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NEUROLOGICAL DIGRESSION

Simulation in neurology

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Abstract Simulation is a frontier for disseminating knowledge in almost all the fields of medicine and it is attracting growing interest because it offers a means of developing new teaching and training models, as well as of verifying what has been learned in a critical setting that simulates clinical practice. The role of simulation in neurology, until now limited by the obvious physical limitations of the dummies used to train students and learners, is now increasing since, today, it allows anamnestic data to be related to the instrumental evidence necessary for diagnosis and therapeutic decision-making, i.e., to the findings of neurophysiological investigations (EEG, carotid and vertebral echography and transcranial Doppler, for example) and neuroradiological investigations (CT, MRI imaging), as well as vital parameter monitoring (ECG, saturimetry, blood pressure, respiratory frequency, etc.). Simulation, by providing learners with opportunities to discuss, with experts, different profiles of biological parameters (both during the simulation itself and in the subsequent debriefing session), is becoming an increasingly important tool for training those involved in evaluation of critical neurological patients (stroke, Guillan Barrè syndrome, myasthenia, status epilepticus, headache, vertigo, confusional status, etc.) and complex cases. In this SIMMED (Italian Society for Simulation in Medicine) position paper, the applications (present and, possibly, future) of simulation in neurology are reported.

Keywords Simulation · Neurology · Field training · Neurocritical care

Introduction

There is no field of medical education and training more suited to the use of advanced simulation models than that of neurological disorders, especially those encountered in the emergency room (ER). Many neurological disorders typically have an acute onset that constitutes an emergency situation; neurological emergencies account for a considerable proportion of the medical emergencies dealt with in any hospital, and prompt around 10 % of all ER visits. In Italy, they are the reason for around a third of all the specialist consultations requested in the ERs of hospitals that provide specialist inpatient services.

Acute neurological disorders are often very serious conditions, characterized by high mortality and substantial costs, the latter related not only to the patient's care and treatment, but also to the disabling sequelae of these conditions. Many of these disorders are very common, such as ischemic/hemorrhagic stroke, head trauma, epilepsy, and acute confusional states; whereas, others are less frequent, such as acute polyneuritis, myasthenia, infections of the central nervous system, and acute spinal infections. Furthermore, in many chronic neurological diseases exacerbations can occur (multiple sclerosis flare-ups, episodes of decompensation in neurodegenerative

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diseases, etc.). The first hours after the onset of a neurological disorder are generally the most crucial in determining the patient's outcome and so these patients need to be managed by staff fully trained in the application of standardized intervention protocols designed to guarantee the best possible care and, at the same time, to allow the specialist to acquire immediately all the information he/she needs to establish the diagnosis and treatment plan, and explain these to the patient's family. The emergency neurologist has to make a rapid and accurate diagnosis, in order to reduced mortality, disability, and health costs by preventing inappropriate hospital admissions (only one consultation in three actually leads to admission of the patient to the neurology department). It follows that the management of neurological emergencies demands peculiar and indispensable expertise as well as a multidisciplinary approach. A multidisciplinary approach, based on teamwork, effective distribution of workloads, and sharing of priorities is essential in emergency situations and the lack of expertise among healthcare professionals having to deal with neurological emergencies makes it more difficult increasing the risk of mistakes and loss of valuable time. Emergency neurology, a relatively new field in the broader discipline of neurology, requires not only detailed theoretical knowledge but also the ability, in highly stressful circumstances liable to considerably increase the risk of medical error, to respond adequately to a patient's rapidly changing clinical conditions and follow the correct course of action. The emergency neurologist is faced with a range of crucial tasks, which include identifying the problem and its urgent aspects, applying decision-making algorithms, planning and initiating diagnostic pathways, implementing complex specialist procedures that require specific skill and expertise (e.g., lumbar puncture), and coordinating a team of healthcare professionals from different disciplines. On the other hand, when the neurologist in the ER is not available, the doctors, nurses and other medical staff in the team are obliged to handle the first crucial moments in the management and treatment of neurological patients without the necessary specialist support. It is important to train ER staff to promptly recognize neurological emergencies, to hypothesize diagnoses, and to set care priorities for managing the patient.

Simulation is a technique or method that reproduces in an environment or system, real or virtual, the behaviors that are activated therein, monitoring changes in the situation over time in order to verify, in real time, the consequences of people's actions [1, 2]. All the above considerations explain the importance of simulation as a crucial tool in the training of emergency neurologists and all the other professionals called upon to collaborate in the management of the acute neurological patient.

Simulation models in neuroscience

Advanced simulation models have, in recent years, been applied in various fields of medicine, especially emergency medicine [3, 4] and anesthesia [5, 6], and found to be of great educational value, capable of significantly increasing the knowledge, expertise and performances of healthcare professionals and, ultimately, of increasing patient safety. However, the literature still lacks data on the use of advanced simulation in neurology and, in particular, in emergency neurology, even though, given the growing demand for the intervention of specialist neurologists in the emergency/acute setting, there is a need for specific training in this area.

Mussacchio et al. [7] developed advanced simulation models for training in the field of neurosurgery (spinal shock, closed head injury, and cerebral vasospasm). They pointed out that while traditional lectures can provide a "solid knowledge base", simulation in a protected environment allows the consolidation of this knowledge that is necessary in order to ensure safe and effective interventions in the field. This has since been confirmed in the more strictly neurological setting by Barsuk et al. [8], in relation both to diagnostic–therapeutic management (status epilepticus, ischemic stroke) and to procedures (lumbar puncture).

Of course, the neurological sciences generally are characterized by the complexity of the diagnostic–therapeutic interventions required and it is therefore hardly surprising that traditional training, based on lectures and direct experience of patient care, is unable to provide neurologists with the know-how they need to deal with neurological emergencies. Today's neurologists, despite being equipped with little or no specific emergency training, can find themselves having to manage, in real life, highly complex situations never previously encountered. In such circumstances, they are obviously ill-prepared to manage the critical aspects of the case and coordinate a team effort.

The limited diffusion of simulators in the neurological sciences is due to the technical limitations of these devices, and in particular to the fact that it is difficult, if not impossible, to replicate neurological examinations, a crucial step in the diagnostic workup, using a dummy. It is tempting to overcome this limitation by using videos of neurological examinations. These could be played during sessions with patient simulators, so as to allow trainees to assess independently the presence/absence of neurological deficits and apply scales to quantify the neurological damage. Furthermore, the most advanced simulators can be used to assess pupillary reflexes, eye opening/closure, and to simulate an epileptic seizure.

NewroSim, a recently developed neurological virtual simulator based on validated mathematical models, allows on-line visualization of the main cerebrovascular/hemodynamic variables involved in the mechanisms of cerebral autoregulation triggered by stenosis and occlusion of the main intra and/or extracranial arteries and by changes in intracranial arterial pressure. Changes in blood flow velocity can be detected both visually, as Doppler velocimetry waveform abnormalities, and acoustically [9]. This instrument, used to simulate neurological scenarios, allows the trainee to assess the impact of changes in physiological parameters and/or therapeutic interventions on cerebral perfusion pressure, and their consequent impact on the neurological picture.

Lumbar puncture is a diagnostic test frequently used in neurological emergencies; at present, lumbar puncture simulation is possible only using separate devices, not incorporated into dummies. These devices are useful for mastering the technique, but they do not make for a realistic scenario. In future, therefore, it will be necessary to develop a "neurological dummy" that allows simulation of this procedure.

Another interesting area is that of pharmacological and/or mechanical recanalization therapy, which is becoming an important tool in the management of acute ischemic stroke, albeit in a small subgroup of patients. Similarly to what is happening in the field of cardiology, emergency neurologists in the future will, in part because of the shortage of interventional neuroradiologists, have to acquire the endovascular skills needed in order to intervene in acute ischemic stroke patients not eligible for systemic thrombolysis, or in whom systemic recanalization has failed. The use of advanced endovascular procedure simulators—stand-alone devices and/or devices integrated into dummies—thus look set to become essential tools in the training of the emergency neurologist.

Simulation training courses: types and targets

Simulation training courses in neurology are aimed at individuals with varying levels of professional expertise: medical students, neurology residents, neurologists, nurses, technicians, etc.; groups of healthcare workers with different skills who, operating in the same healthcare setting, are required to manage, in a synergistic fashion, the same patient (physicians and nurses from the Emergency Department, Emergency Neurology Unit, Intensive Care Unit; physicians, nurses, and volunteers from the Emergency Medical System, etc.); professionals operating in different healthcare settings (local services, ERs, neurocritical care units/emergency neurology departments) who should also work synergistically. The main objectives of simulation training courses in emergency neurology are reported in Table 1.

The educational objectives, as in other healthcare disciplines, fall into two categories: (1) acquisition of specific technical skills; (2) learning of the decision-making process for solving specific clinical cases (problem solving).

The educational objectives of a course must be tailored to the learners it addresses. Therefore, a neurological simulation center should provide different types of training intervention, in particular:

- courses to promote the acquisition of skills relating to specific procedures (lumbar puncture, neurosonology, interpretation of EEGs and neuroimaging data) and their subsequent application in the management of "simple" cases in which there is one main, unequivocal "course of action" (courses aimed at medical students and neurology residents)
- courses to promote the acquisition of specific technical skills (blood pressure measurement, placement of ECG and telemetry electrodes, finger prick blood glucose testing, venipuncture, peripheral venous catheter placement, nasogastric tube placement, etc.) (courses aimed at student nurses)
- courses based on clinical scenarios of increasing complexity that reflect absolutely what is encountered when dealing with neurological patients and that allow the acquisition and application of disease-related diagnostic and treatment pathways [courses aimed at individuals taking part in 2nd-level (Masters) degree courses in emergency neurology and at neurologists]
- courses, for physicians and nursing staff, designed to foster acquisition and application, in the single patient, of diagnostic and treatment pathways through simulation of scenarios that raise certain medical and nursing problems whose resolution requires different professionals, at different times, to take charge of the situation (training courses aimed at the medical and nursing staff of neurocritical care units/stroke units)
- courses based on scenarios that evolve according to the timeline of the diagnostic and treatment pathway and involve different professionals contemporaneously and/or in succession (a typical example is that of the management of a stroke patient from the alerting of the emergency services to the patient's discharge from the stroke unit). These courses are aimed at multidisciplinary groups and may see the participation of doctors from different branches of medicine, but also nursing staff and emergency service volunteers. One of the main aims of a course of this kind is to increase the teamwork skills of people having different levels and types of expertise and training.

Table 1 Main goals of simulation training courses in emergency neurology

To reduce the risk of misdiagnosis
To optimize the allocation of the triage code in patients with acute neurological diseases
To optimize the timing of intervention
To create a multidisciplinary ER team that exceeds the current rigid divisions between medical disciplines promoting collaboration

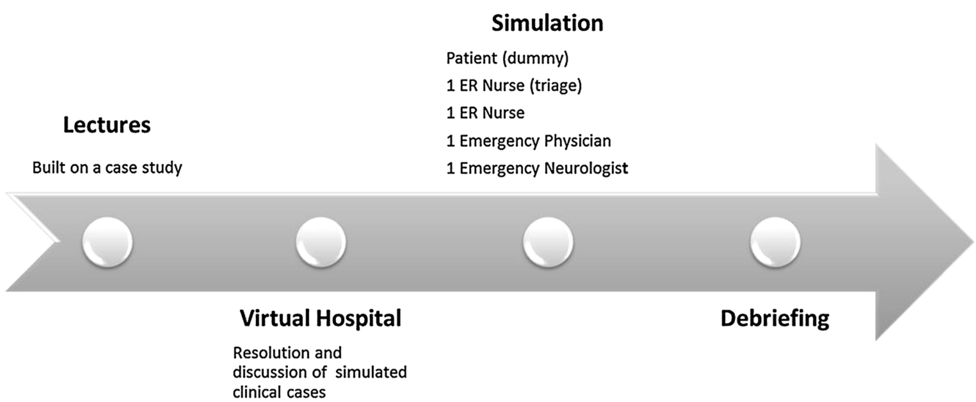

Fig. 1 Structure of a "blended" simulation training course in emergency neurology

The best course structure, taking into account the difficulties in the healthcare setting linked to increasing pressure to reduce staffing levels, seems to be the "blended" structure in which most of the theoretical training and the knowledge consolidation phase are conducted remotely (through video lectures, case resolution using microsimulation models and discussion forums between teachers and students), while the on-site part is limited to a brief session for going over aspects that emerged during the remote training, and the simulation and subsequent discussion of clinical scenarios, focusing in particular on analysis of the teamwork dynamics so as to identify and correct any "dysfunctions" linked to communication processes (Fig. 1). In this regard, the highly innovative simulation training course implemented as part of the Master Degree in Emergency Neurology at the University of Pavia is the first Italian experience on a blended course. The content of this course was divided into four main parts: lectures, macrosimulation, e-learning and practical field experience. The various emergency neurology-related topics are addressed by symptoms, not by etiopathogenetic mechanisms or predefined diagnostic categories. The trainees, on the on-site days, attend lectures during which the presenting symptom, which is the reason for the patient's visit to the ER, is analyzed (considering all the possible differential diagnoses) and discussed with specialists from other disciplines in order to arrive, by the end of the session, at shared decision-making algorithms which are then applied during the macrosimulation (the subsequent session). In the fortnightly intervals between one topic and the next, the course continues in e-learning mode (in the Italian website "Progetto Neurologia Emergenza Urgenza-NEU" devoted to emergency neurology, http://www.progettoneu.it). The e-learning activities are based on a narrative-type teaching approach in which trainees are drawn into a virtual hospital in which they are required to resolve simulated clinical cases and discuss, through dedicated forums, the choices made and difficulties encountered, and so on.

Conclusion

Simulation in neurology is becoming an increasingly important tool for training emergency neurologists and ER staff involved in evaluation of critical neurological patients. This approach allows the acquisition of specific technical skills and to learn the decision-making process for solving urgent and complex clinical cases. A "blended" structure of the courses is suggested with virtual sessions of theoretical training and knowledge consolidation followed by on-site simulation sessions with debriefing. A further technological effort will be done to make the dummy more and more suitable for the creation of neurological scenarios.

Conflict of interest The authors declare that they have no conflict of interest.

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