



Advisory No. 97-03

Hyperventilation in Severe Traumatic Brain Injury

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SEMAC

State Emergency Medical
Advisory Committee

New York State
Department of Health

Note:

This advisory guideline announces important changes in the *Statewide Basic Life Support Adult and Pediatric Treatment Protocols*. Revised copies of each of the protocols affected by these changes are attached. Revised copies of each of the protocols affected by these changes are also being sent to all emergency medical services agencies statewide.

Regional Emergency Medical Advisory Committees, and regional, system, and service medical directors are directed to facilitate use of the revised protocols at the local level, and are further advised to modify local protocols, policies, and procedures accordingly.

Hyperventilation in Severe Traumatic Brain Injury

Current *Statewide Basic Life Support Adult and Pediatric Treatment Protocols* stipulate that hyperventilation, at a rate of 20 breaths per minute in an adult and 25 breaths per minute in a child, should be employed in major trauma whenever a head injury is suspected, the patient is not alert, the arms and legs are abnormally flexed and/or extended, the patient is seizing, or has a Glasgow Coma Scale of less than 8. The State Emergency Medical Advisory Committee has reviewed these protocols, and concludes, on the basis of recent scientific evidence, that in the patient with severe traumatic brain injury (Glasgow Coma Scale score ≤ 8) following open or closed head injury, aggressive hyperventilation should be avoided in the prehospital setting, unless there are active seizures or signs of transtentorial herniation.

Although hyperventilation was used throughout the 1970s and 1980s in the acute management of severe traumatic brain injury, its use has undergone critical reappraisal in recent years. This has occurred following the publication of several reports linking excessive hyperventilation ($P_aCO_2 < 25$ mm Hg) to cerebral ischemia, as well as a large prospective randomized study which failed to demonstrate any benefit, but instead demonstrated a slight detriment, to head injured adult patients ventilated to achieve a P_aCO_2 of 25 mm Hg versus head injured adult patients ventilated to achieve a P_aCO_2 of 35 mm Hg. In 1995, the Brain Trauma Foundation, in collaboration with the American Association of Neurological Surgeons and the Joint Section on Neurotrauma and Critical Care, published evidence-based Guidelines for the Management of Severe Head Injury, which call for moderation in the use of hyperventilation in the acute management of severe traumatic brain injury. The State Emergency Medical Advisory Committee has reviewed these guidelines, and the scientific evidence on which they are based, and endorses the guidelines pertaining to initial resuscitation as an appropriate standard of prehospital care for patients with severe traumatic brain injury.

With respect to integration of brain-specific treatments into the initial resuscitation of the severe head injury patient, the Guidelines state:

“The first priority for the head-injured patient is complete and rapid physiologic resuscitation. No specific treatment should be directed at intracranial hypertension in the absence of signs of transtentorial herniation or progressive neurological deterioration not attributable to extracranial explanations. When either signs of transtentorial herniation or progressive neurological deterioration not attributable to extracranial explanations are present, however, the physician should assume that intracranial hypertension is present and treat it aggressively. Hyperventilation should be rapidly established. The administration of mannitol is desirable, but only under conditions of adequate volume resuscitation.”

With respect to resuscitation of blood pressure and oxygenation, the Guidelines state:

“Hypotension (systolic blood pressure < 90 mm Hg) or hypoxia (apnea or cyanosis in the field or a P_aO_2 < 60 mm Hg) must be scrupulously avoided, if possible, or corrected immediately.”

With respect to use of hyperventilation in the acute management of severe traumatic brain injury, the Guidelines state:

“The use of prophylactic hyperventilation ($P_aCO_2 \leq 35$ mm Hg) therapy during the first 24 hours after severe TBI should be avoided because it can compromise cerebral perfusion during a time when cerebral blood flow (CBF) is reduced.”

With respect to acute neurologic deterioration or refractory intracranial hypertension, the Guidelines state:


“Hyperventilation therapy may be necessary for brief periods when there is acute neurological deterioration, or for longer periods if there is intracranial hypertension refractory to sedation, paralysis, cerebrospinal fluid (CSF) drainage, and osmotic diuretics.”


Thus, normal ventilation is now recognized as the appropriate standard of care for initial management of severe traumatic brain injury. Yet, it is difficult for prehospital personnel to know whether they are achieving normal ventilation, particularly when using a bag and mask. To avoid this problem, prehospital personnel are advised to utilize strategies that maximize oxygen delivery and minimize inadequate ventilation. The State Emergency Medical Advisory Committee believes that these goals can best be accomplished by utilizing ventilatory rates that are likely to avoid both hyperventilation and hypoventilation, hence to assure adequate ventilation, an approach which is consistent with the 1997 Edition of the Advanced Trauma Life Support Course of the American College of Surgeons.

It is assumed that the recommended rates for assisted ventilation contained in the 1992 Edition of the Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiac Care of the American Heart Association, 12 breaths per minute (1 breath every 5 seconds) for an adult and 20 breaths per minute (1 breath every 3 seconds) for a child 8 years of age or less, are sufficient to support adequate ventilation. Thus for adults with severe traumatic brain injury (Glasgow Coma Scale score ≤ 8), the assisted ventilatory rate should be 12 breaths per minute (1 breath every 5 seconds), while for children 8 years of age or less with severe traumatic brain injury (Glasgow Coma Scale score ≤ 8), the assisted ventilatory rate should be up to 20 breaths per minute (1 breath every 3 seconds). Only if active seizures, or signs of transtentorial herniation such as fixed or asymmetric pupils, neurologic posturing (decerebrate or decorticate), Cushing's reflex (hypertension and bradycardia), periodic breathing (Cheyne-Stokes, central neurogenic, ataxic breathing), or neurologic deterioration (further decrease in Glasgow Coma Scale score of 2 or more points), are present may hyperventilation be considered, and ventilatory rates increased to 20 breaths per minute in adults and to 25 breaths per minute in children. The *Statewide Basic Life Support Adult and Pediatric Treatment Protocols* have been modified to reflect this change, and Regional Emergency Medical Advisory Committees, and regional, system, and service medical directors are advised to modify local protocols, policies, and procedures accordingly.

Selected References

1. Brain Trauma Foundation, American Association of Neurological Surgeons, Joint Section on Neurotrauma and Critical Care: Guidelines for Management of Severe Head Injury. New York: Brain Trauma Foundation, 1995.
2. Obrist WD, Langfitt TW, Jaggi JL, et al: Cerebral blood flow and metabolism in comatose patients with severe head injury. J Neurosurg 1984;61:241-253.
3. Muizelaar JP, Marmarou A, Ward JD, et al: Adverse effects of prolonged hyperventilation in patients with severe head injury: a randomized clinical trial. J Neurosurg 1991;75:731-739.
4. Bouma GJ, Muizelaar JP, Stringer WA, et al: Ultra early evaluation of regional cerebral blood flow in severely head injured patients using xenon enhanced computed tomography. J Neurosurg 1992;77:360-368.


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Adult Major Trauma - Continued

- I. Establish and maintain airway control while manually stabilizing the cervical spine.

Note:

The following management may be instituted before or during extrication or en route as appropriate. In no case should patient transport be delayed because of this management!

- II. Assess the patient's ventilatory status.

A. If the ventilatory status is inadequate:

1. Insert an oropharyngeal or nasopharyngeal airway.
2. Ventilate the patient with an adjunctive device and high concentration oxygen at a rate of 12 breaths per minute. **Assure that the chest rises with each ventilation.**

Caution:

If head injury is suspected, the Glasgow Coma Scale (GCS) score is less than 8, and active seizures or one or more of the following signs of brain herniation are present, hyperventilate the patient with high concentration oxygen at a rate of 20 breaths/min.

- Fixed or asymmetric pupils**
- Abnormal flexion or abnormal extension (neurologic posturing)**
- Hypertension and bradycardia (Cushing's reflex)**
- Intermittent apnea (periodic breathing)**
- Further decrease in GCS score of 2 or more points (neurologic deterioration)**

Do not hyperventilate unless the above criteria are met.

3. **Expose the patient's chest to locate and identify injuries and to listen for breath sounds.**
 4. **Seal any open chest wounds with occlusive dressing; Stabilize impaled objects in the chest.**
- B. If the ventilatory status is adequate, administer high concentration oxygen as soon as possible.**

Pediatric Major Trauma - Continued

- I. Establish and maintain airway control while manually stabilizing the cervical spine.
- II. Assess the child's ventilatory status, including exposing the chest to locate and identify injuries.
 - A. **If the ventilatory status is inadequate (the child is cyanotic, the respiratory rate is low for the child's age or capillary refill is greater than 2 seconds):**
 1. Ventilate the child with a pocket mask or bag-valve-mask and high concentration oxygen at a rate of up to 20 breaths per minute. **Assure that the chest rises with each ventilation.**

Caution:

If head injury is suspected, the Glasgow Coma Scale (GCS) score is less than 8, and active seizures or one or more of the following signs of brain herniation are present, hyperventilate the child with high concentration oxygen at a rate of 25 breaths/min.

- Fixed or asymmetric pupils**
- Abnormal flexion or abnormal extension (neurologic posturing)**
- Hypertension and bradycardia (Cushing's reflex)**
- Intermittent apnea (periodic breathing)**
- Further decrease in GCS score of 2 or more points (neurologic deterioration)**

Do not hyperventilate unless the above criteria are met.

2. Expose the child's chest to locate and identify injuries and to listen for breath sounds.
3. Seal any open chest wounds with an occlusive dressing. Stabilize impaled objects in the chest.

Caution:

Adequate ventilation requires disabling the pop-off valve if the bag-valve-mask is so equipped!

- B. **If the ventilatory status is adequate (the child is breathing spontaneously at a respiratory rate appropriate for the child's age, cyanosis is absent and capillary refill is less than 2 seconds), administer high concentration oxygen (preferably humidified) by a face mask as soon as possible.**

Suspected Head or Spinal Injuries (Not Meeting Major Trauma Criteria)

- I. Establish and maintain airway control while manually stabilizing the cervical spine.
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Note:

If the patient is standing, assist the patient to the ground using an appropriate technique.

- II. Assess the patient's ventilatory status and assist the patient's ventilations as necessary; administer high concentration oxygen and suction as necessary.
- A. If the ventilatory status is inadequate, ventilate the patient with an adjunctive device and high concentration oxygen at a rate of 12 breaths/min (adult) or a rate of up to 20 breaths/min (child). **Assure that the chest rises with each ventilation.**
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Caution:

If head injury is suspected, the Glasgow Coma Scale (GCS) score is less than 8, and active seizures or one or more of the following signs of brain herniation are present, hyperventilate the patient with high concentration oxygen at a rate of 20 breaths/min in an adult and 25 breaths/min in a child.

- Fixed or asymmetric pupils**
- Abnormal flexion or abnormal extension (neurologic posturing)**
- Hypertension and bradycardia (Cushing's reflex)**
- Intermittent apnea (periodic breathing)**
- Further decrease in GCS score of 2 or more points (neurologic deterioration)**

Do not hyperventilate unless the above criteria are met.

- B. If the ventilatory status is adequate, administer high concentration oxygen as soon as possible.
- III. Assess the patient's circulatory status.
- IV. Obtain and record the patient's initial vital signs, including the Glasgow Coma Scale and a neurological assessment (i.e., level of consciousness [AVPU], pupils, and sensory and motor function in the extremities) before and after spinal immobilization.
- V. Immobilize the patient's head and spine with a rigid cervical collar and an appropriate immobilization device (i.e., a KED, Kansas Board, XP1, or shortboard) if the patient is sitting or a longboard if the patient is in a face-up position.

Appendix - Pediatric

Appropriate Ventilatory Rates for Assisted Ventilation

<u>Age Group</u>	<u>If Respiratory Rate Is:</u>	<u>Ventilate At:</u>
Infant (< 1 yr)	< 30/min	20/min
Toddler (1 - 2 yr)	< 25/min	20/min
Preschooler (3 - 5 yr)	< 20/min	20/min
School Age (6 - 12 yr)	< 15/min	20/min
Adolescent (13 - 18 yr)*	< 10/min	12/min

Appropriate Ventilatory Rates for Hyperventilation in Severe Head Injury with Coma and Seizures or Herniation

<u>Age Group</u>	<u>Hyperventilate At:</u>
Infant (< 1 yr)	25/min
Toddler (1 - 2 yr)	25/min
Preschooler (3 - 5 yr)	25/min
School Age (6 - 12 yr)	25/min
Adolescent (13 - 18 yr)*	20/min

Hyperventilate only if GCS < 8 and one or more are present:

- Active seizures
- Asymmetric pupils
- Cushing's reflex
- Periodic breathing
- Neurologic posturing
- Neurologic deterioration

Criteria for Tachypnea (Rapid Respiratory Rate)

<u>Age Group</u>	<u>Respiratory Rate:</u>
Infant (< 1 yr)	> 60/min
Toddler (1 - 2 yr)	> 40/min
Preschooler (3 - 5 yr)	> 35/min
School Age (6 - 12 yr)	> 30/min
Adolescent (13 - 18 yr)*	> 30/min

Use this formula to estimate the upper limit of respiratory rate in pediatric patients 1 - 10 yr

$$40 - (2x \text{ age})$$

Criteria for Tachycardia (Rapid Heart Rate)

<u>Age Group</u>	<u>Heart Rate:</u>
Infant (< 1 yr)	> 160/min
Toddler (1 - 2 yr)	> 150/min
Preschooler (3 - 5 yr)	> 140/min
School Age (6 - 12 yr)	> 120/min
Adolescent (13 - 18 yr)*	> 100/min

Use this formula to estimate the upper limit of heart rate in pediatric patients 1 - 10 yr

$$150 - (5x \text{ age})$$

Criteria for Hypotension (Low Blood Pressure)

<u>Age Group</u>	<u>Blood Pressure:</u>
Infant (< 1 yr)	< 60 mm Hg
Toddler (1 - 2 yr)	< 70 mm Hg
Preschooler (3 - 5 yr)	< 75 mm Hg
School Age (6 - 12 yr)	< 80 mm Hg
Adolescent (13 - 18 yr)*	< 90 mm Hg

Use this formula to estimate the lower limit of systolic blood pressure in pediatric patients 1 - 10 yr

$$70 + (2x \text{ age})$$

* Adult Value Used