The Traumatic Airway

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Hillcrest Hospital
Cleveland Clinic

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The Traumatic Airway

No disclosures
Goals and Objectives

• Describe airway anatomy and innervation

• Recognize the association of a traumatic mechanism and a potential airway injury

• Implement the management of a traumatic airway in different clinic settings

• Explain various surgical airway approaches
The Traumatic Airway
The Traumatic Airway

- Case Presentation
- Anatomy
- Mechanism of Injury
- Management
- Summary
The Traumatic Airway

• Case Presentations
  • Anatomy
  • Mechanism of Injury
  • Management
  • Summary
The Traumatic Airway

- Case Presentations
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The Pharyngeal Anatomic Divisions

- **Nasopharynx**
  - Termination of the turbinates and nasal septum
  - Soft palate.

- **Oropharynx**
  - Soft palate
  - Hyoid bone.

- **Hypopharynx**
  - Hyoid bone
  - First tracheal ring
    - AKA Laryngopharynx
Laryngeal Anatomy
Cricoid Cartilage

- Anatomic lower limit of the larynx
- Only complete cartilaginous ring in the upper airway
- Attaches to the thyroid cartilage by the cricothyroid membrane.
  - **Surgical airway**
- Identification in the patient with poor anatomic landmarks.
Innervation of the Airway
Innervation of the Nasal Passage and Nasopharynx: CN 5

- Anterior 1/3 of the nares.
  - Anterior ethmoidal nerve

- Posterior 2/3 of the nares.
  - Greater and Lesser Palatine nerve
Innervation for the Oropharynx: CN 9

- Anatomy
  - Glossopharyngeal nerve (CN9)
Innervation for the Oropharynx: CN 9

- Poster 1/3 tongue,  
  - Gag reflex

- Vallecule,

- Anterior surface of the epiglottis (lingual branch),

- Posterior and lateral walls of the pharynx (pharyngeal branch), and

- Tonsillar pillars (tonsillar branch).
Laryngeal Innervation: CN 10

- CN X (Vagus)
  - Superior laryngeal nerve
    - Internal laryngeal nerve
      - Posterior epiglottis to vocal cords
      - Penetrates at the thyrohyoid membrane
  - External laryngeal nerve
    - Cricothyroid muscle
Innervation of Trachea and Vocal Cords

• Recurrent Laryngeal Nerve
  • Sensory innervation of the tracheobronchial tree up to and including the vocal cords
  • Intrinsic laryngeal musculature except cricothyroid muscle
Why should we know the Anatomy and innervation?

What should I do now?

the INTUBATION
The Traumatic Airway

- Case Presentations
- Anatomy
- Mechanism of Injury
  - Penetrating
  - Blunt
  - Iatrogenic
  - Inhalation
- Management
- Summary
The Traumatic Airway

- Case Presentations
- Anatomy
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  - Penetrating
  - Blunt
  - Iatrogenic
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- Summary
Cavitation effects of a bullet wound in soft tissue
The Trifecta
The Penetrating Neck Trauma Trifecta

- Vascular
- Airway
- Esophagus
## Penetrating neck trauma

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Signs and symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vascular injury</td>
<td>Shock, Hematoma, Hemorrhage, Pulse deficit, Neurologic deficit, Bruit or thrill in neck</td>
</tr>
<tr>
<td>Laryngotracheal injury</td>
<td>Subcutaneous emphysema, Airway obstruction, Sucking wound, Hemiptysis, Dyspnea, Stridor, Hoarseness or dysphonia</td>
</tr>
<tr>
<td>Pharynx/esophagus injury</td>
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<td>Hemorrhage</td>
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<td></td>
<td>Pulse deficit</td>
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<td></td>
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<td></td>
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<td>Dyspnea</td>
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Penetrating Neck Wounds
The Traumatic Airway

- Case Presentations
- Anatomy
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  - Penetrating
  - Blunt
  - Iatrogenic
  - Inhalation
- Management
- Summary
Anatomy / Zone III

- Lies above the angle of the mandible
- Contains the internal and external carotid arteries, the vertebral artery, and several cranial nerves
- Vascular and cranial nerve injuries common
Anatomy / Zone II

• Bound inferiorly by the cricoid and superiorly by the angle of the mandible

• Contains the **larynx, pharynx**, base of tongue, carotid artery and jugular vein, phrenic, vagus, and hypoglossal nerves

• Injuries here are seldom occult

• Common site of carotid injury
Anatomy / Zone I

- Bound superiorly by the cricoid and inferiorly by the sternum and clavicles
- Contains the subclavian arteries and veins, the dome of the pleura, esophagus, great vessels of the neck, recurrent nerve, trachea
- Signs of significant injury may be hidden from inspection in the mediastinum or chest
Blunt Mechanism
Laryngeal Injuries

- Trachea can be injured from violent compression, along with the esophagus, against the cervical spine

- Front-on collision by the seat belt, and sometimes, by the sudden increase of intratracheal pressure against a closed glottis caused by the improper use of the seat belt
Blunt Mechanism
Laryngeal Injuries

- Physical Exam Findings
  - pain on palpation
  - Hemoptysis
  - subcutaneous emphysema
  - Stridor
Blunt Mechanism
Tracheal Injuries

- Neck hyperextension
  - can result in tracheal tears
  - paramedian vertical fractures of the larynx and trachea
  - complete laryngo-tracheal separation

- direct blows usually injure the thyroid and cricoid cartilages

- Trachea injury from a combination of hyperextension and direct blow
Blunt Mechanism
main stem or bronchial Injuries
Major Airways Trauma, Management and Long Term Results

Roya Farzanegan, MD,1 Pouya Aljaniour, MD,1 Hamid Akbarshahi, MD,1 Azizollah Abbasiezdouri, MD,2 Saviz Pejhan, MD,3 Aboulghasem Daneshvar, MD,1 and Mohammad Behgam Shadmehr, MD1

Purpose: The number of patients with traumatic and iatrogenic tracheobronchial injuries is increasing. Early diagnosis, prompt establishment of a secure airway, and appropriate management could prevent sequela and lead to a good outcome.

Methods: Between “1994–2007”, 35 patients with major airways trauma were managed. This descriptive and retrospective study evaluates clinical findings, diagnostic approaches, initial managements, definitive surgical or nonsurgical treatments and follow-up results. SPSS was used for descriptive outcomes.

Results: There were 27 males (77%) and 8 females, with a mean age of 28.2. There were 16 blunt, 11 penetrating and 8 iatrogenic traumas, at the level of the larynx in 1, larynx and hypopharynx in 3, laryngotraceal in 12, tracheal in 13, tracheobronchial in 1, and main bronchi in 5 patients. Fourteen patients (40%) were initially managed, and 21 patients were referred to us after their initial managements at outside hospitals. There were 7 complications (20%); one resulted in mortality (2.9%). The overall final results were good in 57.1%, acceptable in 31.4% and poor in 5.7% of patients, (mean follow-up time, 58.2 months). The respiratory status and the phonation looked better in the initially managed than the delayed managed group.

Conclusion: We recommend that, patients only become respiratory stable with minimum intervention and then be referred to centers with sufficient experience in airway surgery.
Signs found amongst patients with tracheobronchial injury

<table>
<thead>
<tr>
<th>Number %</th>
<th>Manifestations</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 (43%)</td>
<td>Subcutaneous Emphysema</td>
</tr>
<tr>
<td>6 (43%)</td>
<td>Air Bubbling from the Wound</td>
</tr>
<tr>
<td>5 (36%)</td>
<td>Dyspnea</td>
</tr>
<tr>
<td>3 (21.5%)</td>
<td>Dysphonia</td>
</tr>
<tr>
<td>3 (21.5%)</td>
<td>Altered Mental Status</td>
</tr>
<tr>
<td>3 (21.5%)</td>
<td>Visible Tracheal Movement</td>
</tr>
<tr>
<td>2 (14.3%)</td>
<td>Hemoptysis</td>
</tr>
<tr>
<td>2 (14.3%)</td>
<td>Dysphagia</td>
</tr>
<tr>
<td>2 (14.3%)</td>
<td>Hemodynamic Instability</td>
</tr>
<tr>
<td>1 (7%)</td>
<td>Cyanosis</td>
</tr>
</tbody>
</table>
Clinical analysis of eight patients with blunt main stem bronchial injuries

Jie Lei*, Jinbo Zhao*, Feng Tian, Xiaoping Wang, Yongan Zhou, Xiaofei Li, Jian Wang

Department of Thoracic Surgery, Tangdu Hospital, The Fourth Military Medical University, Xi’an 710038, China
Contributions: (I) Conceptualization and design: J Wang, X Li; (II) Administrative support: J Wang; (III) Provision of study materials or patients: J Lei, J Zhao; (IV) Collection and assembly of data: J Lei, F Tian, X Wang; (V) Data analysis and interpretation: J Lei, Y Zhou, X Li; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.
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Background: Blunt main stem bronchial injuries are rare but potentially life-threatening injuries in clinical. The aim of this study was to sum up the experience on diagnosis and treatment of blunt main stem bronchial injuries.

Methods: This report retrospectively analyzed eight cases of main stem bronchial injuries induced by blunt chest trauma between 2013 and 2016 in Tangdu Hospital, Fourth Military Medical University.

Results: There were eight patients, including four men and four women. The definitive diagnosis was confirmed by fibrobronchoscopy. Mean time between injury and treatment in our hospital was 4.23 days (range, 1–12 days). Mean length of airway tear was 1.04 cm (range, 0.5–2 cm). In four patients there was an injury to the left main stem bronchus, in three patients to the right main stem bronchus and in one patient to the ambilateral main stem bronchus. Emergent operation was performed in two patients and elective operation in six patients. End to end bronchial anastomosis was performed via right thoracotomy in two patients and via left thoracotomy in three patients, and primary repair was performed via right thoracotomy in two patients and via left thoracotomy in the remaining one patient. There was no death in this group. Seven patients had no complications and were able to take part in normal activities. One patient suffered from anastomotic stenosis after operation was healed by granulation tissue resection and cryotherapy under fibrobronchoscopy.

Conclusions: Fibrobronchoscopy is able to define the blunt main stem bronchial injuries precisely and surgical approach is the preferred method for patients with these life-threatening complications.
The most common CT characteristics of blunt main stem bronchial injuries were: subcutaneous emphysema (A), pneumothorax (B) and pulmonary atelectasis (C).

Fibrobronchoscopy provides the site, size, and extends of injury (Black arrow) in right main bronchus (A,B) and in left main bronchus (C,D).
Blunt main stem injury

Three theories have been reported to account for the mechanism of blunt main stem bronchial injuries:

1. Shearing force increases at the cricoid cartilage and carina

2. Development of tensile force due to antero-posterior compression of the chest

3. Potential reflex closure of glottis while intrathoracic pressure is rising suddenly
Blunt Mechanism
Main stem and Bronchial Injuries
The Traumatic Airway

- Case Presentations
- Anatomy
- Mechanism of Injury
  - Penetrating
  - Blunt
  - Iatrogenic
    - Inhalation
- Management
- Summary
Iatrogenic Airway Trauma
Percutaneous Tracheostomy

Safety and complications of percutaneous tracheostomy in a cohort of 800 mixed ICU patients

Service of Intensive Care Medicine, Hospital Universitario Marqués de Valdecilla, Avendaña M. B-39008 Santander, Spain

Summary
Percutaneous tracheostomy is used primarily to assist weaning from mechanical ventilation in the ICU. We report our experiences of 800 such procedures performed by a collaborative team of critical care and ENT specialists. Most procedures were performed by residents supervised by the intensive care unit staff. Complications in 17 patients (2.1%), mainly early in the series, included 0.75% complications in six patients, and late postprocedural complications in nine (1.1%). The incidence of complications was directly related to the number of procedures performed by the residents during their initial five attempts. The low incidence of complications suggests that percutaneous tracheostomy can be performed safely at a routine pace of intensive care unit patients.

Table 2: Complications of percutaneous tracheostomy in 800 patients.

<table>
<thead>
<tr>
<th>Events</th>
<th>No. patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intra-operative complications, n = 17</td>
<td></td>
</tr>
<tr>
<td>Small bleeding (25–100 ml)</td>
<td>13</td>
</tr>
<tr>
<td><strong>Paratracheal insertion</strong></td>
<td>1</td>
</tr>
<tr>
<td>Injury to the anterior jugular vein</td>
<td>1</td>
</tr>
<tr>
<td>Displacement of the tracheal tube,</td>
<td>1</td>
</tr>
<tr>
<td>Hypoventilation and ventilricular tachycardia</td>
<td>1</td>
</tr>
<tr>
<td>Fatal pulmonary thromboembolism</td>
<td>1</td>
</tr>
<tr>
<td>Early post procedural complications, n = 6</td>
<td></td>
</tr>
<tr>
<td>Accidental decannulation</td>
<td>2</td>
</tr>
<tr>
<td>Massive haemoptysis</td>
<td>1</td>
</tr>
<tr>
<td>Occlusion of the cannula</td>
<td>1</td>
</tr>
<tr>
<td>Passage of the cannula into the mediastinum</td>
<td>1</td>
</tr>
<tr>
<td>Fatal pulmonary thromboembolism</td>
<td>1</td>
</tr>
<tr>
<td>Late post procedural complications, n = 9</td>
<td></td>
</tr>
<tr>
<td>Occlusion of the cannula</td>
<td>3</td>
</tr>
<tr>
<td><strong>Tracheo-oesophageal fistula</strong></td>
<td>1</td>
</tr>
<tr>
<td>Persistent infection of the stoma</td>
<td>1</td>
</tr>
<tr>
<td>Dysphagia</td>
<td>1</td>
</tr>
<tr>
<td>Accidental decannulation</td>
<td>1</td>
</tr>
<tr>
<td>Tracheal stenosis</td>
<td>1</td>
</tr>
<tr>
<td>Granuloma</td>
<td>1</td>
</tr>
</tbody>
</table>
No statistical difference between percutaneous versus open regarding perioperative or post-op complication rate even up to 20 months
Percutaneous Tracheostomy under Bronchoscopic Visualization Does Not Affect Short-Term or Long-Term Complications

THOMAS S. EASTDAY, M.D., JOSHUA W. MOORE, M.D., MEREDITH H. REDDEN, M.D., DAVID V. FELCIANO, M.D., VERNON J. HENDERSON, M.D., TIMOTHY HUMPHRIES, M.D., KATHERINE E. KOHLER, M.D., PHILIP T. RAMSAY, M.D., STANSTON D. SPENCE, M.D., MARK WALKER, M.D., AMY D. WRYZYKOWSKI, M.D.

From the Department of Surgery, Division of Trauma Surgery and Critical Care, Atlanta Medical Center, Atlanta, Georgia

<table>
<thead>
<tr>
<th>Complications</th>
<th>With Bronchoscope [n = 289 (%)]</th>
<th>Without Bronchoscope [n = 360 (%)]</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complications</td>
<td>17 (5.8)</td>
<td>24 (6.6)</td>
<td><strong>0.68313</strong></td>
</tr>
<tr>
<td>Venous bleeding</td>
<td>6 (2.0)</td>
<td>10 (2.7)</td>
<td><strong>0.566709</strong></td>
</tr>
<tr>
<td>Conversion to open</td>
<td>3 (1.0)</td>
<td>0 (0.0)</td>
<td><strong>0.52669</strong></td>
</tr>
<tr>
<td>Reintubation</td>
<td>1 (0.3)</td>
<td>1 (0.2)</td>
<td><strong>0.876121</strong></td>
</tr>
<tr>
<td>Malposition</td>
<td>1 (0.3)</td>
<td>3 (0.8)</td>
<td><strong>0.430491</strong></td>
</tr>
<tr>
<td>Mucous plug</td>
<td>0 (0.0)</td>
<td>2 (0.5)</td>
<td><strong>0.20599</strong></td>
</tr>
<tr>
<td><strong>Subglottic stenosis</strong></td>
<td>5 (1.7)</td>
<td>6 (1.6)</td>
<td><strong>0.950384</strong></td>
</tr>
<tr>
<td><strong>Tracheoesophageal fistula</strong></td>
<td>1 (0.3)</td>
<td>2 (0.5)</td>
<td><strong>0.695714</strong></td>
</tr>
<tr>
<td><strong>Trachea-innominate fistula</strong></td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td><strong>n/a</strong></td>
</tr>
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Iatrogenic Airway Trauma
Iatrogenic Airway Trauma

UNEXPECTED, LIFE-THREATENING TRACHEAL TEAR FOLLOWING BOUGIE-ASSISTED ENDOTRACHEAL INTUBATION

M Shahnaz Hasan, Julie Razak, Vineya Rai, K K Wong, Gracie Ong
Department of Anaesthesiology, Faculty of Medicine, University of Malaya, Kuala Lumpur, Malaysia

Airway injury is an established complication of endotracheal intubation and it occurs more commonly in patients with difficult airway. ETT introducers or bougies are common adjuncts used to assist intubation and they infrequently caused airway injury. We present a case of distal tracheal tear following bougie-assisted intubation.

A 56 year-old obese (BMI 37), diabetic and hypertensive lady presented to our Trauma Unit with neuroglycopaenic coma. Her GCS did not improve after a dextrose bolus and a decision to intubate was made by the attending emergency registrar. A poor glottic view warranted the use of a bougie (Muallem ET Tube Stilet, 12CH, 65cm; VBM Medizintechnik, Germany). The intubation went smoothly with only small amount of blood seen at tracheal suction. Post-intubation revealed a significantly reduced breath sounds on the right lung and this was confirmed by the presence of massive pneumothorax on chest x-ray.

Patient later developed extensive subcutaneous emphysema involving the chest, neck and upper arm. A needle thoracocentesis was performed followed by a chest tube insertion. A thoracic CT scan confirmed the above findings and a posterolateral tracheal tear measuring 6 mm was noted approximately 2.4 cm above the carina. The patient was taken to ICU whereby a bronchoscopy revealed the above tear and to avoid leakage, the ETT was adjusted to ensure that its cuff is at or below the tear and its tip above the carina. A multidisciplinary team involving cardiothoracic surgeon, chest and ICU physician decided to treat conservatively by allowing spontaneous healing to take place. After 10 days of ventilation, a repeat CT scan revealed a partially healed tear. Patient was extubated uneventfully the following day after a negative bronchoscopy. She was then discharged to the ward for rehabilitation.
The Traumatic Airway

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TABLE. Number and percentage of New York City Fire Department rescue workers who sought emergency medical care during the 24 hours after the collapse of the World Trade Center towers — New York City, September 11, 2001

<table>
<thead>
<tr>
<th>Diagnostic category</th>
<th>No.</th>
<th>(%)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory tract irritation</td>
<td>50</td>
<td>(20.8)</td>
</tr>
<tr>
<td>Chest pain without myocardial infarction or ischemia</td>
<td>8</td>
<td>(3.3 )</td>
</tr>
<tr>
<td>Pneumothorax without rib fracture</td>
<td>1</td>
<td>(0.4 )</td>
</tr>
<tr>
<td>Inhalation injury requiring emergent tracheostomy,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pneumothorax, and prolonged mechanical ventilation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>for adult respiratory distress syndrome</td>
<td>1</td>
<td>(0.4 )</td>
</tr>
<tr>
<td>Respiratory arrest with bronchospasm</td>
<td>1</td>
<td>(0.4 )</td>
</tr>
<tr>
<td>Asthma exacerbation</td>
<td>1</td>
<td>(0.4 )</td>
</tr>
</tbody>
</table>

11,000

343

240

63%

343 v 1,876
Inhalation injury?

- Confined space
- Mental status changes, +LOC
- Burns to face, neck, or chest
- Singed brows or nasal hair
- Carbonaceous sputum
- Pharyngeal edema
- Loss of voice, stridor
Airway Injury

- Mucosal edema
- Decreased surfactant
- Bronchospasm
- Pulmonary capillary leak
- Mucosal sloughing
- Pneumonia
The Traumatic Airway

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  - Pre-hospital
  - Emergency Department
  - Operating Room
- Summary
Goals and Objectives

- Case Presentations
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  - Operating Room
- Summary
Prehospital Setting and History

- Obtain history from witnesses and patient
- Mechanisms of injury - stab wounds, gunshot wound, high-energy, low-energy, trajectory of stab
- Estimate of blood loss at scene
- Any associated thoracic, abdominal, extremity injuries
- Neurologic history
Prehospital Setting and History

- Trauma Identified
- Is there airway compromise?
- Is there respiratory distress?
- Unstable or stable patient?
Prehospital Setting and History

- Trauma Identified
- Is there airway compromise?
- Is there respiratory distress?
- Unstable or stable patient?
- Definitive Airway attempt?
The Process of Prehospital Airway Management: Challenges and Solutions During Paramedic Endotracheal Intubation

Matthew E. Prekker, MD, MPH; Heeman Kwok, MD, MS; Jenny Shin, MD; David Carlbom, MD; Andreas Grabinski, MD; Thomas D. Rea, MD, MPH

Objectives: Endotracheal intubation success rates in the prehospital setting are variable. Our objective was to describe the challenges encountered and corrective actions taken during the process of endotracheal intubation by paramedics.

Design: Analysis of prehospital airway management using a prospective registry that was linked to an emergency medical services administrative database.

Setting: Emergency medical services system serving King County, Washington, 2006-2011. Paramedics in this system have the capability to administer neuromuscular blocking agents to facilitate intubation (i.e., rapid sequence intubation).

Patients: A total of 7,523 patients more than 12 years old in whom paramedics attempted prehospital endotracheal intubation.

Interventions: None.

Measurements and Main Results: An intubation attempt was defined as the introduction of the laryngoscope into the patient’s mouth, and the attempt concluded when the laryngoscope was removed from the mouth. Endotracheal intubation was successful on the first attempt in 77% and ultimately successful in 99% of patients (7,433 of 7,523). Paramedics used a rapid sequence intubation strategy on 54% of first attempts. Among the attempts with a failed first attempt (n = 1,710), body fluids obstructing the laryngoscopic view (50%), obesity (28%), patient positioning (17%), and facial or spinal trauma (9%) were identified as challenges to intubation. A variety of adjustments were made to achieve intubation success, including upper airway suctioning (63% of attempts resulting in success), patient repositioning (38%), rescue bougie use (10%), operator change (10%), and rescue rapid sequence intubation (9%). Surgical cricothyotomy (0.4% of attempts, n = 27) and bag-valve-mask ventilation (0.8%, n = 60) were rarely performed by paramedics as final rescue airway strategies.

Conclusions: Airway management in the prehospital setting has substantial challenges. Success can require a collection of adjustments that involve equipment, personnel, and medication often in a simultaneous fashion. (Crit Care Med 2014; 42:1372-1379)

Key Words: airway management; intubation; paramedics; prehospital emergency care; registries

N = 7,523 patients >12 y/o in whom paramedics attempted prehospital endotracheal intubation.
Endotracheal intubation was successful on the first attempt in 77% and ultimately successful in 99% of patients (7,433 of 7,523)

RSI method used 54% on first attempts of intubation

Why is no airway established?

- bodily fluids obstructing the laryngeal view 50%
- obesity 28%
- patient positioning 17%
- Face or spine trauma 6%

---

The Process of Prehospital Airway Management: Challenges and Solutions During Paramedic Endotracheal Intubation

Matthew E. Prekker, MD, MPH1; Heeman Kwok, MD, MS1; Jenny Shin, MPH2; David Carlstrom, MD2; Andreas Grabinsky, MD; Thomas D. Rea, MD, MPH3

Objectives: Endotracheal intubation success rates in the prehospital setting are variable. Our objective was to describe the challenges encountered and corrective actions taken during the process of endotracheal intubation by paramedics.

Design: Analysis of prehospital airway management using a prospective registry that was linked to an emergency medical service administrative database.

Setting: Emergency medical services system serving King County, Washington, 2008–2011. Paramedics in this system have the capability to administer neuromuscular blocking agents to facilitate intubation (i.e., rapid sequence intubation).

Patients: A total of 7,523 patients more than 12 years old in whom paramedics attempted prehospital endotracheal intubation.

Interventions: None.

Measurements and Main Results: An intubation attempt was defined as the introduction of the laryngoscope into the patient’s mouth, and the attempt concluded when the laryngoscope was removed from the mouth. Endotracheal intubation was successful on the first attempt in 77% and ultimately successful in 99% of patients (7,433 of 7,523). Paramedics used a rapid sequence intubation strategy on 64% of first attempts. Among the cohort with a failed first attempt (n = 1,711), bodily fluids obstructing the laryngeal view (50%), obesity (28%), patient positioning (17%), and facial or spinal trauma (6%) were identified as challenges to intubation. A variety of adjustments were made to achieve intubation success, including upper airway suctioning (49% of attempts resulting in success), patient repositioning (38%), rescue bougie use (10%), operator change (10%), and rescue rapid sequence intubation (9%). Surgical orotracheal intubation (0.4%, n = 27) and bag-valve-mask ventilation (0.9%, n = 63) were rarely performed by paramedics as final rescue airway strategies.

Conclusions: Airway management in the prehospital setting has substantial challenges. Success can require a collection of adjustments that involve equipment, personnel, and medication often in a time-constrained fashion. EMT Int J. Med. 2014; 45:1379–1386

Key Words: airway management; intubation; paramedics; prehospital emergency care; registries

*See also p. 1643.
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Prehospital Airway Challenges and Solutions for Paramedics

The Process of Prehospital Airway Management: Challenges and Solutions During Paramedic Endotracheal Intubation

Matthew E. Prekker, MD, MPH1; Herman Kwock, MD, MS2; Jenny Shin, MPH3; David Carlstrom, MD2; Andreas Grabinsky, MD; Thomas D. Rea, MD, MPH4

Objectives: Endotracheal intubation success rates in the prehospital setting are variable. Our objective was to describe the challenges encountered and corrective actions taken during the process of endotracheal intubation by paramedics.

Design: Analysis of prehospital airway management using a prospective registry that was linked to an emergency medical services administrative database.

Setting: Emergency medical services systems serving King County, Washington, 2006–2011. Paramedics in this system have the capability to administer neuromuscular blocking agents to facilitate intubation (i.e., rapid sequence intubation).

Patients: A total of 2,523 patients more than 12 years old in whom paramedics attempted prehospital endotracheal intubation.

Interventions: None.

Measurements and Main Results: An intubation attempt was defined as the introduction of the laryngoscope into the patient’s mouth, and the attempt concluded when the laryngoscope was removed from the mouth. Prehospital intubation was successful on the first attempt in 77% and ultimately successful in 99% of patients (1,938 of 2,523). Paramedics used a rapid sequence intubation strategy on 54% of first attempts. Among the intubations with a failed first attempt (n = 785), bodily fluids obstructing the laryngeal view (50%), obesity (20%), patient positioning (17%), and facial or spinal trauma (6%) were identified as challenges to intubation. A variety of adjustments were made to achieve intubation success, including upper airway suctioning in 43% of attempts resulting in success, patient repositioning (38%), rescue bougie use (10%), operator change (15%), and rescue rapid sequence intubation (6%). Surgical cricothyrotomy (0.4%, n = 27) and bag-valve-mask ventilation (0.8%, n = 60) were rarely performed by paramedics as final rescue airway strategies.

Conclusions: Airway management in the prehospital setting has substantial challenges. Success can require a collection of adjustments that involve equipment, personnel, and medication often in a simultaneous fashion. (Crit Care Med 2014; 42:1926–1930)

Key Words: airway management; intubation; paramedics; prehospital emergency care; registry

Adjustments for intubation success?

- upper airway suctioning
- patient repositioning (38%)
- rescue bougie use (19%)
- operator change (16%)
- rescue rapid sequence intubation (6%)
- Surgical cricothyrotomy 0.4%, (n = 27)
- bag-valve-mask ventilation (0.8%, n = 60)
Position, patient and mechanism

- GCS?
- Anxiety
  - Large teeth or claws?
- Talking?
- Breath sounds?
Prehospital TRAUMATIC Airway
A bigger Challenge and minimal solutions for Paramedics

Airway Stabilization
The principals of all trauma surgery care starts with....
The Traumatic Airway

• Case Presentations
• Anatomy
• Mechanism of Injury
• Management
  • Pre-hospital
  • Emergency Department
  • Operating Room
• Summary
The principals of all trauma surgery care....
Airway management in trauma
Airway Stabilization
Emergency Department

- be prepared to obtain an airway emergently
- Know your equipment and guidelines/protocols
- intubation or cricothyrotomy
- must assume cervical spine injury until proven otherwise
Airway Stabilization

can we standardize our approach?

A standardized rapid sequence intubation protocol facilitates airway management in critically injured patients

Shana L. Ballow, DO, Krista L. Kaups, MD, Staci Anderson, PharmD, and Michelle Chang, PharmD, Fresno, California

BACKGROUND: In the emergency department (ED) of a teaching hospital, rapid sequence intubation (RSI) is performed by physicians with a wide range of experience. A variety of medications have been used for RSI, with potential for inadequate or excessive dosing as well as complications including hypotension and the need for redosing. We hypothesized that the use of a standardized RSI medication protocol has facilitated endotracheal intubation requiring less medication redosing and less medication-related hypotension.

METHODS: An RSI medication protocol (ketamine 2 mg/kg intravenously administered and rocuronium 1 mg/kg intravenously administered, or succinylcholine 1.5 mg/kg intravenously administered) was implemented for all trauma patients undergoing ED intubation at a Level 1 trauma center. We retrospectively reviewed patients for the 1-year period before (PRE) and after (KITT) the protocol was instituted. Data collected included age, sex, Injury Severity Score (ISS), Abbreviated Injury Scale (AIS) score of the head/face, AIS score of the chest, RSI drugs used for redosing, time to intubation, indication for RSI, and number of RSI attempts.

“Hypothesis: the use of a standardized RSI medication protocol has facilitated endotracheal intubation requiring less medication redosing and less medication-related hypotension”

N = 439 no protocol = 266 protocol RSI = 173

Simplified RSI to:
• ketamine 2 mg/kg iv and rocuronium 1 mg/kg iv, or
• succinylcholine 1.5 mg/kg iv
A standardized rapid sequence intubation protocol facilitates airway management in critically injured patients

Shana L. Ballow, DO, Krista L. Kaups, MD, Staci Anderson, PharmD, and Michelle Chang, PharmD, Fresno, California

<table>
<thead>
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</tr>
</tbody>
</table>

No protocol in the ED setting resulted in:

- Higher rates of medication redosing
- Longer administration times

Airway Management in Trauma

… what about the literature?

• Apnea

• GCS < 9 or sustained seizure activity

• Potential unstable facial fractures

• Large flail segment or respiratory failure

• Inability to otherwise maintain an airway or oxygenation

• Traumatic Airway
Airway Stabilization
Updated 2012 EAST guidelines

Emergency tracheal intubation immediately following traumatic injury: An Eastern Association for the Surgery of Trauma practice management guideline

Julie Mayglothling, MD, Therese M. Duane, MD, Michael Gibbs, MD, Maureen McCunn, MD, MPH, Eric Legome, MD, Alexander L. Eastman, MD, MPH, James Whelan, MD, and Kaushal H. Shah, MD

BACKGROUND: The ABC's of trauma resuscitation begin with the airway evaluation, and effective airway management is imperative in the case of a patient with critical injury. The Eastern Association for the Surgery of Trauma Practice Management Guidelines committee aimed to update the guidelines for emergency tracheal intubation (ETI) published in 2002. These guidelines were made to assist clinicians with decisions regarding airway management for patients immediately following traumatic injury. The goals of the work group were to develop evidence-based guidelines to (1) characterize patients in need of ETI and (2) delineate the most appropriate procedure for patients undergoing ETI.

METHODS: A search of the National Library of Medicine and the National Institutes of Health MEDLINE database was performed using PubMed (www.pubmed.gov).

RESULTS: The search retrieved English-language articles published from 2000 to 2012 involving patients who had sustained blunt trauma, penetrating trauma, or heat-related injury and had developed respiratory system insufficiency or required ETI in the immediate period after injury (first 2 hours after injury). Sixty-nine articles were used to construct this set of practice management guidelines.

CONCLUSION: The data supported the formation of six Level 1 recommendations, four Level 2 recommendations, and two Level 3 recommendations.

In summary, the decision to intubate a patient following traumatic injury is based on multiple factors, including the need for oxygenation and ventilation, the extent and mechanism of injury, predicted operative need, or progression of disease. Rapid sequence intubation with direct laryngoscopy continues to be the recommended method for ETI, although the use of airway adjuncts such as blind insertion supraglottic devices and video laryngoscopy may be useful in facilitating successful ETI and may be preferred in certain patient populations. There is no pharmacologic induction agent of choice for ETI; however, vecuronium is the neuromuscular blockade agent recommended for rapid sequence intubation. (J Trauma Acute Care Surg, 2012;73: S333–S340. Copyright © 2012 by Lippincott Williams & Wilkins)

KEY WORDS: Guideline; endotracheal intubation; trauma; rapid sequence intubation.

• Characterize the patients in need of endotracheal intubation (ETI)
• Delineate the most appropriate procedure for patients undergoing ETI
• Method: Reviewed 69 publications
Airway Stabilization
Updated 2012 EAST guidelines

- the need for oxygenation and ventilation
- the extent and mechanism of injury
- predicted operative need or progression of disease
- Rapid sequence intubation with direct laryngoscopy continues to be the recommended method for ETI
- blind insertion supraglottic devices and video laryngoscopy may be useful in facilitating successful ETI and may be preferred in certain patient populations
- There is no pharmacologic induction agent of choice for ETI; however, succinylcholine is the neuromuscular blockade agent recommended for rapid sequence intubation
Updated 2012 EAST guidelines
Procedure Recommendations

• Bag-valve mask ventilation

• Laryngoscopy

• Surgical airway

• The application of structured assessment tools (e.g., the LEMON law) is recommended

• When significant difficulty is anticipated, neuromuscular blockade should be used with caution, and airway rescue devices, including surgical airway equipment, should be immediately available
Airway Stabilization
ATLS recommendations

L: Look externally
E: Evaluate
M: Mallampati score
O: Obstruction
N: Neck mobility

Airway Stabilization
ATLS recommendations

L: Look externally

E:

M:

O:

N:
Airway Stabilization
ATLS recommendations

L:

E: Evaluate the 3-3-2 rule

M:

O:

N:
Airway Stabilization
ATLS recommendations

L:

E:

M: Mallampati score

O:

N:
Airway Stabilization

ATLS recommendations

L:

E:

M:

O: Obstruction

N:

Airway Stabilization
ATLS recommendations

L:
E:
M:
O:

N: Neck mobility
Video laryngoscopy
Updated 2012 EAST guidelines

- Superior views of the glottis
- Higher intubation success rates for patients with anatomically difficult airways, in obese patients, and in those with the cervical spine held in-line
- Higher intubation success rates by inexperienced airway providers.
Airway Stabilization
Updated 2012 EAST guidelines

When ETI can not be achieved?
Management of Inhalation Injuries

- Confined space
- Mental status changes, +LOC
- Burns to face, neck, or chest
- Singed brows or nasal hair
- Carbonaceous sputum
- Pharyngeal edema or blistering
- Loss of voice, stridor
The Traumatic Airway

- Case Presentations
- Anatomy
- Mechanism of Injury
- Management
  - Pre-hospital
  - Emergency Department
- Operating Room
- Summary
TRACHEOTOMY.

BY CHEVALIER JACKSON, M. D., PITTSBURG.

The operation of tracheotomy occupies a most anomalous position. There is no other justifiable life-saving operation whose reign of usefulness has not been extended by modern methods. This is in part due to the introduction of intubation, but there are several classes of cases in which intubation does not meet the indication and there are frequent individual cases where, for some special reason, the cutting operation is easier, safer and more efficient. Yet even here, the profession hesitates longer to advise tracheotomy than it did fifty years ago. The principal reason for this is probably the introduction of general anesthesia, which in this single instance was a distinct step backward. The cough reflex is the watch-dog of the lung, and when the trachea is to be opened should be preserved or stimulated, rather than drugged asleep. Aside from this, general anesthesia has, strange as it may seem, rendered our technic more hasty and careless than previously. When tracheotomy is decided on, there is usually sufficient dyspnoea to demand some voluntary use of the extraordinary muscles of respiration. As complete anesthesia approaches, this voluntary action ceases, cyanosis increases until the respiratory center is paralyzed from over-stimulation, and the patient makes no further breathing effort. He never will make another breathing effort unless the trachea is opened widely and on the instant. For with an obstructed larynx, artificial respiration is never efficient for complete oxygenation of the blood. The trachea under these circumstances is opened by a stab, rather than an incision, and it is small wonder if the percentage of mortality is almost as high as of stab wounds, inflicted with homicidal intent. In the hands of the most skillful and experienced, the incision is usually badly placed; in the hands of the unskilled or the excitable, serious accidents have occurred, such as the opening of the esophagus or a large vessel. A collection of tracheotomy specimens shows incisions at all sorts of positions and angles. One specimen shows a slitting off of the side of the trachea like a stab from a log. There is no time for asepsis or hemostasis; the opening is made at the bottom of a pool of blood, and the first inspiration necessarily pumps clots, and possibly pus.
German study reported a total of 1,033 tracheal injuries over a 5-year period

429 of these were non-iatrogenic
- blunt trauma 276
- penetrating wounds 94
- bullet wounds 16
- other etiologies 43

604 of these injuries were iatrogenic
- endotracheal intubation/mechanical ventilation 372
- dilatational tracheostomy 181
- endoscopic interventions 51
Manage conservatively if …

- lesion is relatively small
- adequately controlled with thoracostomy tube drainage
- overall no respiratory or hemodynamic compromise
Principles of Traumatic Airway Management

- ETI past the lesion – to oxygenate and ventilate
Operating Room Management

- A, B, Cs
  - Initial ATLS protocol
  - Exclude other life-threatening injuries
- Direct laryngoscopy
- Video assisted intubation
  - Nasal pharyngeal fiberoptic
  - Oral video scope
- Fiberoptic intubation
Operating Room Management
say no to cric
Principles of Traumatic Airway Management

If ETI can not be achieved….Surgical airway past the lesion
Airway Repair

- Surgical approaches
  - cervical incision
  - Thoracotomy
  - Sternotomy
  - clamshell incision
Surgical Approaches

tracheal injury
Surgical Approaches

- ECMO cannulas placed preoperatively
- Low cervical collar incision
- Anterior dissection of trachea and devitalized tissue removed
- Distal flexible tracheostomy tube placed below level of repair

tracheal separation
Principles of Traumatic Airway Management

Ventilation

• Head maintained in flexion position
• Spontaneous ventilation
• Minimize positive pressure ventilation
• Pressure controlled ventilation
• High frequency ventilation (an option)
Surgical Approaches

Main bronchial injuries

- selective intubation of the non-injured main bronchus is usually performed
- Patient in left lateral decubitus position
- injuries are repaired more often through a right posterolateral thoracotomy in the fourth intercostal space
Surgical Repair of Iatrogenic Injuries

Does Surgical Repair Still have a Role for Iatrogenic Tracheobronchial Rupture? Clinical Analysis of a Thoracic Surgeon’s Opinion.

Lee SK¹, Kim DH, Lee SK, Kim YD, Cho JS, I H.

Abstract
PURPOSE: The choice of surgical repair or conservative treatment for iatrogenic tracheobronchial rupture (ITBR) remains controversial. However, thoracic surgeons consider that surgical repair is an important treatment modality. The purpose of this study was to evaluate the clinical results from the perspective of the surgery-preferred group.

METHODS: We treated 11 patients (8 women and 3 men; age: 52.6 ± 22.9 years) with ITBR from January 2011 to January 2016. A postoperative tracheostomy was performed in all cases. The decision for surgical treatment was based on the surgeon's opinion. The surgical procedures included trans-tracheal approach, right thoracotomy, left thoracotomy, cervical incision, and thoracic incision. The patients were divided into two groups: Group A (surgical repair) and Group B (conservative treatment).

Table 1: Patients' characteristics

<table>
<thead>
<tr>
<th>Case</th>
<th>Sex</th>
<th>Age (years)</th>
<th>Injury mechanism</th>
<th>Treatment</th>
<th>Symptom</th>
<th>Injury site</th>
<th>Interval before diagnosis (hour)</th>
<th>POVT (hour)</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F</td>
<td>32</td>
<td>Elective intubation</td>
<td>Rt. thoracotomy</td>
<td>SE, PM, PE</td>
<td>CTT, 6 cm</td>
<td>35</td>
<td>0</td>
<td>Well healed</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>35</td>
<td>Elective intubation</td>
<td>Rt. thoracotomy</td>
<td>SE, hemoptysis</td>
<td>CTT, 10 cm</td>
<td>7</td>
<td>14</td>
<td>Well healed</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>62</td>
<td>Elective intubation</td>
<td>Rt. thoracotomy</td>
<td>SE</td>
<td>CTT, 4 cm</td>
<td>96</td>
<td>0</td>
<td>Tracheal narrowing</td>
</tr>
<tr>
<td>4</td>
<td>F</td>
<td>58</td>
<td>Elective intubation</td>
<td>Rt. thoracotomy</td>
<td>SE</td>
<td>CTT, 5 cm</td>
<td>96</td>
<td>0</td>
<td>Well healed</td>
</tr>
<tr>
<td>5</td>
<td>M</td>
<td>70</td>
<td>Elective tracheostomy</td>
<td>Trans-tracheal approach</td>
<td>Failed ventilation</td>
<td>CTT, 2 cm</td>
<td>5</td>
<td>11</td>
<td>Well healed</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>82</td>
<td>Elective double-lumen intubation</td>
<td>Lt. thoracotomy</td>
<td>Air leakage during surgery</td>
<td>TT, 3 cm</td>
<td>4</td>
<td>0</td>
<td>Well healed</td>
</tr>
<tr>
<td>7</td>
<td>F</td>
<td>80</td>
<td>Elective tracheostomy</td>
<td>Trans-tracheal approach</td>
<td>SE</td>
<td>CTT, 1 cm</td>
<td>96</td>
<td>0</td>
<td>Well healed</td>
</tr>
<tr>
<td>8</td>
<td>F</td>
<td>70</td>
<td>Emergency intubation</td>
<td>Conservative</td>
<td>Bleeding</td>
<td>TT, 6 cm</td>
<td>24</td>
<td>144</td>
<td>Death</td>
</tr>
<tr>
<td>9</td>
<td>F</td>
<td>42</td>
<td>Emergency intubation</td>
<td>Conservative</td>
<td>Bleeding</td>
<td>CTT, 4 cm</td>
<td>312</td>
<td>168</td>
<td>Death</td>
</tr>
<tr>
<td>10</td>
<td>F</td>
<td>37</td>
<td>Emergency intubation</td>
<td>Trans-tracheal approach</td>
<td>Bleeding</td>
<td>CTT, 1 cm</td>
<td>194</td>
<td>204</td>
<td>Well healed</td>
</tr>
<tr>
<td>11</td>
<td>M</td>
<td>10</td>
<td>Emergency intubation</td>
<td>Rt. thoracotomy</td>
<td>SE, PM</td>
<td>CTT, 4 cm</td>
<td>48</td>
<td>72</td>
<td>Well healed</td>
</tr>
</tbody>
</table>

SE: subcutaneous emphysema; PM: pneumomediastinum; PE: pleural effusion; POVT: postoperative mechanical ventilation time; CTT: cervicothoracic trachea; CT: cervical trachea; TT: thoracic trachea.
Innovative Airway Repairs

A novel approach to the management of acute tracheal tear

B Creagh-Brown, A Sheth, A Crerar-Gilbert, B P Madden

- Tracheal stenting has an established role in managing selected patients with tracheoesophageal fistula
- The role of stenting in acute airway injury or in trauma is less clear
- This case report demonstrates that endotracheal stenting is an option for managing an acute large airway tear
- The use of a removable stent not only allows for rapid closure of the defect, but also permits removal once the defect has healed, thus avoiding long-term complications of stent deployment

Clinical Record

doi:10.1017/S0022215107001533

Fig. 1
The Alveolus Aero™ stent.
The Traumatic Airway

- Case Presentations
- Anatomy
- Mechanism of Injury
- Initial Management
- Summary
Summary

"Say hello to my little friend!"