Clothesline Injury to Neck with Transected Trachea and Broken Cervical Spine

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Educational Objectives:
Upon completion of this PBLD, participants will be able to:

1. Discuss the mechanisms of injury and clinical presentation of blunt neck trauma and laryngotracheal disruption in children.
2. Describe the considerations for airway management in patients with suspected laryngotracheal disruption and cervical spine fracture.
3. Summarize best practice recommendations for the anesthetic management of acute cervical spinal cord injuries in children.
4. Compare the effects of various anesthetic agents on neurophysiologic monitoring.

Case History:
A 12-year-old boy sustains a clothesline injury to his anterior neck from a steel cable while riding a dirt bike at 30 miles per hour in a rural part of Colorado. The steel cable strikes him on the upper chest and rolls onto his anterior neck. The patient's father witnesses the accident and reports that the patient lost consciousness for about 30 seconds and had difficulty phonating on regaining consciousness.

Upon arrival at the scene, the paramedics note that the patient is breathing spontaneously, following commands and moving all four extremities. He has a bruise in his anterior neck and is not able to phonate. The paramedics place a cervical collar and decide to transport him via helicopter to a nearby rural hospital.

Questions?
As the paramedic at the scene:
Discuss your options for airway management in this patient.
Knowing that he will be transported in a small helicopter, how does that affect your decision regarding airway management?

The paramedics perform a rapid sequence induction and intubate the patient after direct visualization of the vocal cords. The paramedic also notices 'some kind of tracheal defect' during laryngoscopy. The patient's oxygen saturations are in the mid 80s after intubation and they do not improve during transport. However, the patient's heart rate and blood pressure are stable during transport.

Outside Hospital Course
Upon arrival in the Emergency Department (ED) at the outside hospital, his oxygen saturations are in mid 80s and blood is noted in the endotracheal tube. An Anesthesiologist and ENT surgeon are at the bedside and are unable to pass a

suction catheter through the endotracheal tube. The patient oxygen saturations drop to 60%.

Questions?
As the Anesthesiologist at the outside hospital:
Discuss your options for airway management in this patient.
Describe the considerations for airway management in patients with suspected laryngotracheal disruption.
Discuss the common mechanisms of injury and clinical presentation of laryngotracheal disruption.
Discuss the anticipated complications with a mal-positioned ETT in this patient and their management.
Explain your rationale for ordering imaging studies after his airway has been secured.

After securing the patient's airway, he is transferred to the Operating Room (OR) for an urgent tracheostomy. The ENT surgeon performs a low tracheostomy (just above sternal notch) between the third and fourth tracheal rings and places a cuffed 4.0 Shiley tracheostomy tube. A single safety suture is placed through an upper tracheal ring and it is taped to the upper chest.

A CT scan of the neck reveals an unstable fracture and subluxation of the C2/3 vertebrae with evidence of spinal cord edema and ongoing impingement. There is extensive subcutaneous emphysema in the neck without any evidence of vascular injuries. Subsequently the patient is transferred to our hospital for further management.

Questions?
As the ED physician at the tertiary hospital:
Formulate a plan for consulting other services before the patient is taken to the operating room.
Explain your rationale for ordering any additional imaging studies.

As the Anesthesiologist:
Summarize your anesthetic concerns with this patient.

Tertiary Hospital Course
The patient is taken to the operating room and the orthopedic surgeon wants to perform an urgent closed reduction of his cervical spine and halo vest immobilization. The ENT surgeon wants to perform direct laryngoscopy, flexible tracheoscopy and esophagoscopy.

Questions?
Develop a plan for induction and maintenance of general anesthesia.
Describe the implications of his acute cervical spinal cord injury on your anesthetic management.
Explain your rationale for using any additional monitors.

Direct laryngoscopy by the ENT surgeon reveals normal anatomy. Advancing the flexible bronchoscope beyond the vocal cords reveals complete separation of the trachea below the cricoid cartilage. The orthopedic surgeon is unable to achieve a satisfactory alignment of the cervical spine and is hesitant to proceed in the absence of neurophysiologic monitoring. After halo vest immobilization, the patient is transferred to the Intensive Care Unit for monitoring.

The next morning, the orthopedic surgeon wants to reattempt a closed reduction of the cervical spine with the aid of neurophysiologic monitoring and warns about the possibility of an open posterior cervical spinal fusion and instrumentation in a prone position. The ENT surgeon wants to perform an open neck exploration and repair the tracheal laceration.

Questions?
Explain your rationale for choosing which surgeon should proceed first.
Discuss your back up plan for airway management, should the tracheostomy fall out while the patient is in a prone position.

A closed reduction of the cervical spine is attempted and results in only a minimal improvement in C2-C3 alignment. During the initial manipulation, the left upper extremity motor evoked potentials drop by 50%.

Question?
Compare the effects of anesthetic agents on neurophysiologic monitoring.
Describe your strategies for optimizing the anesthetic in the setting of a decrease in motor evoked potentials.

Open neck exploration reveals complete laryngotracheal separation between the first and second tracheal rings and the proximal and distal segments are separated by approximately 6 cm. An open tracheoplasty is performed with end-to-end anastomosis and the tracheostomy stoma is matured. The patient is transferred to the Intensive Care Unit for monitoring.

A couple of days later, the orthopedic surgeon wants to perform an open cervical spinal fusion from C2 –C4 with instrumentation in the prone position. He plans on using neurophysiologic monitoring and asks if it is safe to turn this patient prone.

Question?
Discuss your concerns regarding positioning this patient in a prone position.
Explain your rationale for proceeding with or waiting to schedule this patient for his next surgery.

Discussion

Laryngotracheal Injuries from Blunt Neck Trauma in Children

Introduction

Pediatric laryngotracheal injuries from blunt neck trauma are extremely rare, but can be potentially catastrophic. Early diagnosis and skillful airway management is critical in avoiding the significant morbidity and mortality associated with these cases.

Laryngotracheal injuries secondary to blunt trauma are encountered in less than 1% of all trauma patients.[1, 2] The incidence of pediatric laryngotracheal injuries from blunt trauma is even lower secondary to a combination of behavioral and anatomical factors.[1-4] Children are less likely to be involved in motor vehicle accidents and violent altercations. Anatomically the superior position of pediatric larynx and a relatively shorter neck allows the mandibular arch to shield the larynx to some extent. Additionally the laryngeal cartilages in children are more pliable, decreasing the likelihood of laryngeal fractures. However the narrower lumen of the pediatric airway and the loose adherence of laryngeal mucosa to the perichondrium in children increase the risk of soft tissue damage, edema and hematoma formation with possible airway obstruction. [1-4]

Mechanisms of Injury

The mechanisms of laryngotracheal injury from blunt neck trauma include: [1-5]

1. Direct impact to laryngeal cartilages crushing it against the cervical vertebrae.
2. Rapid deceleration injuries that generate high shearing forces at the points of relative fixation (cricoid cartilage and carina) causing tracheal disruption.
3. Sudden increase in intra tracheal pressure associated with reflex glottic closure causing barotraumatic rupture.
4. Sudden increase in transverse diameter of the chest caused by antero-posterior compression of the chest wall, resulting in lateral traction on the trachea and linear rupture.

Common etiologies of laryngotracheal injuries from blunt neck trauma include: [1-5]

1. Rapid deceleration of a motor vehicle, causing an unrestrained occupant to be thrown forward, usually with the head extended. The neck collides with the steering wheel or dashboard.
2. Clothesline injuries to the neck while riding motorcycles, all-terrain vehicles or snowmobiles when the rider strikes a stationary object such as a wire fence or tree limb. Clothesline injuries can also occur in high contact sports and martial arts.
3. Direct trauma to the neck from interpersonal violence (direct blows using fists, feet or blunt weapons)
4. Strangulation from hanging, ligature suffocation or manual choking.
5. Blunt trauma to the chest.

In younger children, common etiologies include falls onto furniture and bicycle handlebars with the neck extended. [1-5]

Clinical Presentation
Early diagnosis often requires a high index of clinical suspicion. The presenting symptoms of pediatric laryngotracheal injuries from blunt neck trauma are varied and range from mild dysphonia and hoarseness of voice to stridor and acute respiratory distress.[1-5] Other symptoms include dyspnea, dysphagia, anterior neck pain, hemoptysis and cough. On physical examination, particular attention must be paid to subcutaneous emphysema, edema, abrasion or ecchymosis in the neck, loss of laryngeal landmarks and palpable cartilage fractures. It is important to note that patients who are relatively asymptomatic or stable on initial presentation may rapidly deteriorate and develop respiratory distress from airway obstruction. [1-5]

Initial Management
On arrival at the Emergency Department, advanced trauma and life support protocols must be followed. The initial management of the patient depends on the stability of the patient's airway. If the patient's airway is stable, a detailed history and physical examination is performed followed by a flexible fiberoptic laryngoscopy at the bedside. In the presence of minor endolaryngeal edema or hematoma without any evidence of airway compromise, the patient can be managed conservatively with serial endoscopies and discharged home if there is no evidence of progression after 24 to 48 hours.[6] Chest and neck radiographs must be ordered to rule out the presence of cervical spine fractures, subcutaneous emphysema, pneumothorax or pneumomediastinum.

The initial airway management of a child with an unstable airway in acute respiratory distress remains controversial.[6] Direct laryngoscopy and endotracheal intubation runs the risk of aggravating an existing injury, converting a partial injury to a complete transection or creating a false passage. Performing a tracheostomy at the bedside under local anesthesia in children can be very challenging. If the ENT surgeon and operating room are immediately available, the airway must be secured after induction of general anesthesia under direct vision with a rigid bronchoscope.[6] After securing the airway, a tracheostomy can be performed over the bronchoscope. A panendoscopy that includes microlaryngoscopy, bronchoscopy and esophagoscopy must be performed to rule out associated injuries.

A CT scan of the neck provides valuable information regarding the anatomy of the endolarynx and the presence of laryngeal cartilage fractures, cervical spine injuries and vascular injuries. The routine use of a CT scan in blunt neck injuries remains controversial and is usually reserved for cases where the results determine the management course.[1, 6]

Classification of laryngotracheal injuries
Based on the severity of the injury, laryngotracheal injuries are classified into five groups. Traditionally patients in groups 1 and 2 are managed conservatively, while surgical intervention is reserved for patients in groups 3 to 5.[7]

Group	Characteristics

I	Minor endolaryngeal hematoma; minimal airway compromise, if any; no detectable fractures
II	Endolaryngeal hematoma or edema associated with compromised airway; minor mucosal lacerations without exposed cartilage; non displaced fracture on CT scan
III	Massive endolaryngeal edema with airway obstruction; mucosal tears with exposed cartilage; immobile vocal cord(s)
IV	Same as group III with more than two fracture lines on imaging studies; massive derangement of endolarynx
V	Laryngotracheal separation

Table 1: Classification of laryngotracheal injuries.[7]

Cervical Spine Injuries in Children

Cervical spine fractures and dislocations are less common in children than in adults, representing less than 2% of all pediatric trauma cases.[8] Unlike adults, cervical spine injuries in children less than 8 years of age typically involve the upper cervical spine (i.e. occiput, C1, C2) and are more likely to be associated with neurological injury.[8] Young children have proportionally larger heads and less well developed muscular control of their heads. Children over 12 years of age have anatomy similar to adults and incur injuries throughout the cervical spine.

Motor vehicle accidents are the most common cause of cervical spine injuries in children. Falls in young children and sports related injuries in older children are the second most common cause of cervical spine injuries.[8]

Initial Management

Early immobilization of the cervical spine and a high index of suspicion are essential to prevent further neurological damage. A combination of a hard cervical collar and spine board are commonly used to immobilize the cervical spine. When children less than 8 years of age are positioned supine on a spine board, the relatively larger head circumference causes relative cervical flexion.[8] So immobilization should be achieved using a spine board with a head recess or the trunk should be elevated by 25 mm. Upon arrival at the hospital, the spine board offers no advantage over a firm bed and should be removed.

Airway Management

Manual in-line stabilization (MILS) of the cervical spine is recommended during direct laryngoscopy. MILS is typically provided by an assistant positioned either at the head of the bed or by the side facing the head of the bed.[8, 9] While positioned at the head of the bed, the assistant grasps the mastoid processes with their fingertips and cradles the occiput in the palms of their hands. Ideally the assistant counteracts the force generated by the laryngoscopist by applying an equal force in the opposite direction and avoids traction forces.[9] During MILS, the anterior portion of the cervical collar can be removed to increase mouth opening. When correctly performed MILS decreases laryngeal exposure, making direct laryngoscopy and intubation more difficult.

In addition to direct laryngoscopy with MILS, various other intubation techniques have been described. These include fiberoptic bronchoscope assisted intubation, Glidescope video laryngoscope, Lightwand, Bullard laryngoscope, retrograde wire techniques and blind nasotracheal intubation.[8]

Systemic Effects
Cervical spine fractures may be associated with acute cervical spine cord injury. Neurogenic shock presents as hypotension and bradycardia resulting from a functional sympathectomy.[8] The loss of cardiac accelerator fibers (T1-T4) prevents tachycardia that normally occurs in response to hypotension. The loss of peripheral vasoconstriction from the functional sympathectomy increases the venous capacitance resulting in relative hypovolemia. To decrease the risk of secondary injury to the spinal cord, hypotension and hypoxia must be treated aggressively, maintaining the mean arterial pressures more than 85 mmHg and PaO_2 more than 60 mmHg. [8]

Positioning
Patients with unstable cervical spine injuries being temporarily managed with cervical orthosis or halo vest must be positioned with extreme caution to prevent further injury. When transferring the patient, log roll precautions and a sliding board must be used. When positioning a patient with a halo vest in the prone position, the halo ring is attached to a Mayfield headrest on the operating table.[8]

Neurophysiologic Monitoring
Intraoperative neurophysiologic monitoring (IONM) is routinely used during cervical spine surgery to continuously assess the functional integrity of the spinal cord. Typically a combination of neurophysiologic monitoring modalities are used that include transcranial electric motor evoked potentials (tceMEPs), somatosensory evoked potentials (SSEPs) and electromyography (EMG). [10]

SSEPs are cortical or subcortical responses to repetitive electrical stimulation of a peripheral nerve (e.g. ulnar, median, posterior tibial, common peroneal nerves) and directly assess the integrity of the ascending spinal cord sensory tracts. A 50% decrease in signal amplitude and a 10% increase in latency are considered clinically significant.[10] Motor evoked potentials on the other hand evaluate the descending motor pathways. In tceMEPs, following the transcranial application of an electrical stimulus, the MEPs are recorded either directly from the spinal cord (D- or I- waves) or from muscle (compound muscle action potential-CMAP). The stimuli for tceMEPs are of much higher amplitude causing patient movement and so MEPs are measured intermittently during the surgery. A bite block is necessary to prevent injury to the tongue. A 50% decrease in amplitude is considered clinically significant.[10] EMGs are used to assess the integrity of specific spinal nerve roots.

Most anesthetic agents have a profound influence on neurophysiologic signals.[10] All volatile anesthetic agents including nitrous oxide have more depressant effects on neurophysiological monitoring than intravenous agents. SSEPs are depressed by volatile agents in a dose-related fashion and are only obtainable at sub MAC doses of volatile agents. Motor evoked potentials are extremely sensitive to the effects of inhalational agents. Monitoring of MEPs also precludes the use of muscle relaxants. Opioids and benzodiazepines have negligible effects on neurophysiologic monitoring. Propofol attenuates the amplitude of all evoked potentials, but can still be used for neurophysiologic monitoring. Total intravenous anesthesia with propofol and short acting opioids (fentanyl, remifentanil) are commonly used for monitoring of MEPs.[10]

References

1. Osthuzien JC. *Pediatric blunt laryngeal trauma: A review.* Intl J Otolaryngol. doi:10.1155/2011/183047.
2. Wootten CT, Bromwich MA, Myer CM 3rd. Trends in blunt laryngotracheal trauma in children. Int J Pediatr Otorhinolaryngol 2009; 73(8): 1071-5.
3. Sidell D, Mendelsohn AH, Shapiro NL, St.John M. Management and outcomes of laryngeal injuries in the pediatric population. Ann Otol Rhinol Laryngol. 2011; 120(12): 787-95.
4. Mandell DL. *Traumatic emergencies involving the pediatric airway.* Clin Ped Emerg Med. 2005 6; 41-48.
5. Hamid UI, Jones JM. *Combined tracheoesophageal transection after blunt neck trauma*. J Emerg Trauma Shock 2013: 6 (2); 117-122.
6. Gold SM, Gerber ME, Shott SR, Myers CM. *Blunt laryngotracheal trauma in children.* Arch Otolaryngol Head Neck Surg. 1997; 123(1): 83-7.
7. Fuhrman GM, Stieg FH, Buerk CA. Blunt laryngeal trauma: classification and management protocol. J Trauma. 1990; 30:87-92.
8. Vanderhave KL, Chiravuri S, Caird MD, Farley FA, Graziano GP, Hensinger RN, Patel RD. *Cervical spine trauma in children and adults: perioperative considerations.* J Am Acad Orthop Surg 2011; 19: 319-327.
9. Crosby ET. *Airway management in adults after cervical spine trauma.* Anesthesiology 2006; 104:1293-318.
10. Kincaid MS, Lam AM. Anesthesia for neurosurgery. In: Barash PG, Cullen BF, Stoelting RK, Cahalan MK, Stock MC editors. Clinical Anesthesia. 6th edition. Philadelphia: Wolter Kluwer, Lippincott Williams and Wilkins. ; 2009. pg 1010-1012.