ENLS Version 2.0

Neurocritical Care Society

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REVIEW ARTICLE

Emergency Neurologic Life Support (ENLS): Evolution of Management in the First Hour of a Neurological Emergency

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Abstract Emergency neurological life support (ENLS) is an educational program designed to provide users advisory instruction regarding management for the first few hours of a neurological emergency. The content of the course is divided into 14 modules, each addressing a distinct category of neurological injury. The course is appropriate for practitioners and providers from various backgrounds who work in environments of variable medical complexity. The focus of ENLS is centered on a standardized treatment algorithm, checklists to guide early patient care, and a structured format for communication of findings and concerns to other healthcare professionals. Certification and training in ENLS is hosted by the Neurocritical Care Society. This document introduces the concept of ENLS and describes the revisions that constitute this second version.

Keywords Emergency · Algorithm · Neurocritical care · Resuscitation · Critical care

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Background

Emergency neurologic life support (ENLS) was created upon the principle that efficient and appropriate management of the early stages of a neurological emergency has substantial impact on patient outcome. Despite an appreciation for this association, the medical community had not historically had standardized approaches to neurologic injuries similar to those developed for trauma and cardiac arrest. The inconsistencies in the methodologies of neurologic resuscitation have been further multiplied by the diversity of expertise of individuals who participate in the initial care of these patients. Few of these providers possess specific training in the neurosciences and, therefore, may struggle to deliver care focused on the neurologic needs of the patient.

ENLS was designed to focus on the fundamentals of acute management of patients suffering a range of neurologic emergencies. The treatment algorithms were devised to be simple, able to be administered across a spectrum of care environments, and clinically applicable for medical care givers of a variety of backgrounds. The basic structure of ENLS education was created by its inaugural chairs, Dr. Wade Smith and Dr. Scott Weingart. They observed a dualistic template for construction of the materials where each of the 13 topics was co-chaired by a practitioner from a critical care and emergency medicine background. The original ENLS algorithms and supporting manuscripts which embodied these tenants were published in *Neurocritical Care* in July 2012 and presented at the Neurocritical Care Society Annual Meeting the following fall [1]. Since that launch, the ENLS curriculum has been taken by hundreds of paramedics, nurses, advanced practice providers, pharmacists, resident and fellow trainees, and physicians of assorted training from around the world.

These individuals have undergone ENLS training either through live courses given by accredited trainers or by on-line self-study on the ENLS training website (http://www.neurocriticalcare.org/).

Participants in the ENLS program undergo an educational experience that possesses a common set of objectives. Each module is built around a central treatment algorithm intended to effectively and efficiently guide the provider through the essential early steps of care. Check lists are provided to ensure consistent and timely completion of crucial tasks. Significant emphasis is placed on instructive and concise communication among team members, particularly during transition to a new care environment. While competency for ENLS materials is assessed by a post-course examination, the educational benefit of the course is intended to be longitudinal. Participants retain access to module manuscripts, algorithms, presentations, and instructional videos throughout the duration of their accreditation. Given the breadth and detail of the materials, users are encouraged to revisit the ENLS website to access reference resources. Due to the paucity of data available regarding best management of emergent neurologic conditions, much of the ENLS recommendations originate from expert opinion rather than established high level evidence. Accordingly, the materials are dynamic documents and users are encouraged to provide constructive feedback to improve the quality of the product. Additionally, it is a goal of the ENLS program to highlight areas where well-supported recommendations are lacking and stimulate academic pursuits to conduct research in these areas of need.

Changes in ENLS Version 2.0

Observation and scrutiny of the original ENLS project have shaped the process and form of the current revision. The content change for the new manuscripts center around three chief priorities:

(A) More comprehensive direction for pre-hospital management of neurological emergencies,
(B) Inclusion of content unique to care of the pediatric patient,
(C) Greater emphasis on the pharmacologic aspects of emergent neurologic care.

Where appropriate, each module contains dedicated pre-hospital and pediatric sections. Furthermore, a new module, *ENLS: Pharmacotherapy,* has been added to the series. All 14 of the module revisions were reviewed by an editor, critical care physician, emergency medicine physician, pharmacists, a pediatric intensivist, neurologist or neurosurgeon, and a paramedic. The final manuscripts have undergone an external peer review process. Special attention was made to align the suggestions of the ENLS protocols with NCS, national, and international guidelines on the same topic. Since the initial launch, all certification questions have undergone numerous reviews to achieve consistency in format, level of difficulty, and relevance to care for the early hours of a neurological emergency. Users are now also able to review a succinct referenced commentary at the end of each module that addresses the correct and incorrect responses to their certification testing. Beginning in the fall of 2015, certified participants of ENLS will be eligible to renew their 2-year certification through an abbreviated on-line course.

New Highlights in Care of the Emergency Neurological Patient

The release of a new version of ENLS is supported by the significant advancements seen in the field of emergency neurology in the past few years. Recent success of endovascular trials for treatment of acute ischemic stroke has impacted the time course and treatment options relevant to these patients and has created the necessity for improved communication and collaboration among treating facilities [2–4]. The recent release of the American Heart Association Guidelines for Spontaneous Hemorrhage addresses new treatment goals for blood pressure control and coagulation reversal [5]. New comparative studies of therapeutic temperature management after cardiac arrest raise questions regarding best temperature targets for neuroprotective therapy and the appropriateness of extrapolation of this strategy to children [6, 7]. These updates and many more have shaped the suggestions found in the following manuscripts.

For participants who wish to improve the convenience and accessibility of their ENLS resources, an ENLS iBook is now available which provides a comprehensive prose reference that is complimentary to the course manuscripts and algorithms [8]. Individual chapters are also available for purchase.

The ENLS project is indebted to the authors and reviewers who spent considerable time ensuring that the revised version met expectations for content, quality, and clinical guidance. The authors and reviewers are listed in Tables 1 and 2. Special gratitude is appropriate for Becca Stickney, who has provided extraordinary management and administrative support throughout this process.

Table 1 List of ENLS protocols and their authors

Topic	Authors
Acute non-traumatic weakness	**Oliver Flower, MD**
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	Mark S. Wainwright MD, PhD
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	Anna Finley Caulfield, MD
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Airway and ventilation and sedation	**David Seder, MD**
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	Andy Jagoda, MD
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	Becky Riggs, MD
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Approach to the comatose patient	**Rhonda S Cadena, MD**
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Intracerebral hemorrhage	**Ed Jauch, MD, MS**
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Intracranial hypertension and herniation	**Robert D. Stevens, MD**
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Ischemic stroke	**Harmut Gross, MD**
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Meningitis/encephalitis	**David Gaieski, MD**
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Resuscitation following cardiac arrest	**Jon Rittenberger, MD**
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Status epilepticus	**Jan Claassen, MD**
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	James J. Riviello, Jr., MD
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	Robert Silbergleit, MD
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	Owen Samuels, MD
	Emory University School of Medicine
Traumatic brain injury	**Rachel Garvin, MD**
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	Chitra Venkatasubramanian, MD, MSc.
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	Angela Lumba-Brown, MD
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	Chad M. Miller, MD
	OhioHealth
Traumatic spine injury	**Deborah Stein, MD**
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	Vincent Roddy, MD
	Broward Health Medical Center
	William Knight, MD
	University of Cincinnati
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Conclusion

The revised version of ENLS maintains its aim to provide guidance for management of patients with emergent neurologic conditions. This latest version has expanded upon

Table 2 ENLS Version 2 manuscript reviewers

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the multi-disciplinary approach to algorithm creation and has integrated new science and lessons learned from the original version into the new protocols. ENLS is appropriate and relevant for all types of providers practicing in a diverse array of settings. The educational value of ENLS is intended to extend beyond the initial instructional encounter as the supporting materials can serve as a convenient reference.

Acknowledgments We wish to thank all of the co-chairs in Table 1 for their efforts, as well as Dr. Daryl Gress for providing peer review of the manuscripts. Becca Stickney from the Neurocritical Care Society has taken the administrative management of ENLS to a higher level. We wish to thank many contributors in Table 2 who provided extensive feedback on pharmaceutical aspects of each protocol and at the editorial level within their specialty. Lastly, to all those members of the Neurocritical Care Society who took time from their busy practices to provide feedback: these protocols are yours. Please use them to educate others outside of your craft so that all patients have access to the best care possible in those critical first hours.

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REVIEW ARTICLE

Emergency Neurological Life Support: Airway, Ventilation, and Sedation

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Abstract Airway management and ventilation are central to the resuscitation of the neurologically ill. These patients often have evolving processes that threaten the airway and adequate ventilation. Furthermore, intubation, ventilation, and sedative choices directly affect brain perfusion. Therefore, airway, ventilation, and sedation was chosen as an emergency neurological life support protocol. Topics include airway management, when and how to intubate with special attention to hemodynamics and preservation of cerebral blood flow, mechanical ventilation settings, and the use of sedative agents based on the patient's neurological status.

Keywords Airway · Ventilation · Sedation · Neurocritical care · Emergency

Introduction

Intubation of the acutely brain-injured patient can be a matter of life or death. Failure to intubate a patient with rapidly progressive neurological decline may result in respiratory arrest, secondary brain injury from hypoxia, acidosis, or elevated intracranial pressure (ICP), and severe aspiration pneumonitis or acute respiratory distress syndrome (ARDS).

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Conversely, the process of induction and intubation can elevate intracranial hypertension when a mass lesion is present, complete a massive infarction when brain tissue is marginally perfused, and result in temporary loss of the neurological examination at a time when neurological and neurosurgical decision-making is required.

The goals of airway management in neurological patients are to maintain adequate (but not excessive) oxygenation and ventilation, preserve cerebral perfusion, and prevent aspiration. A neurological assessment prior to the administration of sedating and paralyzing medications should be performed to provide a functional baseline, whereby neurological and neurosurgical decision-making may ensue.

The emergency neurological life support (ENLS) suggested algorithm for the initial management of airway, ventilation, and sedation is shown in Fig. 1. Suggested items to complete within the first hour of evaluating a patient are shown in Table 1.

Assessing the Need for Intubation

Patients in severe respiratory distress or impending arrest should be intubated without delay. Additionally, a patient who cannot "protect his airway" because of depressed mental status or vomiting with aspiration may need tracheal intubation. Intubation has the potential for complications, creates significant hemodynamic disturbances, and should not be undertaken without a risk benefit assessment. However, it should not be delayed when necessary. The decision to intubate is influenced by factors specific to patient physiology, clinical environment, and the anticipated course of care.

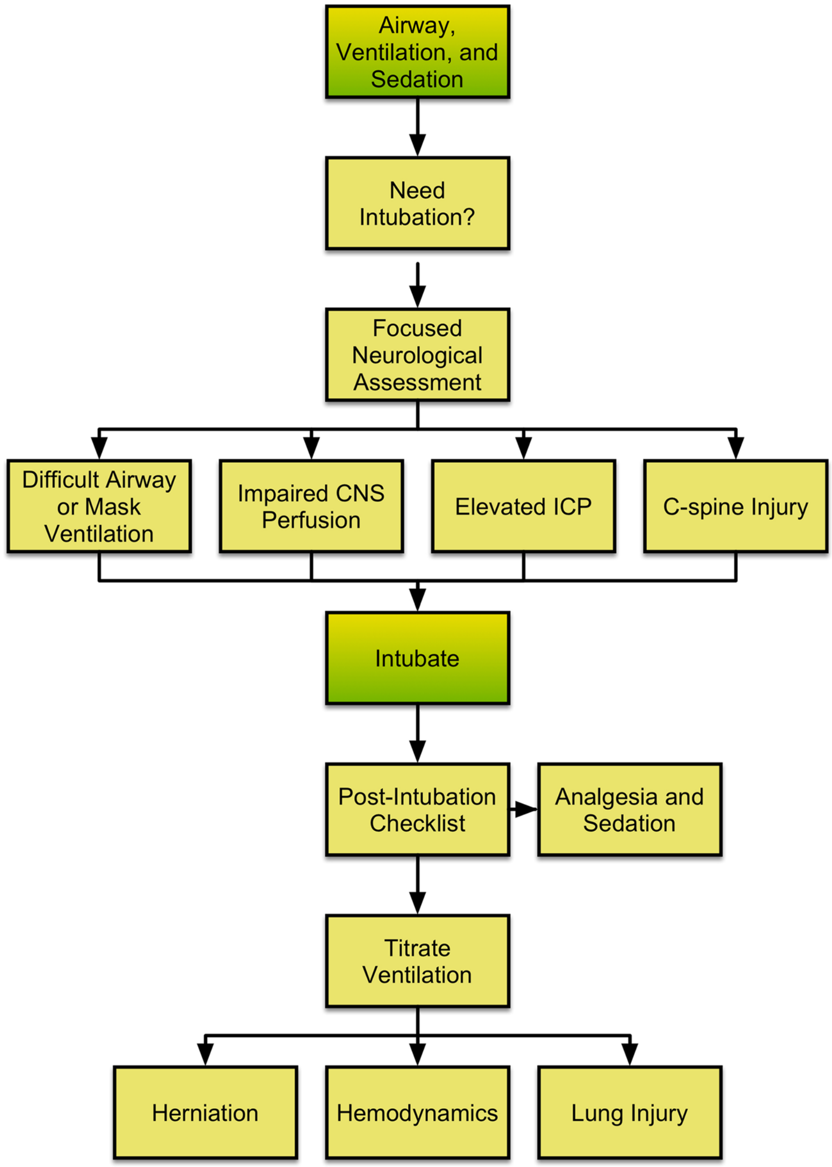

Fig. 1 ENLS airway, ventilation, and sedation protocol for patients requiring intubation, consideration should be given to difficult airway or mask ventilation, impaired CNS perfusion, elevated ICP, and potential cervical spine injury

Table 1 Airway, ventilation, and sedation checklist within the first hour

Checklist
☐ Assess the need for intubation or non-invasive positive pressure ventilation
☐ Perform and document a focused neurological assessment prior to intubation
☐ Verify the endotracheal tube position
☐ Determine ventilation and oxygenation targets, and verify with ABG/SpO_2/$ETCO_2$
☐ Assess the need for analgesia and/or sedation in mechanically ventilated patients

In the prehospital or emergency department (ED) environment, a stuporous or comatose patient with an unknown diagnosis requiring extended transport, transfer, imaging, or invasive procedures may be most appropriately managed by intubation. The same patient with a known physiology, an anticipated stable or improving course, and no planned transportation may not require intubation and might be managed by a more conservative approach.

With these considerations in mind, there are four commonly accepted indications to intubate:

Failure to Oxygenate

This finding may be determined by pulse oximetry (limitations include regional or systemic hypoperfusion, severe anemia, and opaque nail polish), arterial blood gas analysis, or the patient's visual appearance (cyanosis).

Failure to Ventilate

Ventilation is assessed by capnometry through nasal cannula monitoring (does not always correlate with pCO_2, but provides a valuable tool for monitoring trends in ventilation) [1], arterial blood gas analysis, or gross visual appearance (excessive or inadequate work of breathing).

Failure to Protect the Airway

Airway protection determined by bulbar function, airway anatomy, quantity and quality of secretions, strength of cough reflex, and ability to swallow after suctioning [2]. The presence of a gag reflex is an inaccurate method of assessing airway protection [3].

Anticipated Neurological or Cardiopulmonary Decline Requiring Transport or Immediate Treatment

Anticipation of the trajectory of the patient's condition can avoid rushed or emergent intubations and allow for appropriate preparation for the procedure.

Airway Assessment

Full assessment of the airway includes determination of the ease of bag-mask ventilation and the potential for a difficult intubation. Expectation of a difficult airway enables appropriate planning and use of available advanced airway equipment. This may include assistance from airway management specialists (e.g., call for anesthesia assistance), use of specialized devices, such as fiberoptic bronchoscopy, or mobilizing equipment for a cricothyrotomy). In certain circumstances availability of a laryngeal mask airway (LMA), may be warranted.

The "LEMON" pneumonic helps to predict the difficult airway [3]:

L Look
E Evaluate the mouth opening and airway position
M Mallampati score
O Obstruction
N Neck mobility

The "MOANS" pneumonic predicts difficulty of bag-mask ventilation [3]:

M Mask seal
O Obesity/obstruction
A Age > 55
N No teeth
S Stiff lungs

Decision Made to Intubate: Perform Neurological Assessment

Whenever possible, urgent management of the airway should coincide with a rapid but detailed neurological assessment. The examination can typically be conducted in 2 min or less.

The pre-sedation/pre-intubation neurologic exam establishes a baseline that is used to assess therapeutic interventions (e.g., patients with stroke, seizures, hydrocephalus, or other disorders) or may identify injuries that are at risk of progressing (e.g., unstable cervical spine fractures). The assessment identifies the type of testing required and may help to limit unnecessary interventions, such as radiological cervical spine clearance. In general, the pre-intubation neurological assessment is the responsibility of the team leader who is coordinating the resuscitation. Findings should be documented and communicated directly to the team that assumes care of the patient.

As demonstrated in Appendix 1, the pre-intubation neurological examination includes an assessment of:

- Level of arousal, interaction, and orientation, as well as an assessment of simple cortical functions, such as vision, attention, and speech comprehension and fluency
- Cranial nerve function
- Motor function of each individual extremity
- Tone & reflexes
- Comment on subtle or gross seizure activity
- Cervical spine instability
- Sensory level in patients with suspected spinal cord injury

Intubating the Patient with Intracranial Pathology

Rapid sequence intubation (RSI) is the preferred method of securing the airway in patients with suspected elevated ICP. RSI limits elevation of ICP often associated with the physiologic responses to laryngoscopy [4–7]. The presence of coma should not justify proceeding without pharmacological agents, or administration of only a neuromuscular blocking agent without appropriate pre-treatment and induction agents. Although the patient may seem unresponsive, laryngoscopy and intubation often provoke reflexes that elevate ICP unless appropriate pre-treatment and induction agents are used [8].

Outcomes in patients with intracranial catastrophes are related to the maintenance of both brain perfusion and oxygenation. Consequently, close assessment and