Penetrating neck injury (PNI) comprises 5 to 10 percent of traumatic injuries in adults and is caused primarily by bullets, knives, and other impaling objects.

Mandatory surgical exploration was widely accepted well into the 1990s. While the mortality rate was low with this approach, the rate of negative surgical explorations was unacceptably high (58 percent in one series).

From this observation came the concept of selective surgical management.
Anatomic Zones Used in PNI

- Zone I: extends from the sternal notch and clavicles to the cricoid cartilage.
- Zone II: continues cephalad from the cricoid cartilage to the angle of the mandible.
- Zone III: includes the region above the angle of the mandible up to the base of the skull.
Anatomic Triangles of Neck

- Anterior triangle: bordered anteriorly by the midline, posteriorly by the sternocleidomastoid muscle, and superiorly by the lower edge of the mandible.

- Posterior triangle is located within the boundaries of the sternocleidomastoid muscle anteriorly, the clavicle inferiorly, and the anterior border of the trapezius muscle posteriorly.
Initial PNI Algorithm

- Assess airway, breathing, and circulation
- Is patient stable?

- Is the platysmus violated?
  - Yes
    - Evidence of aerodigestive injury?Δ
      - Hemoptysis
      - Voice change/hoarseness
      - Subcutaneous air
      - Painful swallowing
      - Proximity wound
    - Obtain aerodigestive studies (institution dependent):
      - MDCT
      - Endoscopy
      - Esophagoscopy
  - No
    - Evidence of vascular injury?Δ
      - Hematoma
      - Bruit/Thrill
      - Decreased pulse
      - Wide mediastinum on CXR
    - Obtain vascular studies (institution dependent):
      - MDCT-A
      - Invasive angiography
      - Colorflow doppler US

- No
  - Secure airway
  - Initiate trauma resuscitation
  - Obtain immediate surgical consultation
  - Perform history and examination
  - Treat superficial wound
  - Observe for brief period in ED, with repeat examination
  - May discharge if injuries limited to superficial wound plus observation period uneventful
  - Observe in consultation with trauma surgeon in monitored setting with serial exams

* Please note that in select institutions patients with PNI (especially zone II injuries) undergo mandatory surgical exploration and ancillary diagnostic testing is not performed in the ED.

Δ Careful physical examination can miss important injuries. Obtain diagnostic imaging if there is the slightest concern about occult injury.
Most research supports selective operative management of stable patients with PNI. Nevertheless, controversy continues about the indications for mandatory surgical exploration, particularly with zone II injuries.

Many structures are injured with PNI and an understanding of the anatomy is imperative.

- Laryngotracheal injuries
- Vascular injuries
- Pharyngoesophageal injuries
- Nervous system injuries
Dissection

Dissection of the anterior and posterior neck was performed following guidelines that can be found in *Grant’s Dissector Textbook* (see reference page).

Dissection steps and structures located during dissection will not be discussed here, but can be referenced in above-mentioned text.
Procedures Commonly Performed in the Emergency Dept.

- Lumbar Puncture
- Cricothyrotomy
- Needle Thoracostomy
- Tube Thoracostomy
- Orotracheal Intubation
Lumbar Puncture

- Performed to obtain cerebrospinal fluid for diagnostic tests

- Contraindications:
  - Local infection
  - Suspected intracranial mass lesion
  - Bleeding diathesis
  - Suspected spinal cord mass lesion
Equipment required for LP

- Materials for skin sterilization
- Materials for sterile technique
- Spinal needles, 20 & 22 gauge
- Manometer
- Three-way stopcock
- CSF collection tubes (5)
- Sponges
- Lidocaine, 1% with 5-ml syringe with 22 & 25 gauge needles
- Sterile drapes
- Adhesive dressing
Positioning of patient

- **Lateral decubitus**: Lumbar spine should be flexed as much as possible by assuming fetal position (opens the intervertebral spaces), with head on a pillow (keeps entire spine parallel to bed), and having the line of the pt’s shoulders and pelvis be perpendicular to the bed (facilitates orientation of the needle track).

- **Sitting**: useful when CSF pressure is low (dehydration) or in obese pts.
Anatomy for LP

- LP should enter the subarachnoid space below the level of the conus medullaris (L1-L2 in adults and L2-L3 in children).
- L3-L4 space most commonly used
  - At the level of the posterior iliac crests
- Needle should enter the exact midpoint of the interspace between the spinous processes
LP Procedure (abbreviated)

- Locate puncture site and anesthetize skin
- Hold spinal needle (20 gauge) between index and middle fingers, with thumb over stylet.
- Introduce needle at 30 degrees rostrally toward the umbilicus. In infants, the angle is nearer to the perpendicular, whereas in elderly, the angle may approach 45 degrees.
- Bevel should face up if the patient is in the lateral decubitus position, so that the fibers of the dura split longitudinally.
Advance needle slowly. There will be a “pop” as the needle passes through the ligamentum flavum and the spinal arachnoid membrane.

Since the spinal venous plexus is anterior to the spinal canal, the chance of a traumatic spinal tap can be minimized by frequent withdrawal of the stylet to check position.

If the needle hits bone deep in the penetration, withdraw to the ligamentum flavum and redirect the tip in a more caudal direction. Pain radiating to the leg or buttock is an obvious indication to direct the needle toward the midline and away from involved side.

When cerebrospinal fluid begins to flow, discard first few drops, attach manometer for pressure, and collect 3 tubes.
Ligamentum flavum
Cricothyrotomy

- Indications - performed when the airway must be secured or maintained and when attempts at OT or NT intubation have failed.
- Should not be performed in children <12 yrs old (Transtracheal jet ventilation or “needle cricothyrotomy” should be done instead).
Equipment and Supplies for Cricothyrotomy

- **Lidocaine**, 1% with 10-ml syringe and 25-gauge needle.
- Sponges, 10x10
- Drapes and rolled bath towel
- No. 11 scalpel blade, mounted.
- Mosquito clamps (2)
- Kelly clamps (2)
- Self-retaining skin retractors.
- Orotracheal tube (usually a small- 4-6mm tube)
- Syringe, 10-ml to inflate balloon on OT tube.
- Self-refilling bag-valve mask combination.
- Tincture of benzoin
- Tape
Procedure

- Identify the cricothyroid membrane.
- Using the 10-ml syringe with the 25-gauge needle, infiltrate the skin and underlying cricothyroid membrane with 1% lidocaine.
- Using the No. 11 blade, make a vertical incision in the skin overlying the cricothyroid membrane. Retract the skin with self-retaining retractors and relocate the cricothyroid membrane by palpation.
Make a horizontal incision through the cricothyroid membrane. Extend the incision for approximately 1 cm on each side of the midline.

Insert the mosquito or kelly clamp into the incision and spread it.

Insert tube through incision.

Connect the bag-valve unit and ventilate patient. Check for respiratory movement and breath sounds.

Inflate balloon just enough to stop any audible air leak.

Attach gauze and tape tube in place.
Needle Thoracostomy (Pleural Decompression)

- Life saving technique for tension pneumothorax.

- Equipment needed:
  - BSI (Body substance isolation)
  - 14 Gauge 3 inch over-the-needle catheter (14 gauge IV catheter or larger)
  - Flutter valve or one-way valve if available (can be preassembled)
  - The flutter valve allows air to escape from the chest, but does not allow air to enter the chest
  - 10 ml Syringe filled with sterile water or saline if available
Tension pneumothorax
Procedure

The 1\textsuperscript{st} rib cannot normally be felt. The 2\textsuperscript{nd} rib can be felt just below the collar bone. The 2\textsuperscript{nd} intercostal space is the area between the 2\textsuperscript{nd} and 3\textsuperscript{rd} rib.

Insert the needle just OVER the 3\textsuperscript{rd} rib, through the intercostal muscles and into the chest cavity (neurovascular bundle lies just INFERIOR to ribs).

A hiss of air confirms the presence of pneumothorax and is effective treatment for it.
Procedure (continued)

- Slide the catheter over the needle and into the chest cavity.
- Attach a syringe and aspirate all the free air.
- Remove the syringe and let the catheter flow to free air.
- Secure catheter to chest wall with tape.
Tube Thoracostomy (chest tube placement)

- Performed in order to drain air or fluid from the pleural space.
- Positioning of patient- tubes are usually inserted laterally when fluid, pus, or blood is drained, irrespective of whether air is also being removed. Patient should lie with affected side up, and ipsilateral arm extended over the head.
Equipment Required

- Lidocaine, 1% with 10-ml syringe and 25/22-gauge needles
- Sterile towels
- Chest tube
- No. 11 surgical blade, mounted.
- Mayo clamp
- Kelly clamp
- Tape
- Surgical silk suture (size 0) with large curved cutting needle
- Needle holder
- Gauze
- Suction apparatus, 3-bottle, with water-seal, collection, and water-column sections (Pleur-evac).
Chest Tube Placement

Pneumothorax

Re-expanded lung

Chest tube
Procedure

Select proper chest tube-
- 36-40F for trauma patients
- 26-32F for non-trauma patients.

Connect suction apparatus to wall suction and adjust so that a steady stream of bubbles is produced in the water column.

Determine insertion site-
- Most tubes inserted in the lateral thorax at the anterior axillary line, just lateral to the nipple (4th or 5th intercostal space). This places the needle above the dome of the diaphragm.
Anesthetize the skin with 1% lidocaine
Using a No. 11 blade, make a horizontal incision through the skin along the inferior aspect of the rib. Incision should be about 1.5 times as wide as the tube selected. Incise down to subcutaneous tissue.

Use the Mayo clamp with the tips down as a dissector. Spread the tips to open tissue planes, and create a tunnel aiming toward the superior aspect of the rib. Make sure the clamp stays next to the rib.
When the Mayo clamp is just over the superior edge of the rib, close the clamp, and push it with steady pressure through the parietal pleura and into the chest.

Once the clamp has penetrated the pleural space, air, fluid, or blood may escape.

Widen the hole in the parietal pleura by spreading the Mayo clamp.

Use the index finger to dilate the tract and hole in the pleura.

Guide tube down the tract into the pleural space, making sure that the last hole in the chest tube is within the pleural space.
Connect the chest tube to the suction apparatus, and make sure that the level in the water column varies with respiration.

If the tube has been inadvertently inserted between the parietal pleura and the chest wall, no fluid will drain from the tube, and the level in the water column will not vary with respiration.

Sew the tube to the chest wall. Partially close the incision with a mattress stitch, and use one throw of a square knot to close the skin around the tube. Then, wind both ends of the suture around the tube, working up. Tie the ends around the top of the tube.
Pre and Post- Chest Tube Placement

Figure 1 - a) Chest X-ray revealing left-sided pleural effusion accompanied by bands in both upper lobes of the lung; b) Computed tomography scan of the chest revealing bronchiectasis and nodules.

Figure 2 - Chest X-ray revealing pulmonary expansion after drainage and tube thoracostomy with the prosthesis inserted into the left costophrenic angle.
Orotracheal Intubation

Indications:

- Inadequate oxygenation not corrected by supplemental oxygen supplied by mask or nasal cannula
- Inadequate ventilation
- Need to control and remove pulmonary secretions.
- Need to provide airway protection
- Need to perform urgent or emergent diagnostic studies in a multiply injured or intoxicated patient.
Equipment Required

- Self-refilling bag-valve mask combination (Ambu-bag), connector, tubing, end tidal CO2 detector, and oxygen source.
- Laryngoscope with curved and straight blades.
- Endotracheal tubes of correct size.
- Oral and nasal airways.
- Introducer
- Suction apparatus
- Syringe, 10-ml, to inflate cuff.
- Water-soluble sterile lubricant.
## Endotracheal tube sizes

<table>
<thead>
<tr>
<th>Age</th>
<th>Orotracheal Tube</th>
<th>Nasotracheal Tube</th>
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<tbody>
<tr>
<td>Premature</td>
<td>2</td>
<td>NA</td>
</tr>
<tr>
<td>Term</td>
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<td>NA</td>
</tr>
<tr>
<td>3-18 months</td>
<td>3-4</td>
<td>NA</td>
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<tr>
<td>1.5-3 years</td>
<td>4-5</td>
<td>NA</td>
</tr>
<tr>
<td>3-5 years</td>
<td>5-6</td>
<td>5</td>
</tr>
<tr>
<td>5-7 years</td>
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<td>8-14 years</td>
<td>7-8</td>
<td>6-7</td>
</tr>
<tr>
<td>Over 14 female</td>
<td>7-8</td>
<td>7</td>
</tr>
<tr>
<td>Over 14 male</td>
<td>7-9</td>
<td>7-8</td>
</tr>
</tbody>
</table>
Procedure

- Pre-oxygenate
- Open pt’s mouth with right hand. Grasp laryngoscope with left hand. Spread pt’s lips and insert blade, passing it to the right of the tongue. Advance blade into hypopharynx. Lift laryngoscope upward and forward.
- When the glottis and vocal cords are in view, gently pass the tube through the vocal cords and into the trachea.
- Withdraw stylet, and inflate the cuff.
- Confirm placement via ETCO2 detector, chest wall rise, and auscultation (listen for equal breath sounds—if right>left, tube placed too far).
- Secure tube in place and obtain CXR
Orotracheal Intubation
Resources

Stone, Keith and Humpries, Roger: Current: Emergnecy Diagnosis and Treatment. 2004.

Tank, Patrick: Grant’s Dissector. 2005.