz identified on qEEG. Other studies have shown that after educating non-experts to screen raw EEG their sensitivity and specificity for NCSz varies between 63%–100% and 65%–100% (Kromm et al., 2021) respectively, which is comparable to the sensitivity of 98% and specificity of 76% achieved by our study participants. Our study differs from these other studies, as we focused our educational efforts on RNs, whereas others have mainly focused on medical students, residents, or fellows. Our curriculum also focused on a two-step process whereby potential seizures would be identified on CDSA, then on raw EEG as opposed to isolated review of raw EEG.

Another means by which accuracy of identification of NCSz may be improved is the approach taken by Kang and colleagues who performed a prospective study in which qEEG was utilized at the bedside by ICU RNs, who received individualized, patient-specific qEEG instructions while caring for patients, with examples provided of what CDSA, amplitude EEG, and rhythmicity spectrogram tracings looked like during previous seizures. With this pragmatic approach, RNs had excellent diagnostic accuracy in recognizing seizures (sensitivity 85%, specificity 89%) and a high rate of inter observer agreement (Kang et al., 2019).

In our study, RN confidence did not always correlate with competence. Although ICU RNs were relatively proficient in identifying EEG artifacts at baseline, a disconnect remained between performance and confidence, with 64% reporting low confidence before the curriculum and 60% reporting confidence afterward. While significant improvement was noted in seizure identification from pre- to post-curriculum tests (36% vs 81%, p <0.0001), 80% of RNs still lacked confidence in this skill after completing the curriculum. Studies have shown that self-assessment of skill is poor, and confidence is a multidimensional construct that can be influenced by many factors, including stress, cognitive load, emotions, uncertainty, and group dynamics (Gottlieb et al., 2022). While most curriculums

focus only on competence, confidence, and its relationship to competence, the competence-confidence ratio is also important to monitor and foster to develop both mindful and capable professionals who can self-reflect and calibrate appropriately (Gottlieb et al., 2022).

Overall, the feedback for our curriculum was that it was effective and efficient. However, several constructive comments were provided including requests for dedicated time and compensation for training, in addition to other teaching methods and resources. A recent study (Marks et al., 2021) that evaluated rapid deployment of critical care nursing education during the COVID-19 pandemic found that a combination of a distributed practice model which gives critical care learners short bursts of didactic teaching over a longer period is beneficial for cognitive processes, retention, and psychomotor skill acquisition, which is supported by prior research (Gerbier & Toppino, 2015). We offered our curriculum electronically, however, based on the feedback from our participants, it may be beneficial to offer a combination online and in-person/didactic format with tutorials and individualized and hands on cEEG interpretation training to support various learning styles over a longer period (i.e. 6–12 months) to maximize knowledge retention and skill acquisition.

In addition to modifying the curriculum style, resources, and period in which participants have to complete it, we have also developed a Neurocritical Care Champion (NC3) group for ICU RNs and ICU respiratory therapists (RTs) at our centre, with the goal of improving the chain of survival and recovery for patients with life-threatening neurological disorders. Our aim, through focused education activities and resources, such as an online EEG curriculum and other educational activities (lectures, grass roots educational publication, drop-in sessions, and journal club), to empower the NC3 participants to not only provide comprehensive neurocritical care (NCC) but also to utilize their knowledge and skills to support colleagues and serve as a team resource.

Limitations

Limitations of our study include its small size due to limited funding. This was compounded by a 29% attrition. However, this attrition was informative in identifying barriers to curriculum completion and developing solutions to address these in the future. We also enrolled a convenience sample without randomization and thus our results cannot be generalized outside the group of RNs included in the study. Critical care is a demanding specialty with increased complexity, frequent life-threatening situations, and need for prompt decision-making based on available data points. The complexity of patients in critical care is increasing; however, the time and resources available to train and support critical care practitioners has not (Joyce et al., 2017).

Conclusion

Piloting this curriculum that focused on training ICU RNs in a two-step screening process of CDSA and raw EEG for NCSz was both novel and informative for future studies aimed at developing processes to facilitate more timely diagnosis and management of NCSz in patients who are critically ill. In addition, further refinement and implementation of this curriculum will improve ICU RN knowledge and skills, broaden their scope of practice and potentially improve their job satisfaction. Our spiral curriculum comprising online tutorials and practice modules was effective at improving ICU RNs' diagnostic accuracy for detection of NCSz with the ultimate goal of creating processes to facilitate more timely diagnosis and management of NCSz in patients who are critically ill.

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Appendix

Targeted needs assessment survey

What is your professional role in the ICU?

❏ Bedside Nurse ❏ Nurse Clinician ❏ Nurse Educator ❏ Nurse Practitioner

Please indicate the duration you have been working in an ICU. ___ years

For all of the following, please indicate 1) your level of comfort (knowledge or skills) and 2) interest in learning more about the following:

The difference between a seizure, epilepsy, and status epilepticus.

❏ Not comfortable ❏ Somewhat comfortable ❏ Comfortable ❏ Very comfortable
❏ Not interested ❏ Somewhat interested ❏ Interested ❏ Very interested

Types of seizures and their clinical presentations.

❏ Not comfortable ❏ Somewhat comfortable ❏ Comfortable ❏ Very comfortable
❏ Not interested ❏ Somewhat interested ❏ Interested ❏ Very interested

Which patients are at increased risk for non-convulsive seizures.

❏ Not comfortable ❏ Somewhat comfortable ❏ Comfortable ❏ Very comfortable
❏ Not interested ❏ Somewhat interested ❏ Interested ❏ Very interested

What an EEG is and what it measures.

❏ Not comfortable ❏ Somewhat comfortable ❏ Comfortable ❏ Very comfortable
❏ Not interested ❏ Somewhat interested ❏ Interested ❏ Very interested

Indications/uses for EEGs.

❏ Not comfortable ❏ Somewhat comfortable ❏ Comfortable ❏ Very comfortable
❏ Not interested ❏ Somewhat interested ❏ Interested ❏ Very interested

How the EEG signal is recorded and processed.

❏ Not comfortable ❏ Somewhat comfortable ❏ Comfortable ❏ Very comfortable
❏ Not interested ❏ Somewhat interested ❏ Interested ❏ Very interested

Causes for and identification of EEG artifacts

❏ Not comfortable ❏ Somewhat comfortable ❏ Comfortable ❏ Very comfortable
❏ Not interested ❏ Somewhat interested ❏ Interested ❏ Very interested

Basic EEG waveform interpretation (e.g., identifying burst suppression, seizures, periodic discharges, etc.)

❏ Not comfortable ❏ Somewhat comfortable ❏ Comfortable ❏ Very comfortable
❏ Not interested ❏ Somewhat interested ❏ Interested ❏ Very interested

What a Colour Density Spectral Array is and what it is used for.

❏ Not comfortable ❏ Somewhat comfortable ❏ Comfortable ❏ Very comfortable
❏ Not interested ❏ Somewhat interested ❏ Interested ❏ Very interested

How to interpret a Colour Density Spectral Array.

❏ Not comfortable ❏ Somewhat comfortable ❏ Comfortable ❏ Very comfortable
❏ Not interested ❏ Somewhat interested ❏ Interested ❏ Very interested

Identification and reapplication of loose electrodes/leads.

❏ Not comfortable ❏ Somewhat comfortable ❏ Comfortable ❏ Very comfortable
❏ Not interested ❏ Somewhat interested ❏ Interested ❏ Very interested

How to enter text (e.g., document medication administration) on an EEG recording.

❏ Not comfortable ❏ Somewhat comfortable ❏ Comfortable ❏ Very comfortable
❏ Not interested ❏ Somewhat interested ❏ Interested ❏ Very interested

How to focus the EEGs recording camera.

❑ Not comfortable	❑ Somewhat comfortable	❑ Comfortable	❑ Very comfortable
❑ Not interested	❑ Somewhat interested	❑ Interested	❑ Very interested

What to do with the EEG when the patient goes for an MRI, or other test.

❑ Not comfortable	❑ Somewhat comfortable	❑ Comfortable	❑ Very comfortable
❑ Not interested	❑ Somewhat interested	❑ Interested	❑ Very interested

Please indicate other relevant areas of interest to you.

Please indicate you preferred methods of learning (check all that apply):
❑ Didactic lectures
❑ Small group tutorials/discussions
❑ Self-directed reading/manuals
❑ Online modules
❑ Simulation/hands on practice
❑ Other (please indicate)

Pre-Curriculum Survey

What is your gender?
❑ Male
❑ Female

What is your age?
Free text entry

What is your nursing role within the ICU?
❑ Bedside RN
❑ Nurse Clinician
❑ Nurse Educator
❑ Nurse Practitioner
❑ Other

❑ How long have you been working in an ICU?
Free text entry

How much time learning about seizures have you done previously?
❑ None
❑ 1–60 minutes
❑ 61–120 minutes
❑ 121–180 minutes
❑ > 180 minutes

How much time learning about EEGs have you done previously?
❑ None
❑ 1–60 minutes
❑ 61–120 minutes
❑ 121–180 minutes
❑ > 180 minutes

I am confident in my understanding of seizure principles (e.g., difference between seizure, epilepsy, and status epilepticus, types of seizures, and their presentations, which patients are at increased risk for seizures, etc.)
❑ Strongly Disagree
❑ Disagree
❑ Neutral
❑ Agree
❑ Strongly Agree

I am confident in my understanding of basic EEG principles (e.g., what an EEG measures, indications/uses for EEGs, how an EEG is recorded and processed, what causes EEG artifacts, etc.)
❏ Strongly Disagree
❏ Disagree
❏ Neutral
❏ Agree
❏ Strongly Agree

I am confident at identifying artifacts on EEG
❏ Strongly Disagree
❏ Disagree
❏ Neutral
❏ Agree
❏ Strongly Agree

I am confident at identifying non-convulsive/electrographic seizures on EEG.
❏ Strongly Disagree
❏ Disagree
❏ Neutral
❏ Agree
❏ Strongly Agree

I am confident at identifying non-epileptic abnormalities on EEG (e.g., burst suppression, periodic epileptiform discharges, intermittent rhythmic delta activity, triphasic waves).
❏ Strongly Disagree
❏ Disagree
❏ Neutral
❏ Agree
❏ Strongly Agree

I am confident at identifying potential non-convulsive/electrographic seizures on Colour Density Spectral Array (CDSA).
❏ Strongly Disagree
❏ Disagree
❏ Neutral
❏ Agree
❏ Strongly Agree

Practising is required for acquiring EEG interpretation skills.
❏ Strongly Disagree
❏ Disagree
❏ Neutral
❏ Agree
❏ Strongly Agree

I expect online tutorials and practice modules for EEG interpretation will be EFFICIENT (good learning for my time spent).
❏ Strongly Disagree
❏ Disagree
❏ Neutral
❏ Agree
❏ Strongly Agree

I expect online practice modules for EEG interpretation will be EFFECTIVE (they will actually work for me)
❏ Strongly Disagree
❏ Disagree
❏ Neutral
❏ Agree
❏ Strongly Agree

If you have any comments, please tell us:
Free text entry

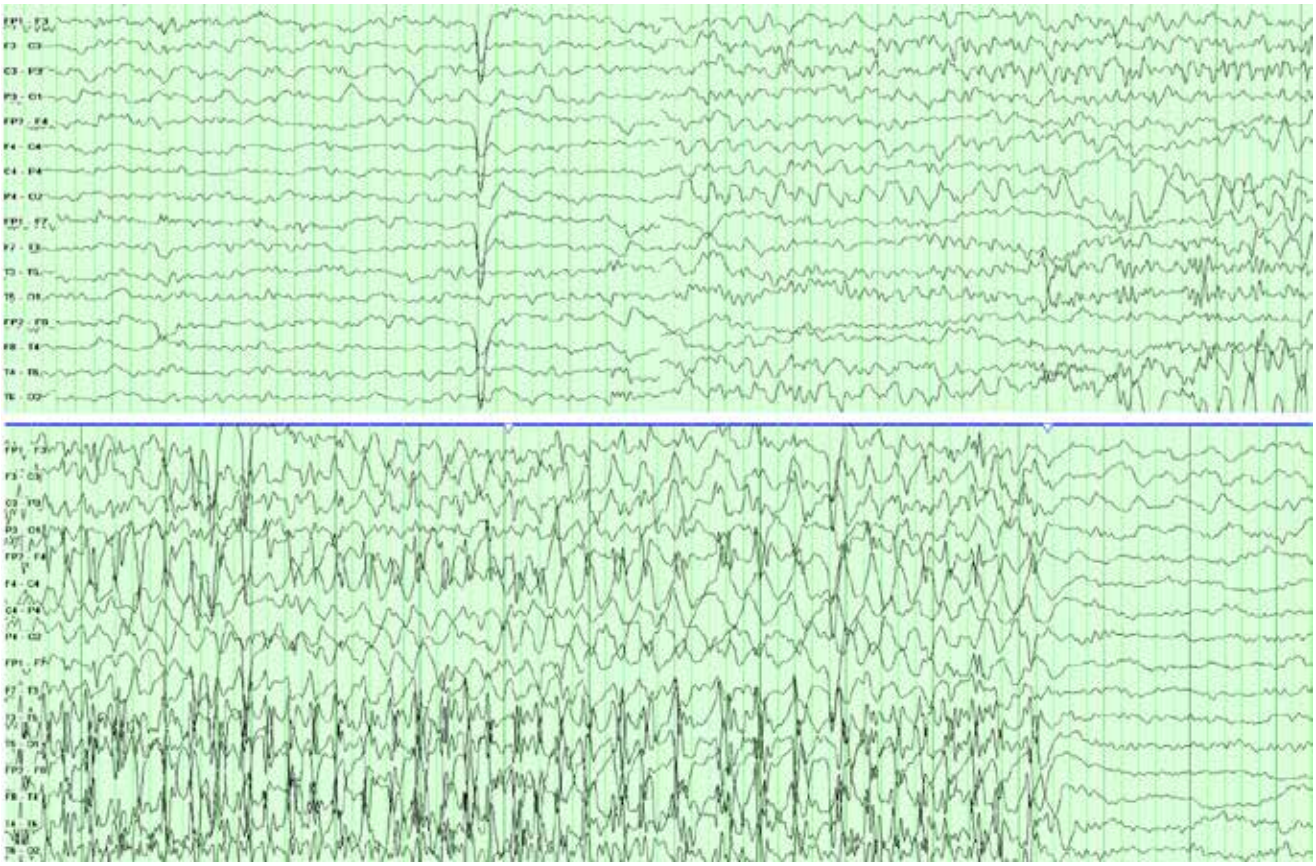
EEG Curriculum Overview

Tutorial	Title	Objectives	Associated Practice Module
1	Neuroanatomy	Distinguish between the central and peripheral nervous system	Yes
		Define the main functional components of the central and peripheral nervous systems	
		Distinguish between grey and white matter	
		List the various functions of each lobe of the brain	
2	Seizures, Epilepsy & Status Epilepticus	List the 4 elements that make up a seizure	Yes
		Distinguish between seizures, epilepsy, and status epilepticus	
		Explain where seizures arise within the brain and define focal versus generalized seizures	
		Localize clinical seizures based on their manifestations	
		Describe the two main types of status epilepticus	
3	Introduction to EEG	Describe what an electroencephalogram measures	Yes
		List the three ICU indications of EEGs	
		Appreciate how common non-convulsive seizures are, and what diseases they are likely to occur	
4	Neurophysiology – The Source of the EEG	Describe the source of the EEG signal	Yes
		Explain volume conduction	
5	EEG Electrodes	Describe the international 10–20 system of scalp electrode placement	Yes
		Correlate electrode letters and numbers with their location on the scalp	
6	EEG Acquisition	List the four basic elements of the EEG circuit	Yes
		Describe the two ways to compare EEG electrode signals	
		Explain the purpose of electrode montages	
		Identify electrode chains and their corresponding localization	
		Describe the purpose of amplifiers within the EEG circuit	
		Describe the purpose of filters within the EEG circuit	
7	EEG Interpretation & Terminology	Describe the approach to interpreting an EEG	Yes
		Identify EEG waveforms as beta, alpha, theta, or delta frequencies	
		Define and identify EEG transients including spikes/polyspikes and sharps	
		Describe the difference between interictal epileptiform activity and epileptic activity	
		Localize EEG activity as diffuse/generalized, lateralized, focal, or multifocal	
8	EEG – Physiologic Artifacts	Describe how an EEG signal is processed in order to remove artifact, and understand that this processing is not perfect	Yes
		List the two broad categories of artifacts	
		Describe the two ways in which artifacts can interfere with EEG interpretation.	
		List the general rules that can help identify artifacts	
		Identify various physiologic artifacts on EEGs, especially movement, muscle, ECG, pulse, and eye movement artifacts	

9	EEG – Non-Physiologic Artifacts	Identify various non-physiologic artifacts, especially 60Hz, electrode pop, salt bridge, and other mechanically induced artifacts	Yes
10	EEG – Normal Background Activity	Appreciate normal EEG background activity so as to prepare them to identify abnormal background activity	Yes
		Understand that EEG background activity changes with the state (awake, drowsy, asleep) of the patient	
11	EEG Abnormalities – Background	List the three major categories of EEG abnormalities	Yes
		List the two major categories of EEG background abnormalities	
		Describe the underlying reason for focal background abnormalities	
		Describe the underlying generalized background abnormalities, and explain how the EEG changes as a patient becomes more and more encephalopathic/ comatose	
		Identify an EEG background as normal or abnormal, and if abnormal as focal or generalized	
		Identify burst suppression and understand its diagnostic and therapeutic connotations	
12	EEG Abnormalities – Non-Epileptic	List the three main categories of non-epileptic abnormalities.	Yes
		Describe and identify the three main types of periodic patterns, and provide a differential diagnosis of the cause for each	
		Describe and identify intermittent rhythmic delta activity, particularly FIRDA and provide a differential diagnosis of the causes for each	
		Describe and identify triphasic waves, and provide a differential diagnosis of the causes for them	
13	EEG Abnormalities – Seizures	Describe and recognize sharp waves, spikes, and poly-spikes	Yes
		Define interictal epileptiform activity	
		Define ictal epileptic activity (i.e., seizures)	
		Identify ictal epileptic activity and categorize it as either focal or generalized	
14	Continuous EEG and Colour Density Spectral Array	Describe why continuous EEG is better than routine EEG in patients at risk for non-convulsive seizures/status epilepticus	Yes
		Understand the resource, cost and system implication of performing continuous EEG on patients.	
		Describe the scientific basis for colour density spectral array	
		Identify potential seizures on an CDSA and define potential mimics	
15	Putting it All Together		No

Example Test Questions

For the following EEG



I. Is there artifact?

   A. Yes

   B. No

II. Are electrographic seizures present?

   A. Yes – focal seizures

   B. Yes – generalized seizures

   C. No

Post Curriculum Survey

I am confident in my understanding of seizure principles (e.g., difference between seizure, epilepsy, and status epilepticus, types of seizures and their presentations, which patients are at increased risk for seizures, etc.)
Strongly disagree
Disagree
Neutral
Agree
Strongly Agree

I am confident in my understanding of basic EEG principles (e.g., what an EEG measures, indications/uses for EEGs, how an EEG is recorded and processed, what causes EEG artifacts, etc.)
Strongly disagree
Disagree
Neutral
Agree
Strongly Agree

I am confident at identifying artifacts on EEG.
Strongly disagree
Disagree
Neutral
Agree
Strongly Agree

I am confident at identifying non-convulsive/electrographic seizures on EEG.
Strongly disagree
Disagree
Neutral
Agree
Strongly Agree

I am confident at identifying non-epileptic abnormalities on EEG (e.g., burst suppression, periodic epileptiform discharges, intermittent rhythmic delta activity, triphasic waves).
Strongly disagree
Disagree
Neutral
Agree
Strongly Agree

I am confident at identifying potential non-convulsive/electrographic seizures on Colour Density Spectral Array (CDSA).
Strongly disagree
Disagree
Neutral
Agree
Strongly Agree

Practising is required for acquiring EEG interpretation skills.
Strongly disagree
Disagree
Neutral
Agree
Strongly Agree

The online TUTORIALS were EFFICIENT (good learning for my time spent).
Strongly disagree
Disagree
Neutral
Agree
Strongly Agree

The online TUTORIALS were EFFECTIVE (they actually worked for me).
Strongly disagree
Disagree
Neutral
Agree
Strongly Agree

I used the additional resources listed at the end of tutorials.
Yes
No

I found the additional resources useful.
Strongly disagree
Disagree
Neutral
Agree
Strongly Agree

More additional resources would be useful
Strongly disagree
Disagree
Neutral
Agree
Strongly Agree

Please provide any comments you have about the online TUTORIALS:
Free text entry

Indicate if you used any of the available PRACTICE MODULES (Note: this does not include the pre- or post-curriculum tests)
Yes
No

Indicate the time you spent practising via the PRACTICE MODULES (Note: this does not include the pre- or post-curriculum tests)
< 1 hour
1–2 hours
2–3 hours
3–4 hours
4–5 hours
> 5 hours

The online PRACTICE MODULES were EFFICIENT (good learning for my time spent).
Strongly disagree
Disagree
Neutral
Agree
Strongly Agree
Not applicable (Did not complete the practice modules)

The online PRACTICE MODULES were EFFECTIVE (they actually worked for me).
Strongly disagree
Disagree
Neutral
Agree
Strongly Agree
Not applicable (Did not complete the practice modules)

The instant feedback on the PRACTICE MODULES was useful
Strongly disagree
Disagree
Neutral
Agree
Strongly Agree
Not applicable (Did not complete the practice modules)

Please provide any comments you have about the online PRACTICE MODULES:
Free text entry

Hemodynamic Monitoring: What the Monitor and the Patient Say

Kari Taylor, MN, RN, CNCC(C)

Hemodynamic monitoring is a basic intervention in the intensive care unit (ICU). Nurses can glean clinically relevant information from the waveforms on the monitor. However, hemodynamic data are valuable only when interpreted alongside a comprehensive physical assessment. y! When nurses perform a comprehensive physical assessment, they should be able to match those findings with the waveforms on the monitor. ***Always*** treat the patient, not the monitor!!

Let's talk about what makes up basic hemodynamic monitoring: nurses can interpret a 5- or 12-lead electrocardiogram (ECG); assess an arterial pressure waveform; and evaluate the significance of a central venous pressure measurement. In some situations, they also need the information obtained from a pulmonary arterial catheter that has seen declining use over the years.

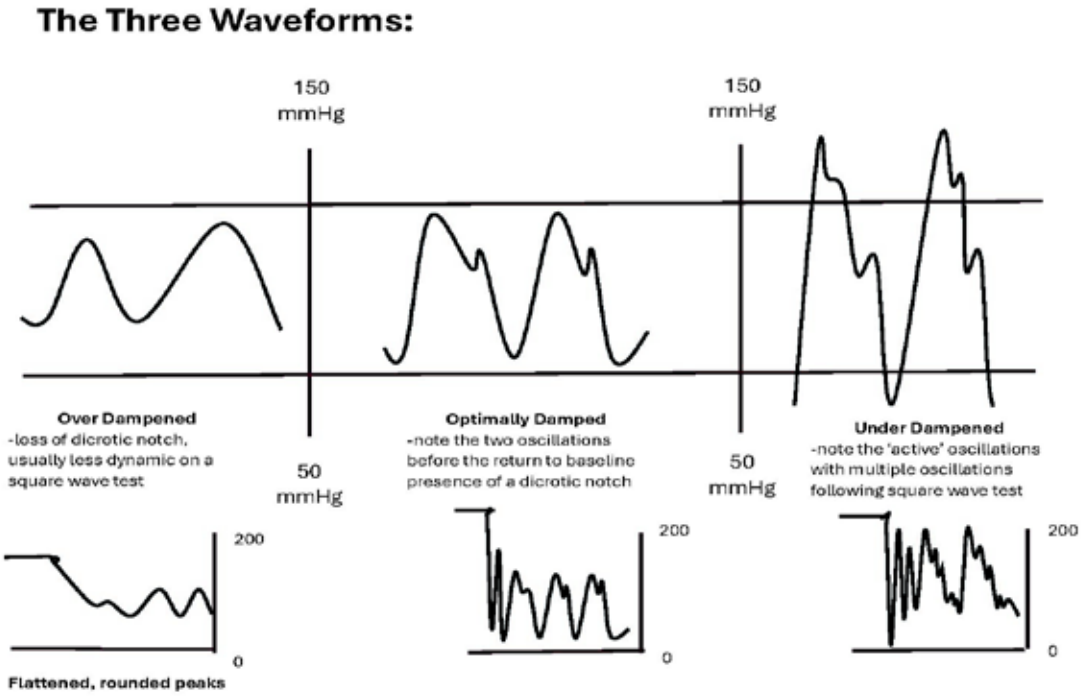
We are going to focus on ECG monitoring and arterial line monitoring. Though ECG is not a 'hemodynamic parameter,' the heart rate (HR) is integral when looking at hemodynamic numbers. Remember, cardiac output (CO) is dependent on HR and stroke volume (SV).

5-Lead and 12-Lead ECG Monitoring

- Five- and 12-lead monitoring is a standard of care in the ICU. It is not formally a 'hemodynamic parameter,' but it is essential when interpreting hemodynamic findings. It is a seemingly simple intervention, but the interpretation of the ECG waveform provides us with a wealth of information about the patient's clinical status. Questions to ask yourself:
  - What is the underlying rhythm?
  - Does the patient have an abnormal heart rhythm?
  - What are the causes of abnormal heart rhythms?
  - Are there any ectopic (extra) beats? If so, from where?
  - How does the rhythm correlate with the patient's physical assessment and hemodynamic findings?
- Remember, CO = HR x SV
  - If the HR is high or low, CO will change
  - If the SV is high or low, CO will change
  - There is a direct impact from the HR on the patient's CO. So, always consider the HR when looking at hemodynamics.

Figure 1

Three Hemodynamic Waveforms



Invasive arterial blood pressure monitoring (arterial line)

- Arterial lines can be placed in many sites—radial, brachial, femoral, and pedal. The location of the arterial line may matter; the important thing is that when monitoring an arterial line, it is determining if the values on the monitor match what is happening in the patient. *This speaks directly to the accuracy of the device*. Specific troubleshooting exists to ensure the accuracy of the line.
  - Optimally damped lines show us that the line is accurately reflecting the 'flow' through the line and the pressure you are seeing on the monitor is, in fact, the patient's real pressure.
  - Over and under damped lines show us that the line is not accurately conveying the patient's actual blood pressure. It can be falsely elevated or falsely decreased.

Let's look at a clinical example:
The patient was admitted 2 days ago with septic shock and is ventilated, on vasopressors (titrated to a goal mean arterial pressure [MAP] of 65mmHg), and is barely peeing. Norepinephrine is infusing at 0.3 mcg/kg/min and vasopressin is infusing at 0.04 units/min. Blood pressure via arterial line is 72/38 (49), and the non-invasive blood pressure is 96/58 (71). The bedside RN has been using the cuff pressure because the arterial line appears to be dampened. Here is the arterial waveform:



Let's troubleshoot this scenario. Forget the numbers for now. Let's look at the patient! Your assessment reveals the following:

- The patient is sedated with propofol, midazolam, and fentanyl; GCS 3 (Glascow Coma Scale) 3; goal RASS-5 (Richmond Agitation-Sedation Scale); T max (time to maximum) overnight was 38.3°C
- The patient is tachycardic, HR 121 bpm with occasional premature ventricular contractions (PVCs). Skin is cool and mottling is noted to the knees and lower leg. Feet are cold, pulses by Doppler only. Blood pressure has trended down overnight, and the arterial line looks overdamped, with a good square wave test. The RN has been using the cuff pressure because it was 'better.' The patient received a total of 1L Ringer's lactate (RL) bolus with minimal improvement in arterial blood pressure (BP). Non-invasive systolic blood pressure (SBP) improved by 10 mmHg
- The patient is ventilated on a control mode of ventilation, positive end-expiratory pressure (PEEP) 10, fraction of inspired oxygen (FiO2) 0.9. There are bilateral crackles with diminished breath sounds throughout. Bronchial breath sounds are audible over the entire right lung. Chest x-ray (CXR) shows significant consolidation in the R (right) lung. Heart is normal size on x-ray
- The patient is being trickle fed; residuals are minimal
- The patient has minimal urine output, less over the past 12 hours. Thoracic fluid index (TFI) 250mL/hr, patient is +3.7 L over last 24 hour
- Lines: right radial arterial line, right internal jugular central vascular access device (IJ CVAD), 3 peripheral IVs, #7.5 ETT, orogastric (OG), thermistor foley

When assessing a patient, always look at ALL the contributing factors to their clinical assessment. What stands out in this assessment?

- The patient is sedated with agents that cause hypotension
- The patient is tachycardic
- The patient is peripherally shut down
- The patient is mottled and has cold, clammy skin
- The patient is not peeing! (and they had been)
- When you do a square wave test you note this:

Figure 2

Overdampened Waveform



Note. Taken from (Bardes & Lam, 2019).

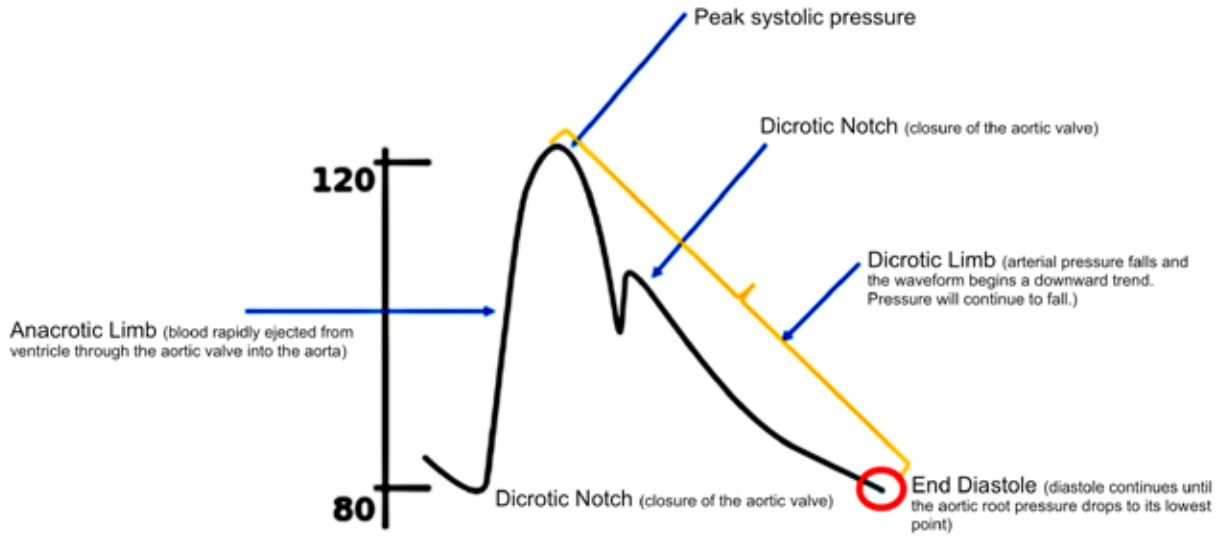
The oncoming RN has requested help with troubleshooting the arterial line, because they believe that the pressure might be real. What does the waveform and the pressure reveal? Let's remember the composition of an arterial waveform (Figure 3).

With the patient, the dicrotic notch has been lost, but the waveform remains optimally dampened. What does this mean? It means that the transmission of the pressure from the patient, through the transducer, to the monitor is accurate. If the waveform is over dampened, we would not see this optimal square wave test, and we would believe that the transduction of the waveform is not being accurately transmitted. At this point, if this was the case, troubleshooting may include:

- Flushing the line
- Eliminating any air bubbles or blood clots in the system
- Removing any excess tubing **this is one of the most common problems—get rid of that extra tubing! Sometimes it cannot be avoided but do your best!
- Priming and attaching a new line.

Figure 3

Optimally Dampened Waveform



Note. Taken from (Myatra, S.N., & Divatia, J., 2020).

If the line remains dampened and the clinical decision is to not use the arterial line for pressure monitoring, the line should be removed and a new arterial line placed. Now, having said that, some patients are difficult placements, have bleeding disorders, are a tough poke for blood work, etc., so it may not be appropriate to remove the line. However, if the choice is to NOT use the arterial line, it must be clearly communicated that the non-invasive blood pressure (NIBP*) is the one that the vasoactives are titrated to. With a patient on high-dose vasopressors, an arterial line will always be preferred for titration of same.

*NIBP is a measurement of *pressure*, an arterial line is a measurement of *flow,* and they cannot be compared apples to apples. One would expect that a NIBP be higher than the arterial line. BUT, if the nurse has an optimally dampened art line, they do not need to perform a NIBP to 'compare it' because the two measurements cannot be compared.

Let's go back to the patient and solve the problem! Vasoactives are infusing at increasing doses, the patient is clinically more unstable with clear evidence of poor peripheral perfusion and organ dysfunction (specifically the kidneys), and your gut is telling you that something is off. The nurse makes the clinical decision to follow the arterial line pressure and titrate up your vasoactives and notify the NP/MD of the patient's deteriorating state, and they order another 1L of Ringer's Lactate. Norepinephrine is titrated up to a MAP of 65 and within 2 hours the patient's urine output starts to pick up. The nurse still has an optimally damped waveform, and the dicrotic notch is now visible. The patient's HR has also dropped to 112 bpm.

Likely, the patient's pressure had truly been low with a MAP much less than 65mmHg. The kidneys were hypo-perfused for an extended period. Patient assessment guided the RN to determine that the patient required a higher BP and acted accordingly.

Does this happen often? Probably. Should we question clinical judgment? Always. Match the patient assessment with numbers. Assess a patient with a level of curiosity as if no previously recorded information has been documented. Troubleshoot, ask questions. Dig for answers. They are all a bit of a mystery, and nurses get to try and find the answers.

Author Notes

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Prevent Hypoglycemia: Insulin for the Treatment of Acute Hyperkalemia

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In this regular column, ISMP Canada will feature a critical care-related medication story and share practical learning for critical care nurses.

Potassium abnormalities are among the most common electrolyte disturbances. Hyperkalemia is an electrolyte abnormality characterized by an elevated serum potassium level typically greater than 5.0 to 5.5 mEq/L, which when severe, can lead to complications like fatal cardiac arrhythmias (Alfonzo et al., 2026; Simon & Rout, 2025). The high-alert medication insulin is often used to treat acute hyperkalemia. Recognizing the risks when treating high potassium with insulin is essential to preventing patient harm.

Background

Insulin administered for hyperkalemia is intended to temporarily move potassium from the bloodstream into the cells, a process known as "potassium shift" (Simon & Rout, 2025). However, this use of insulin can also cause hypoglycemia, which requires both intensive monitoring and careful replacement of glucose (in the form of dextrose) to maintain safe levels of glucose in the blood. Concurrent administration of dextrose with insulin is a key strategy to reduce the risk of hypoglycemia (Simon & Rout, 2026). However, dextrose may be withheld for patients with elevated baseline blood glucose levels, provided sufficient glucose monitoring is undertaken (Ward & Moneo, 2022).

Incident Example

A patient received 10 units of intravenous (IV) regular insulin for the treatment of hyperkalemia, followed by one ampoule of IV dextrose 50% in water. There was no documentation of glucose monitoring until the physician's assessment approximately 1.5 hours later. The patient experienced a seizure which may have been as a result of hypoglycemia (glucose less than 3.0 mmol/L). Administration of a dose of IV dextrose led to elevation of glucose levels. However, further monitoring showed a subsequent hypoglycemic event, for which additional dextrose was required.

Discussion

In a recent analysis of medication incidents related to the prevention and management of hyperkalemia, one subtheme was lack of monitoring of blood glucose after insulin administration (ISMP Canada, 2026). Key contributing factors to the incidents that involved missed monitoring included misapplication of standard procedure/protocol, performance factors, and miscommunication. In the case described here, staffing and workload were also identified as contributing factors.

Meticulous blood glucose monitoring is required to identify glucose irregularities when IV insulin is administered, even with concurrent administration of dextrose. At a minimum, guidelines suggest measuring blood glucose every hour for 6 hours after insulin is administered (Ward & Moneo, 2022). Also, key to monitoring blood glucose is the recognition of clinical signs and symptoms of hypoglycemia, including trembling, palpitations, sweating, anxiety, and hunger (Lega et al., 2023).

The implementation of insulin order sets with monitoring requirements has been associated with a reduction in the incidence of hypoglycemia for inpatient diabetes management (Sly et al., 2022). Such findings support development of a corresponding order set, with standardized blood glucose monitoring expectations to prevent harm from hypoglycemia, when insulin is used for treatment of hyperkalemia.

Recommendations

Key Practice Tips for Critical Care Nurses

The following are practice tips to mitigate the risk of hypoglycemia resulting from the treatment of hyperkalemia.

- Before administration of insulin
  - Confirm the most recent serum potassium and blood glucose levels.
  - Perform an independent double check of the insulin product, dose, and route of administration against the original order, as well as patient identifiers, prior to administration.
  - Confirm that dextrose has been ordered and administered according to protocol.
- During and after administration of insulin
  - Monitor and document blood glucose at baseline per protocol/orders or every hour for 6 hours as recommended by guidelines (Ward & Moneo, 2022).
  - Reassess serum potassium levels to gauge treatment response.

Recommendations for Nursing Leadership

To address system-based gaps identified in the multi-incident analysis, the following recommendations are shared:

- Advocate for a hyperkalemia order set at your institution, if not already established.
- Ensure the hyperkalemia order set includes the following details:
  - monitoring parameters for blood glucose if IV insulin and IV dextrose are administered
  - monitoring parameters for serum potassium (including consideration of hemolyzed samples)
  - Sequence of therapy is specified (e.g., insulin followed immediately by dextrose, if dextrose is ordered).

Conclusion

Insulin remains an effective treatment for hyperkalemia, and its use demands monitoring to prevent harmful hypoglycemia. Lack of monitoring when insulin is administered to treat hyperkalemia has led to significant harm in critical care settings (ISMP Canada, 2026). Critical care nurses play a central role in ensuring the safety of insulin administration through blood glucose monitoring, early recognition of signs and symptoms of hypoglycemia, and timely intervention when abnormalities are identified.

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The full analysis of incidents involving the prevention and management of hyperkalemia is available: ***https://ismpcanada.ca/bulletin/hyperkalemia/***

The new MedSafety CheckPoint supports safety huddle discussions on organizational risk and safer practices for hyperkalemia prevention and management: ***https://ismpcanada.ca/wp-content/uploads/ISMPCSB2026-i10-hyperkalemia.pdf***