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# Shaping the future of neurocritical care in France

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Neurology and critical care medicine share a long common history that can be traced back to the last European polio epidemic in the 50's. The French neurologists Pierre Mollaret and Maurice Goulon were amongst the pioneers of the field of critical care medicine and contributed to creating one of the first French intensive care units (ICU) in France (at the Claude-Bernard Hospital in Paris). Their landmark paper describing “le coma dépassé”, was published in this journal in 1959 [1]. This work paved the way towards the concept of brain death and organ transplantation. During the next decade, monitoring techniques (e.g. intracranial pressure monitoring, continuous EEG, ...) developed by intensivists, neuroanesthesiologist and neurosurgeons began to be applied to neurological ICU patients. After a primarily neuromuscular-focused infancy, the field of neurocritical care took different paths across the world...

Nowadays, neurocritical care medicine refers to the care of critically ill patients with primary and/or secondary neurological or neurosurgical conditions. Most of the patients who require neurocritical care present a severe disorder of consciousness due to various central nervous system (CNS) pathologies that include traumatic brain injury (TBI), neurovascular diseases (subarachnoid hemorrhage - SAH, severe stroke), refractory status epilepticus, meningitis, viral or dysimmune encephalitis, encephalopathy and complications of neurosurgery. Less frequently, patients require neurocritical care for peripheral nervous system (PNS) diseases such as myasthenia gravis and Guillain Barré syndrome [2].

The scope of neurocritical care medicine also encompasses neurological complications of critical illnesses (e.g. delirium, delayed awakening or ICU acquired weakness) that can occur in general ICUs. Finally, the increasing prevalence of chronic neurologic diseases in ageing populations has led to a higher frequency of neurological issues in general ICUs. The management of these fragile patients can raise medical and ethical challenges that can also benefit from a neurocritical care expertise.

The evolution of neurology moving from a mostly contemplative to a very proactive and complex specialty (e.g. thrombolysis, neuromodulation, immunotherapies, ...) has led to the sub-specialization of neurologists. In

some countries (e.g. US, Germany, ...) Neuro-ICUs are run by neurointensivists with a neurological background. Similarly, the progress in neuroanesthesiology brought to the development of Neuro-ICUs run by neurointensivists with an anesthesiologist - critical care medicine background. The PRINCE Study recently showed a significant variability in the delivery of neurocritical care worldwide [3]. In addition to the physicians' background, organisational structures also vary in terms of leadership (open / closed ICU, dedicated Neuro-ICU or dedicated beds in general ICU). However, similarly to what has been shown for stroke patients, many studies suggest that outcome is improved when patients are cared for in specialized Neuro-ICUs [3,4]. In addition to physicians, highly specialized nurses are also essential success factor (e.g. critical care techniques, neurologic assessment in CNS diseases, respiratory failure in PNS diseases, external ventricular drainage management, intracranial pressure monitoring, continuous EEG, ...).

The modern neurointensivist must know how to recognize and treat a wide range of neurological pathologies. In addition, they need to master the basics of critical care medicine and mobilize integrative knowledge for the interpretation of biological, neurophysiological and neuroradiological explorations. In fact, integrative approaches are a hallmark of the field. Neurologically critically ill patients often require a “multidisciplinary neuroscience team” including a wide panel of highly specialized health care providers. For instance, the acute phase of a severe TBI, stroke, refractory status epilepticus or dysimmune encephalitis could mobilize several different specialists (e.g. neurosurgeon, neuroanesthesiologist, neuroradiologist, neurophysiologist, neurologist ...). “Neuroscience teams” are also necessary at the subacute phase when neuroprognostication takes place. Prognosis of consciousness recovery and of disability are constant medical and ethical matters of concern in neurocritical care. This requires specific expertise to help define the most appropriate medical plan that can include withdrawal of life sustaining therapy, a frequent procedure in Neuro-ICU. Both acute and sub-acute management of patients are active medical research areas inspired by the most recent advances in neuroscience.

The most prominent dedicated society, the Neurocritical Care Society, founded in 2002, gathers thousands of

international members, mostly with a neurology background. In many countries, neurocritical care has become an established sub-specialty and has proven to be very attractive for young neurologists [5]. The dedicated journal Neurocritical Care (ISSN: 1556-0961), launched in 2004 now reaches a broad audience (impact factor = 3.21). The European Academy of Neurology has a Neurocritical Care Scientific Panel that has been developing a dedicated Neuro-ICU fellowship program, for both neurologists and critical care physicians.

In France, most of the Neuro-ICUs are neurosurgical ICUs, primarily managing post operative patients, TBI, SAH and severe strokes. This represents the majority of patients that require neuro critical care. Patients with medical CNS or PNS diseases, that are less frequent are mainly managed in general ICUs. Some tiers-2 Neuro-ICUs can deliver more specific techniques in neurophysiology (e.g. continuous video-EEG, cognitive evoked potentials) or neuroimager (e.g. quantified DTI, spectro MRI) when needed as for instance in case of challenging neuroprognosis [6].

Teaching of neurocritical care also has to be multidisciplinary. In France, two specific one-year training courses dedicated to neurocritical care, have been attended by ~50 students/year for the past 10 years. Attendees are essentially residents and physicians specialized in anesthesiology-intensive care medicine, intensive care medicine and neurology. This large audience has set a solid basis for the constitution of multidisciplinary neuroscience teams and neuroscience networks.

Each health care and faculty system needs to find its optimal organization based on its own constraints. In France, the future of neurocritical care is yet to be determined. It could take the form of acute neurological units working in close relation with the stroke and the general ICU or, Neuro-ICUs managing both neurosurgical and neurologic patients, as in the US and Germany.

In any case, there is no doubt that the increasing number of patients that require multidisciplinary neurocritical and neuroscience teams will prompt us to reshape the organization and the future of neurocritical care in France. We hope that this special issue (the first on this topic in this journal) will contribute to this endeavor by giving the reader a better understanding of the landscape and recent advances of the field of neurocritical care medicine.

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