Which neurocritical care skills support daily work in general critically ill patients?

Raffaele Aspide,[1] Carlo Alberto Castioni,[1] Alfredo Del Guadio,[2] Francesca Rubulotta[3,4]

[1]IRCCS Istituto delle Scienze Neurologiche di Bologna, Anesthesia and Neuro Intensive Care Unit, Bologna, Italy; [2]UOC of Anesthesia and Resuscitation II, Fondazione IRCCS Casa Sollievo della Sofferenza, San Giovanni Rotondo, Foggia, Italy; [3]Department of Critical Care Medicine, McGill University, Montreal, Canada; [4]IWIN Foundation, Agira, Italy

Abstract

Intensive Care Medicine is a relatively new discipline that now deals with increasingly complex patients. Aside from the various specificities of the Intensive Care Unit, there are transversal skills that can aid in the care of critically ill patients. Some neurocritical care tools, in particular, deserve adequate dissemination because they have the potential to be useful for a variety of purposes. This manuscript discusses specific indications for electroencephalographic monitoring systems, the use of ultrasonography to measure the diameter of the optic nerve, and, finally, the use of transcranial Doppler. The last two are for the diagnosis or suspicion of intracranial hypertension. Multidisciplinarity and the culture of "patient-centered approach to care" are non-technical skills that are indispensable for quality personalized medicine.

Correspondence: Raffaele Aspide, IRCCS Istituto delle Scienze Neurologiche di Bologna, Anesthesia and Neuro Intensive Care Unit, via Altura 3, 401239 Bologna, Italy.

Key words: neurocritical, pupillometry, optic nerve sheath diameter, transcranial doppler, electroencephalogram.

Conflict of interest: the authors declare no potential conflict of interest, and all authors confirm accuracy.

Ethics approval and informed consent: not applicable.

Availability of data and materials: all data generated or analyzed during this study are included in this published article.

Received: 2 March 2024.
Accepted: 19 April 2024.

Advances in Anesthesia and Pain Medicine 2024; 2:41
doi:10.4081/aapm.41

Introduction

Several reflections can be made to emphasize and provide additional insights on the nature of Neurocritical Care (NCC) as a multidisciplinary sub-specialty requiring numerous skills at the bedside.[1] NCC is inherently multidisciplinary, requiring collaboration among neurologists, neurosurgeons, neuro-angiographers, intensivists, anesthetists, nurses and nurse practitioners, pharmacists, physiotherapists, nutritionists, and many more health care professionals. This collaborative approach is crucial for addressing the complex nature of most critical neurological conditions. Proficiency in hands-on patient care, rapid decision-making, and effective communication with patients, families, and the broader healthcare team is therefore essential.

Defining the skills needed at the bedside in NCC as well as in general Intensive Care Units (ICUs) involves recognizing the unique challenges and dynamics of caring for critically ill neurological patients. These (bedside clinical) skills extend beyond initial assessment; they encompass continuous monitoring and adaptation to the evolving dynamic clinical status of patients. NCC professionals are comfortable utilizing monitoring technologies and integrating real-time data into their decision-making processes.

The authors will present skills that include the ability to work cohesively with diverse healthcare professionals, ensuring a comprehensive and patient-centered approach to care. Simulation-based training and real-world case studies can be invaluable in preparing professionals for the dynamic challenges they will face at the bedside in NCC.

Intensive Care Medicine (ICM) is a relatively young discipline, and it has recently evolved using different models. One end of this spectrum is represented by specialized units such as cardiac ICUs, pediatric ICUs, NCCs, and others. On the other hand, some hospitals have adult or pediatric mixed ICUs. These last models are becoming very common for adult patients due to the increase in comorbidities, the aging of the population, and the complexity of neurological pathologies treated.[2] Moreover, there is a substantial difference between the "open" ICU model most frequent in the United States of America (physicians of different specialties - pulmonologists, cardiologists, neurologists, surgeons - who treat patients hospitalized in critical areas) and the "closed" ICU model mostly used in Australia, New Zealand, Canada and in some European countries (clinicians dedicated trained intensivists).[3]

ICM is a specialty that can be performed by physicians training in internal medicine or emergency medicine as well as anesthesiology. In some other cases, doctors in the ICUs are cardiologists, neurologists, or pediatricians dedicated to critical care patients.[4]

Leaving aside this merely organizational interpretation, the NCC could be defined as the care environment in which the "ICU culture" becomes highly focused on neuroprotection, preventing secondary brain injury. The most recent literature shows that despite the heterogeneity of the studies, mortality is lower in neurocritical patients admitted to specialized NCC.[5] However, the exclusive presence of a neuro-intensivist is not enough, and it is also unclear what specific elements can concretely make a difference in terms of care.[6]

The table in the Appendix could summarize specific skills needed in NCC. In this manuscript Authors will focus on some macro-categories: i) the neurological clinical examination and neuro-imaging; ii) the brain ultrasound and electrophysiology; iii) teamwork and multidisciplinary approach in the golden hours.

The neurological clinical examination and neuro-imaging

The clinical neurological examination is fundamental to recognizing the level of consciousness as well as the severity of the coma. An adequate examination could distinguish structural cerebral pathologies from reversible non-structural causes of decreased consciousness or coma (intoxication, metabolic). These are poorly defined and communicated using for example the Glasgow Coma Scale. Recognizing the signs of deep coma helps prevent misdiagnosis for brain death. These skills are important, even in a general ICU. In an ideal world, all ICUs should declare brain death appropriately given a possible organ or tissue donation.[7,8] A simple tool to implement the clinical examination is represented by automated pupillometry and provides valuable data, much less operator-dependent. The automated pupillometry generates some derived indices that are increasingly correlated with prognosis in some specific pathological contexts (post-anoxic coma after cardiac arrest):[9] it is an inexpensive, easily usable bedside device, through which data can be collected that can be easily communicated even from the territory to the hospital, with almost no learning curve.

Imaging and monitoring include the Magnetic Resonance Imaging (MRI). Apparent Diffusion Coefficient Sequence assumes an important prognostic value in the diagnosis of post-cardiac arrest coma and Return of spontaneous circulation.[10] Together with the continuous electroencephalogram (EEG),[11] from which patterns related to unfavorable neurological outcomes can be highlighted (the incidence of non-convulsive status epilepticus ranges from 12% to 24%), these skills must also be possessed by the doctor who works in a general ICU (Table 1).[11]

The brain ultrasound and electrophysiology

An already centralized patient, who after negative brain image diagnostics, suddenly does not respond to painful stimulus, and presents with anisocoria, may have developed intracranial hypertension: with a 7.5 Mhz linear probe, reducing acoustic power output, Optic Nerve Sheath Diameter (ONSD) can be measured.[12,13] Projects are already underway on the application of Artificial Intelligence for inexperienced operators,[14] but with the right ultrasound settings and about twenty-five examinations, acceptable images and measurements are obtained.[15] ONSD > to 5.5 mm is suspicious for a picture of intracranial hypertension warranting coma (Table 2).[16] If intracranial hypertension is suspected, applying the first measures of protective treatment of the brain (30° test-bed tilt, treating pain, hyperthermia, agitation, and repeating a brain Computer Tomography - CT), helps us gain time:[17] time is brain!

Another method, whose learning curve for a basic examination is slightly more complex, but whose availability is probably very wide (almost all new generation ultrasound machines have the dedicated preset) is TransCranial-Color Doppler (TCCD; Table 3).[18]

Table 1. Electroencephalogram.

Electrophysiological neuromonitoring: now low-cost and available bedside. Bispectral Index (BIS), Sedline©, processed electroencephalography (various brands), allow even non-neurologists an approach to reading. Through index generation or spectrogram display, it is possible to interpret the depth of spontaneous/pharmacological coma, the presence of critical activity (Status Epilepticus - SE), and the presence of hemispheric asymmetries.18
Some applications: - general anesthesia, correct depth of narcosis; - patient in urgent/emergency with altered state of consciousness: discover SE and/or Non-Convulsive SE; - continuous monitoring of the sedated patient in a critical care setting: avoid burst suppression and discover Non-Convulsive SE; - pediatric patient neuromonitoringann altered state of consciousness, abnormal movements or behavior; - patient suspected for meningitis/encephalitis with altered state of consciousness; - continuous monitoring in cardiovascular surgery: early signs of hypoperfusion, macro-embolic events

Table 2. Optic Nerve Sheath Diameter (ONSD).

ONSD: with a 7.5 Mhz linear probe, reducing acoustic power to 20-25%, setting a gain of 50-60%, a measurement of ONSD can be obtained. It is recommended to measure with the patient in the supine position (slightly inclined chest - max 20°), both sagittal and longitudinal diameter, and considering the average of the two values. The caliper marker should be applied to the outer margin of the sheath (hyperechogenic concerning the optic nerve). By adding the color effect, it is possible to visualize the central retinal artery and vein: a useful biomarker to make sure the most accurate measurement possible.16
Some applications: - patient in urgent with sudden cognitive impairment: suspected intracranial hypertension; - pregnant patient with eclamptic evolution in whom there is a contraindication to CT examination; - pediatric patient with suspected hydrocephalus in whom there is contraindication for CT and MRI examination; - intra-operative evaluation of the patient in Trendelenburg position and/or pneumoperitoneum thrust and prolonged (e.g. robotic surgery).

Table 3. TransCranial-Color Doppler (TCCD).

TCCD: 3.5 Mhz sectoral probe (cardiology) with dedicated Transcranial preset. Basic examination: middle cerebral artery insonation with measurement of Peak Systolic Velocity, Diastolic Velocity, and Mean Velocity, automatic calculation of Pulsatility Index, has a high negative predictive value for intracranial hypertension.17 Brain parenchymal ultrasound can also provide reliable information in patients with life-threatening conditions.
Some applications: - patient in urgent/emergency with cognitive impairment: decreased Diastolic Velocities (a sign of intracranial hypertension), TCCD can exclude incipient intracranial hypertension; - patient in spontaneous or pharmacological coma: assessment of cerebral perfusion and possible cerebral reactivity (self-regulation test: advanced TCCD use); - patient in coma: presence of negative waves or systolic spikes with zero diastole: it is a specific pattern for diagnosis of death with brain criteria; - patent foramen ovale for the presence of hits to the tracing after intravenous injection of microbubbles; - continuous monitoring during carotid surgery, major cardiac and Extracorporeal Membrane Oxygenation (ECMO), and intra-arterial balloon pump: monitoring of cerebral hypo/hyper-perfusion, gas/fat embolism diagnosis, correct synchronization of the perfusion pump; - always using the same TCCD probe and the same settings, but with different inclinations, it is possible to obtain a reliable measurement of midline shift and width of the third cerebral ventricle.

Team-work and multidisciplinary approach in the golden hours

The importance of teamwork and a multidisciplinary approach improve the outcome of neurocritical patients.[5] The education also of nurses in the approach to neurological emergencies, makes it possible to deal with time-dependent conditions such as ischemic stroke, reduce the damage produced by the epileptic state, and improve the outcome (correct blood pressure and coagulation management) of the patient with cerebral hemorrhage.[19] A basic platform, which aims to share a common "neuro-vocabulary" may be Emergency Neurological Life Support, a constantly updated Neurocritical Care Society certificate available worldwide.[20]

Conclusions

There are courses and hands-on, scientific societies with training pathways worldwide, but only multidisciplinary collaboration with experts can lead a team to reliably use these non-invasive methods. No system replaces another, but only integration with clinics and imaging can be of real support in daily patient care.

References

1. Tempro K, Chang CWJ. The history of neurocritical care as a subspecialty. Crit Care Clin 2023;39:1-15.
2. Busl KM, Bleck TP, Varelas PN. Neurocritical care outcomes, research, and technology: a review. JAMA Neurol 2019; 76:612-8.
3. Chowdhury D, Duggal AK. Intensive care unit models: Do you want them to be open or closed? A critical review. Neurol India 2017;65:39-45.
4. Rubulotta F, Moreno R, Rhodes A. Intensive care medicine: finding its way in the "European labyrinth". Intensive Care Med 2011;37:1907-12.
5. Kramer AH, Zygun DA. Do neurocritical care units save lives? Measuring the impact of specialized ICUs. Neurocrit Care 2011;14:329-33.
6. Samuels O, Webb A, Culler S, et al. Impact of a dedicated neurocritical care team in treating patients with aneurysmal subarachnoid hemorrhage. Neurocrit Care 2011;14:334-40.
7. Sprung CL, Cohen SL, Sjokvist P, et al. End-of-life practices in European intensive care units: the Ethicus Study. JAMA 2003;290:790-7.
8. Michelson DJ, Ashwal S. Evaluation of coma and brain death. Semin Pediatr Neurol 2004;11:105-18.
9. Oddo M, Sandroni C, Citerio G, et al. Quantitative versus standard pupillary light reflex for early prognostication in comatose cardiac arrest patients: an international prospective multicenter double-blinded study. Intensive Care Med 2018; 44:2102-11.
10. Abdulmajeed F, Hamandi M, Malaiyandi D, Shutter L. Neurocritical care in the general intensive care unit. Crit Care Clin 2023;39:153-69.
11. Rasulo FA, Hopkins P, Lobo FA, et al. Processed electroencephalogram-based monitoring to guide sedation in critically ill adult patients: recommendations from an international expert panel-based consensus. Neurocrit Care 2023;38:296-311.
12. Chen W, Zhang X, Ye X, Ying P. Diagnostic accuracy of optic nerve sheath diameter on ultrasound for the detection of increased intracranial pressure in patients with traumatic brain injury: A systematic review and meta‑analysis. Biomed Rep 2023;19:103.
13. Aspide R, Bertolini G, Albini Riccioli L, et al. A Proposal for a new protocol for sonographic assessment of the optic nerve sheath diameter: The CLOSED Protocol. Neurocrit Care 2020;32:327-32.
14. Moore BT, Osika T, Satterly S, et al. Evaluation of commercially available point-of-care ultrasound for automated optic nerve sheath measurement. Ultrasound J 2023;15:33.
15. Zeiler FA, Ziesmann MT, Goeres P, et al. A unique method for estimating the reliability learning curve of optic nerve sheath diameter ultrasound measurement. Crit Ultrasound J 2016;8:9.
16. Berhanu D, Ferreira JC, Abegão Pinto L, et al. The role of optic nerve sheath ultrasonography in increased intracranial pressure: A systematic review and meta analysis. J Neurol Sci 2023;454:120853.
17. Hawryluk GWJ, Aguilera S, Buki A, et al. A management algorithm for patients with intracranial pressure monitoring: the Seattle International Severe Traumatic Brain Injury Consensus Conference (SIBICC). Intensive Care Med 2019;45: 1783-94.
18. Rasulo FA, Calza S, Robba C, et al. Transcranial Doppler as a screening test to exclude intracranial hypertension in brain-injured patients: the IMPRESSIT-2 prospective multicenter international study. Crit Care 2022;26:110.
19. Greenberg SM, Ziai WC, Cordonnier C, et al. 2022 Guideline

for the management of patients with spontaneous intracerebral hemorrhage: a guideline from the American Heart Association/American Stroke Association. Stroke 2022;53: e282-e361.

20. O'Phelan KH, Miller CM. Emergency neurological life support: third edition, updates in the approach to early management of a neurological emergency. Neurocrit Care 2017; 27:1-3.

Online supplementary material:

Appendix: Key skills that are crucial at the bedside in NCC.