Emergency Neurological Life Support® Airway, Breathing, and Mechanical Ventilation Version 6.0

Authors
Thomas Delmas, MD
Gentle S Shrestha, MD, FNCS

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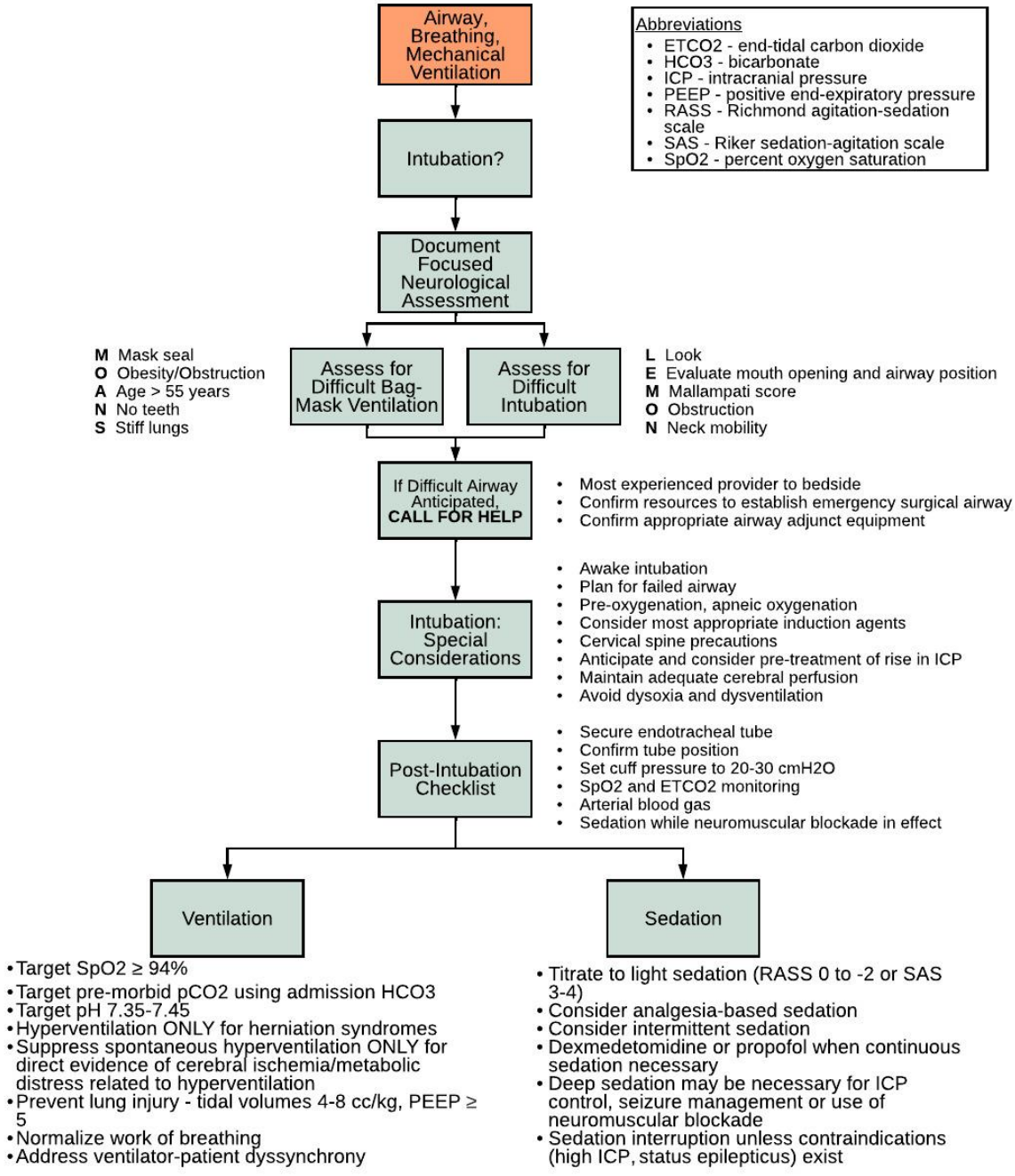
AIRWAY, VENTILATION AND SEDATION ALGORITHM



CHECKLIST

- ☐ Assess the need for intubation or noninvasive positive pressure ventilation
- ☐ Perform and document a focused neurological assessment prior to intubation
- ☐ Perform adequate airway assessment, complete pre-intubation checklist and intubate patient
- ☐ Verify the endotracheal tube position
- ☐ Determine ventilation and oxygenation targets, and verify with ABG/SpO2/ETCO2
- ☐ Assess the need for analgesia and/or sedation in mechanically ventilated patients

COMMUNICATION

- ☐ Mental status and neurological examination immediately pre-intubation
- ☐ Vitals, hemodynamics and gas exchange pre- and post-intubation
- ☐ Relevant drugs used around intubation
- ☐ Technique of intubation, confirmation of tube position
- ☐ Ease of bag mask ventilation, intubation and tube passage
- ☐ Cormack-Lehane grade, if appropriate
- ☐ Ventilator settings, ventilation, and ETCO2 targets
- ☐ Analgesia and sedation strategy
- ☐ Pending investigations

AIRWAY, VENTILATION, SEDATION

Neurocritically ill patients often have evolving processes that threaten the airway and adequate ventilation; as such, airway and respiratory management are of utmost importance. Airway management, intubation, ventilation, and sedative choices directly affect brain physiology and perfusion. Emergency Neurologic Life Support® (ENLS) topics discussed here include acute airway management, indications for intubation with special attention to hemodynamics and preservation of cerebral blood flow, initiation of mechanical ventilation and the use of sedative agents based on the patient's neurological status in the setting of acute neurologic injury.

INTUBATION - DOES THE PATIENT NEED TO BE INTUBATED?

There are five commonly accepted indications to intubate a patient:

1. **Failure to oxygenate:** The assessment of hypoxemia includes visual inspection for respiratory distress or cyanosis and objective findings of hypoxia on pulse oximetry or arterial blood gas (ABG) analysis.

2. **Failure to ventilate:** The assessment of hypercapnia includes visual inspection of respiratory effort and accessory muscle use, elevated carbon dioxide (CO_2) on capnography and hypercapnia with acidosis on ABG.

3. **Loss of airway reflexes:** The assessment of airway reflexes incorporates numerous variables including bulbar function, airway anatomy, secretion burden, strength of cough reflex and ability to swallow after suctioning. The presence of a gag reflex alone is an inadequate method of assessing airway protection.

4. **Elective peri-procedural intubation:** Anticipation of peri-procedural intubation can allow for preemptive intubation for the procedure as opposed to rushed or emergent intubations.

5. **Neuromuscular weakness:** Neuromuscular weakness may affect ventilation. Hypercapnia followed by poor oxygenation are late signs of neuromuscular respiratory failure. To rapidly assess at the bedside prior to respiratory failure, have the patient count as high as possible on a single exhalation and test neck flexion and extension strength. Forced vital capacity of 1.0 L is roughly equal to counting from 1–10 and counting above 20 is normal. Frequent pulmonary function testing may be needed to monitor for progressive ventilatory failure.

DOCUMENT FOCUSED NEUROLOGICAL ASSESSMENT

Before sedatives/paralytics administered

Whenever possible, urgent management of the airway should coincide with a focused neurological exam that may be conducted as quickly as possible. Document the neurological exam in the record. This is an important baseline for subsequent care and is essential prior to sedation or chemical paralysis.

Exam should include:

- Level of arousal, interaction, and orientation, as well simple cortical functions such as vision, attention, and speech comprehension and fluency
- Cranial nerve function
- Motor function of each individual extremity
- Tone and reflexes
- Sensory level in patients with suspected spinal cord injury
- Involuntary movements such as tremor or seizure
- Cervical tenderness or gross spinal abnormality

AIRWAY ASSESSMENT

Assess for difficult bag-mask ventilation and intubation.

A difficult airway may be broadly defined as an endotracheal intubation attempt in which a provider who is appropriately trained in airway management experiences difficulty with bag-mask ventilation, tracheal intubations or both.

The "MOANS" mnemonic helps predict ease of bag-mask ventilation:

M = Mask seal; may be compromised by abnormal facies, facial hair
O = Obesity / Obstruction (e.g., 3rd trimester pregnancy, neck swelling, angioedema, hematomas, cancer)
A = Age > 55 years
N = No teeth
S = Stiff lungs

The "LEMON" mnemonic helps to predict difficult tracheal intubations:

L = Look for abnormal external facial features and body habitus
E = Evaluate the mouth opening and airway position using the 3-3-2 rule
- 3 fingers in open mouth between incisors
- 3 fingers between chin (mentum) and hyoid
- 2 fingers between hyoid and superior thyroid notch

M = Mallampati score
- Grade I- Soft palate, entire uvula, faucial pillars visible
- Grade II- Soft palate, entire uvula visible
- Grade III- Soft palate, base of uvula visible
- Grade IV- Only hard palate visible

O = Obstruction/obesity
N = Neck mobility

The “MACOCHA” mnemonic successfully predicts difficult tracheal intubation:

M = Mallampati Score III or IV (5 points) (Figure 2)
A = Apnea Syndrome (obstructive) (2 points)
C = Cervical spine limitation (1 point)
O = Opening mouth < 3 cm (1 point)
C = Coma (1 point)
H = Hypoxia (<80%) (1 point)
A = Anesthesiologist non-trained (1 point)
Score > 3 suggests a difficult airway

PRE-INTUBATION CHECKLIST

PATIENT

1. **RELIABLE IV/ IO ACCESS**
2. **OPTIMAL POSITION**
   - Head of bed- consider 30º-45º elevation
   - Bed height
   - Access to airway
   - Sniffing/ neutral
3. **PRE-OXYGENATION**
   - Heated high flow nasal cannula 60-70 L/min
   - Noninvasive positive Pressure ventilation
   - Reservoir-bag mask
   - Bag-valve mask
4. **APNEIC OXYGENATION IN PLACE**
   - Heated high flow nasal cannula 60-70 L/min
   - Nasal cannula 15L/min
5. **OPTIMIZE PATIENT STATE**
   - Pre-treat with fentanyl and lidocaine
   - Raised intracranial pressure- 23.4% NaCl or mannitol
   - Hypotension / hypovolemia- fluid bolus or vasopressors infusing
   - Left / right ventricular failure- vasopressor available/infusing

EQUIPMENT

1. **MONITORING**
   - SpO2 with volume turned up
   - Quantitative waveform capnography (ETCO2)
   - Electrocardiogram Blood pressure- cuff to cycle every 2 minutes or arterial line. Cuff not on side of SpO2 probe.
2. **EQUIPMENT**
   - Laryngoscope handle and blades, test bulb
   - Video laryngoscope, blade and rigid stylet
   - Endotracheal tube x2 with stylet- selected size and smaller option
   - Bougie
   - Oral / nasal airway
   - Suction
   - CO2 detector
   - Supraglottic airway
   - Kit for invasive airway
3. **MEDICATIONS**
   - Sedative
   - Neuromuscular blocking agent
   - Vasopressor
   - Sedation / analgesia following intubation

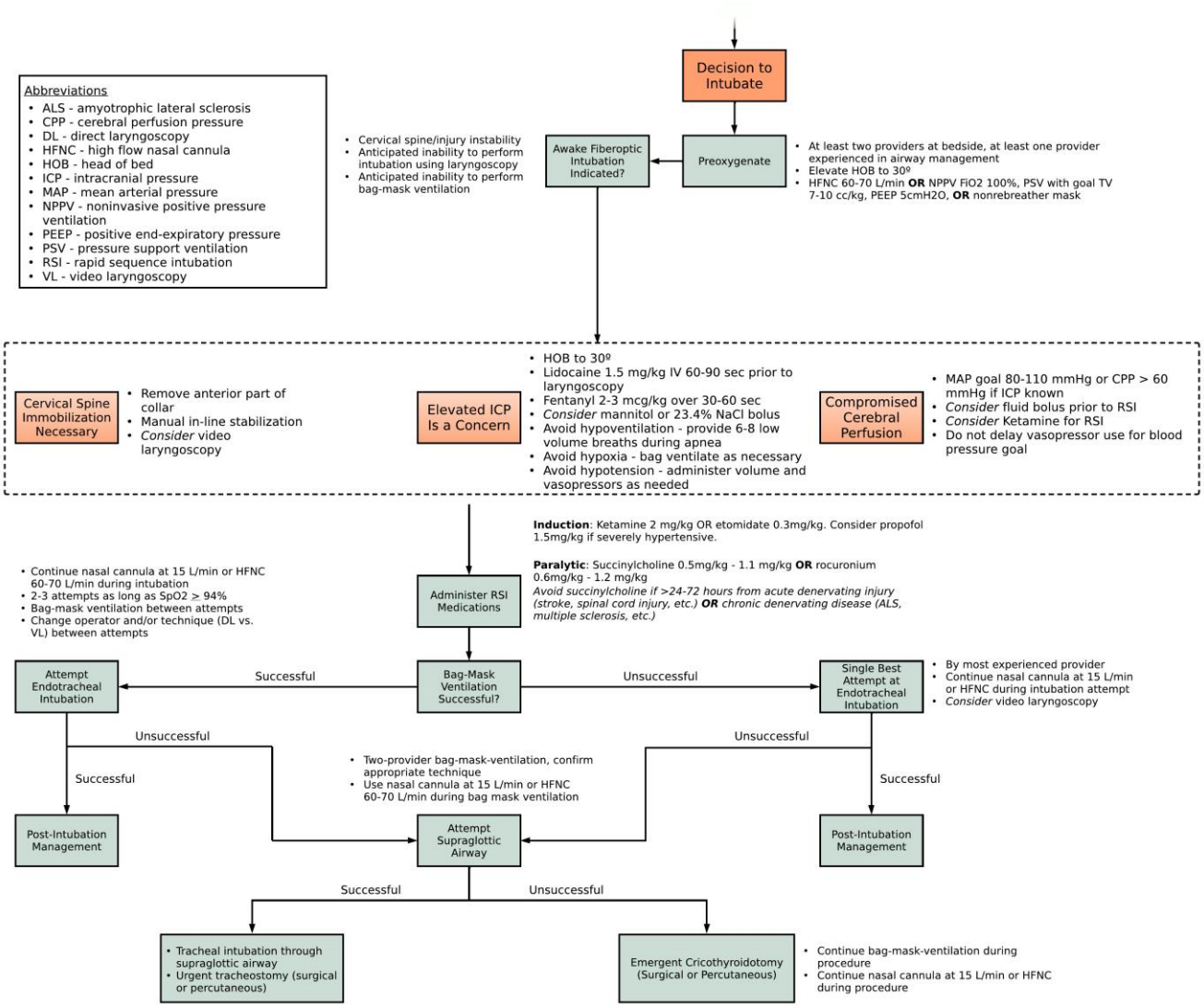
TEAM

1. **ASSIGN ROLES**
   - First intubator
   - Backup intubator
   - Bag-mask ventilation
   - Manual in-line stabilization
   - Drugs
   - Monitoring
   - Documentation
   - Invasive airway
2. **Who will be called for backup?**

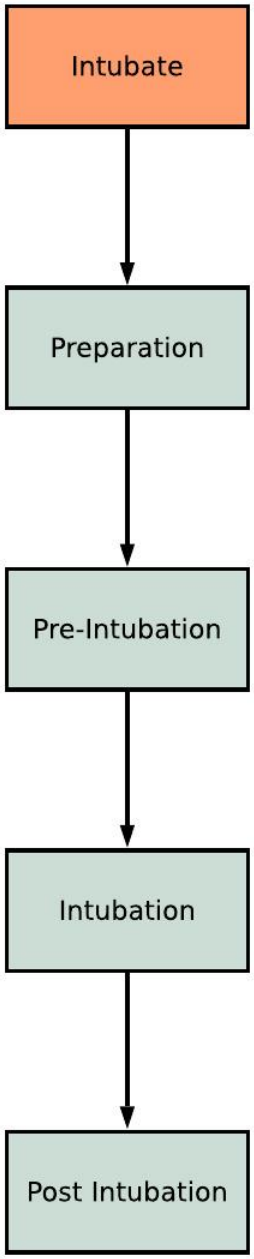
PLAN FOR DIFFICULTY

1. **CANNOT INTUBATE CAN VENTILATE**
   - 2-3 attempts by experienced operator with apneic oxygenation as long as SpO2 ≥94%
   - Supraglottic airway
   - Invasive airway
2. **CANNOT INTUBATE CANNOT VENTILATE**
   - Supraglottic airway
   - Emergent Cricothyroidotomy

ALGORITHM FOR ENDOTRACHEAL INTUBATION



INTUBATION SEQUENCE FOR ELEVATED ICP



Preparation

- Elevate head of bed
- Intravenous access at two sites
- Infuse isotonic crystalloid
- Have vasopressor available
- Have intubation medications ready
- NPO, consider gastric decompression

Pre-Intubation

- Preoxygenate
- Administer any pretreatment medications
- Consider osmotic agents (mannitol or hypertonic saline)
- Administer induction agent and paralytic simultaneously
- Allow for full muscle relaxation (45 sec for succinylcholine, 60 sec for rocuronium)
- Administer 6-8 low volume ventilations during apnea

Intubation

- Lower head flat to intubate
- Return to 30 degree elevation when completed
- Avoid hypotension
- Avoid hypoventilation
- Bag-mask ventilate immediately if desaturation occurs

Post Intubation

- Keep head elevated at 30 degrees
- Do not hypoventilate
- Avoid hypoxia
- Consider $EtCO_2$ monitoring
- Keep $SpO_2 \geq 94\%$
- Secure ETT and check position by CXR

POST-INTUBATION CHECKLIST

- ✓ Secure endotracheal tube
- ✓ Confirm tube position, order chest x-ray
- ✓ Set cuff pressure to 20-30 cmH_2O
- ✓ Pulse oximetry and quantitative waveform capnography
- ✓ Arterial blood gas measurement
- ✓ Consider analgo-sedation for patient comfort
  - Deep sedation while neuromuscular blockade in effect
  - Consider hemodynamic support for hypotensive patients
- ✓ Counsel next of kin on change in patient status

GOALS OF MECHANICAL VENTILATION

Mechanical ventilation must be carefully titrated to maintain physiologic homeostasis as $PaCO_2$ is a potent acute mediator of cerebral vascular tone and cerebral blood flow. Hyperventilation to a low $PaCO_2$ and high pH may cause decreased cerebral blood flow, worsening brain ischemia. Hypoventilation to a high $PaCO_2$ and low pH may cause cerebral vasodilation and worsen intracranial hypertension. Hypoxia is an important cause of secondary brain injury, while hyperoxia may also be harmful.

Immediately following intubation, respiratory and hemodynamic homeostasis should be restored. The goals of mechanical ventilation are:

- Normalization of oxygenation utilizing the lowest FiO_2 that will maintain oxygen saturation of hemoglobin ≥ 94%
- Normalization of ventilation to achieve a systemic pH of 7.35–7.45, and $PaCO_2$ to 35–45 mmHg (4.7 – 6.0 kPa) or $ETCO_2$ that corresponds to $PaCO_2$ target
- Therapeutic hyperventilation ONLY in the setting of acute cerebral herniation
- Normalization of the work of breathing
- Prevention of ventilator induced lung injury, using tidal volumes of 6-8 ml/kg ideal body weight and positive end-expiratory pressure (PEEP) ≥ 5
- Management of ventilator-patient dyssynchrony

Ideal Body Weight:

Men - 50 kg + 2.3 kg for every inch > 60 inches height (or every 2.54 cm above 152 cm)

Women - 45.5 kg + 2.3 kg for every inch > 60 inches height (or every 2.54 cm above 152 cm)

Oxygenation Goal: PaO_2 > 110 mmHg, or SpO_2 ≥94%, or disease specific goal.

ANALGO-SEDATION

The goal of analgesia and sedation in the critically ill patient with neurological illness is to use the lowest dose of sedative/ analgesic that maintains comfort and ventilator-patient synchrony, while avoiding over-sedation and preserving the ability to clinically assess the patient's neurological status.

Occasionally, severe intracranial hypertension, status epilepticus, or the need for neuromuscular blockade may necessitate a state of deep, continuous sedation.

- Titrate to light sedation using a validated sedation scoring system- Richmond Agitation-Sedation Scale (RASS) 0 to -2 or Riker Sedation Agitation Scale (SAS) 3 to 4.
- Consider starting with analgo-sedation, using a short acting opioid infusion.
- Consider intermittent sedation.
- Dexmedetomidine or Propofol are preferred when continuous sedation is necessary.
- Deep sedation is necessary when neuromuscular blocking agents are used, in the presence of intracranial hypertension refractory to light sedation, and the management of seizures refractory to other antiseizure therapy.
- Perform daily sedation interruption unless contraindications exist (e.g., high ICP, status epilepticus).
- Employ non-pharmacological strategies: attention to day/night sleep cycles, limit noise, play music as appropriate, reassuring presence of family and friends.

Commonly used sedative and analgesic agents in the neurocritical care unit

Fentanyl: Fentanyl is an opioid agonist exhibiting analgesic effects with a rapid onset and a short duration of action. It is an agent which can be used for analgo-sedation, or in combination with a sedative.

Propofol: The lipid formulation of propofol allows for rapid penetration of the blood brain barrier, resulting in rapid onset and cessation of action. It has potent and immediate depressant effects on cerebral electrical and metabolic activity and does not require renal or hepatic metabolism for elimination. Disadvantages include robust vasodilating and hypotensive effects, considerable IV lipid load, and the potential for the rare, but frequently fatal, propofol infusion syndrome. Not preferred in pediatric patients.

Benzodiazepines: Midazolam has a rapid onset of action and short duration of effect with bolus administration, making it an ideal agent for procedural sedation. Bolus-dose midazolam is a good choice for intermittent agitation in the NCCU population. Conversely, midazolam infusions have been associated with prolonged mechanical ventilation and delirium.

Dexmedetomidine: Dexmedetomidine is a centrally acting alpha-2 agonist. Desirable properties include rapid onset and termination of activity, mild to moderate sedation without significant respiratory depressant action, analgesic effects and less delirium than the benzodiazepines. Undesirable properties include a high incidence of bradycardia and hypotension.