Penetrating Neck Trauma

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Outline

• Introduction to topic (why I chose it)
• Anatomy involved (Zones III, II, and I)
• Brief overview of properties of projectiles and knives
• Initial management and ABC stabilization
• Management algorithm
• Surgical exploration and repair of specific areas of neck
  – Major blood vessels, nerves, larynx, esophagus
• Post-exploration management and considerations
General Information

- Occur in 5-10% of all trauma cases
- Originally all trauma violating the platysma was surgically explored
- Large portion of data obtained through times of war (WWI/II, Vietnam)
- Leading cause of death
  - hemorrhage from major blood vessels
## Wartime Injury Perspective

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<th>War</th>
<th># Cases</th>
<th>Mortality %</th>
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<td>15</td>
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<tr>
<td>Spanish-American War</td>
<td>188</td>
<td>18</td>
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<td>World War I</td>
<td>594</td>
<td>11</td>
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<tr>
<td>World War II</td>
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<td>7</td>
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<td>2.5</td>
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<td>Vietnam</td>
<td>?</td>
<td>15</td>
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<td>Gulf Wars</td>
<td>?</td>
<td>12</td>
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<td>OIF, OEF</td>
<td>?</td>
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<td>Civilian Experience</td>
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Asensio et al. 1991
Projectiles

- More kinetic energy = more damage
- Higher entering velocities (v1, e.g. rifle) with lower exiting velocities (v2, e.g. explosive bullets) equate to more KE and thus more damage

**Box 7.1. Formula for the Relationship Between Projectile Injury and Kinetic Energy**

The formula for the relationship between the severity of projectile injury and the kinetic energy that the missile imparts to the target tissue is as follows:

\[
KE = \frac{1}{2} M (v1 - v2)^2
\]

KE = kinetic energy of the missile
M = missile mass
V1 = entering velocity
V2 = exiting velocity

*Resident Manual of Trauma to the Face, Head, and Neck*
Projectile Velocities

- \( KE = \frac{1}{2} \text{Mass}(V_{\text{entry}} - V_{\text{exit}})^2 \)

- Handguns – Lower muzzle velocity (210-600 m/s)
- Shotguns – Low muzzle velocity (300 m/s)
- Rifles – High muzzle velocity (760 – 2,000 m/s)
Unclear of type of gun used here

Projectiles
Projectiles: Shotgun Blast

Shotgun wound here

Saito et al. 2014
Figure 115-2. Types of injuries caused by different missiles. Both temporary cavity (dotted line) and permanent cavity (stipple area) are large.

Expanding Bullets

Cummings pg 1626
Knives/Swords

• More predictable path of damage/injury
  – Lack explosive/expansile properties
• Increased incidence of subclavian vessel injury
  – Skiving under the clavicle
• Lower incidence of spinal injuries compared to projectiles

http://www.trauma.org/archive/vascular/images/zone2.jpg
Anatomy- Zones of the neck

http://www.fpnotebook.com/_media/ErTraumaNeckAnterior.jpg

http://www.fpnotebook.com/_media/ErTraumaNeckAnterior.jpg
Zones III.....II.....I (Recap)

Zone III
- Angle of mandible to skull base

Zone II
- Cricoid cartilage to Angle of mandible

Zone I
- Clavicles/sternum to cricoid

http://m.trauma.utoronto.ca/img/neck_lat_250.png
Zone Anatomy

-Multi-detector CT Angiography reconstruction
- Also known as MDCTA

Offiah and Hall 2012
Important structures

Zone III ➔
   Distal carotid and vertebral arteries, jugular veins, spinal cord, CN IX-XII, sympathetic trunk

Zone II ➔
   Mid carotids, esophagus, hypopharynx, larynx, RLN/CN X, spinal cord

Zone I ➔
   Proximal carotid, vertebral/subclavian arteries, subclavian/innominate/jugular veins, trachea, RLN/CN X, esophagus, thoracic duct

* RLN = recurrent laryngeal nerve   CN = cranial nerve
Stabilize the Patient!→ ATLS

- **Airway** → **Breathing** → **Circulation**
- 10% have airway compromise (larynx/trachea injury)
  - May need nasotracheal intubation, cricothyrotomy, or tracheostomy
  - Majority of patients can have standard orotracheal intubation
- Apply direct pressure to hemorrhaging
  - No deep probing of neck wounds in ED
- Two large bore IV’s → 18 gauge or higher
  - If subclavian vein injury, place IV on contralateral side to decrease fluid extravasation
- Stabilize the spine → C-collar
- Bedside Xrays → A/P & lateral neck, chest x-ray

Usually the job of the trauma team. Deep probing may dislodge blood clot.
Emergent Cricothyroidotomies

• Grab and retract thyroid cartilage up

• Vertical skin incisions

• Horizontal stab incisions in the cricothyroid membrane

http://www.cmaj.ca/content/178/9/1133.figures-only
Workup and Management - Tradition

- Traditionally → all patients had mandatory neck exploration in OR with penetrating injury violating the platysma

- Negative findings in up to 50% of mandatory neck explorations
Work up & Management

Figure 115-4. Selective management of penetrating neck injury. (Adapted from McConnell D, Trunkey D. Management of penetrating trauma to the neck. Adv Surg. 1994;27:97.)

Cummings pg 1631
Key Point

Hemodynamic instability

or

evolving signs of stroke

Explore Immediately!
Mandatory Exploration

• Mandatory = immediate = life threatening
  – “Hard” signs include:
    • massive hemorrhage
    • expanding hematoma
    • stable hematoma in presence of hemodynamic instability
    • hemothorax
    • hypovolemic shock
    • Stroke-like symptoms (hemiparesis, facial droop)

• Must surgically explore regardless of zone if appropriate diagnostic equipment not available
Key Point

If symptomatic (but stable)

Needs Exploration 

Zone I and III $\rightarrow$ May delay exploration (a.k.a “selective”) for further testing (e.g CT angio)
Zone II $\rightarrow$ Mandatory exploration
  • Debatable $\rightarrow$ some would delay for testing
Zone I and III- Key Point

• If symptomatic or asymptomatic, as long as hemodynamically stable, may observe to allow testing to evaluate location and extent of damage
Zone II

• Most frequently injured zone ➔ 60-75%

• Controversy ➔ mandatory vs selective exploration

• Must at least admit for observation
Zone II Management

Figure 115-5. An algorithmic approach to penetrating neck wounds of zone II.

Cummings pg 1630
Foley tamponade ➔ Van Waes et al. 2011

Fig. 3 Algorithm for initial management of patients with penetrating neck injury. ATLS®, Advanced Trauma Life Support; FCBT, Foley catheter balloon tamponade; CTA, computed tomography angiography.

Fig. 2 Foley catheter balloon tamponade. A Foley catheter is introduced into the bleeding neck wound following the wound track. The balloon is inflated with 10–15 ml water or until resistance is felt. The catheter is clamped to prevent bleeding through the lumen. The neck wound is sutured around the catheter. Continuing bleeding around the catheter is an indication to proceed to surgery.
Western Trauma Association 2013

[Diagram showing management algorithm for penetrating neck trauma.]

- **“Unstable”**
- **“Asymptomatic”**
- **“but symStable ptomatic”**
  (i.e. suspicion for injury)

- Major difference is that CT angio recommended over standard angiogram initially
- CT angio is recommended in every zone injury, even when asymptomatic
Work up & Management - Unstable

- Shock or evolving stroke
  - Penetrating
  - Zones
    - II
    - Neck exploration

Penetrating Neck Trauma (Platysma Violation)

- Hard Signs or HD Instability
  - Yes
    - Attempt Tamponade Secure Airway for Air leak/Hematoma
  - No

Cummings 1631
Work up & Management- Asymptomatic
Work up & Management - Symptomatic

Western Trauma Association management algorithm for penetrating neck trauma.
Now that you when know when you should run to the OR and when you can wait for testing....
Testing

• Angiography/CT angiography
• Endoscopy/esophagoscopy
• Swallow studies
• Direct laryngoscopy, bronchoscopy
Angiography/CT

• CT angiography considered procedure of choice to evaluate cervical vessel injuries in asymptomatic patient
• Traditional angiography via IR and groin catheters used to be gold standard
  – Obsolete for initial evaluation secondary to time, risk of stroke, etc.
• CT angiography with sensitivity of 90-100%, with specificity ranging between 93-100%
• Signs of injury on CT
  – Hematoma, subcutaneous air to carotid sheath, IV contrast extravasation, missile tracts close to vital structures
• Bullet/metal fragments may cause artifact making study non-diagnostic

Resident Trauma Manual, 170
Occlusion of Left Internal Carotid

Fig. 1—CT angiograms in 26-year-old man with gunshot wound to neck. A and B, Axial source image (A) and sagittal multiplanar reformation (B) show occlusion of left internal carotid artery (arrows), despite beam-hardening artifact from bullet fragments retained in neck. This patient was managed conservatively without further imaging or intervention.

Impact of MDCT Angiography on the Use of Catheter Angiography for the Assessment of Cervical Arterial Injury After Blunt or Penetrating Trauma

Stuhlfaut et al 2005
Internal Carotid Pseudoaneurysm - Stuhlfaut et al. 2005

Fig. 2—CT angiogram and 3D volume-rendered reconstruction in 28-year-old woman with gunshot injury to neck. A and B, Axial source image (A) and 3D reconstruction (B) show dissection (arrows) of left internal carotid artery with associated pseudoaneurysm (arrowheads). This injury was repaired by endovascular coil embolization.
Swallow Studies

• Barium vs gastrograftin swallow

  • Barium can lead to infection/mediastinitis if leaks but considered more sensitive contrast agent

  • Gastrograftin safer but potentially less sensitive
Swallow Studies - Barium Swallow

Red arrow → Contrast leak from the left pyriform sinus

Blue arrow → Bullet in left Zone II

Translucent shadow in esophagus = nasogatric tube

Offiah and Hall 2012
Rigid/Flexible Esophagoscopy

- Sensitivity of esophageal injury diagnosis nears 100% using combination of esophagoscopy, swallow study, and physical exam.

- Rigid argued to be more accurate near cricopharyngeus muscle secondary to redundant mucosa.

- Missed tears may progress to mediastinitis.
Direct Laryngoscopy/Bronchoscopy

**Indications**

- vocal cord paralysis
- hoarseness
- crepitus/tenderness over larynx
- hemoptysis
- subcutaneous emphysema

• Identify mucosa disruption within the larynx or tracheal lumen
Once Surgery Is Decided Upon...
Surgery - Zone I

- Difficult to explore secondary to bony shield of clavicles and sternum
- Low threshold to involve cardiothoracic surgery
- Right sided injuries → median sternotomy
- Left sided injuries → left anterior thoracotomy
- High mortality rate → 12%
Surgery Zone III

- Difficult to explore \( \rightarrow \) mandible shielding it
  - May need midline or lateral mandibulotomy to access bleeding vessels at skull base

Zone III- Internal Carotid Bleeding

• Difficult for primary repair secondary to poor access location
  – Requires mandibular dislocation, CN VII injury risk
• Often interventional radiology needed to place covered stent over injured area
• During exploration, *may temporize* utilizing vascular shunts and Fogarty embolectomy catheters until definitive stenting can occur
Vascular Shunts & Fogarty Catheters

Cummings pg 1634


Newer Vascular Shunt

Pruitt-Inahara shunt

Used in vascular surgery, carotid endarterectomy
Surgery → Zone II

- Structures much more easily accessible with surgery in this zone
- Typically explored by using collar incision
  - May extend to SCM incision if needed
- Multi-detector CT angiography (MDCTA) shown to be highly sensitive to identify aerodigestive injuries in this zone
Larynx/Cricoid

- Patient will likely need tracheostomy prior to surgical repair
- If thyroid or cricoid cartilage is damaged, open repair with internal fixation recommended
- May need 1.0 or 1.3 mm plates if calcified → miniplates
- May use stainless steel wires or bolsters if soft
- If endolaryngeal mucosa damaged, perform midline thyrotomy and repair mucosa with absorbable sutures

http://www.healthmantra.com/ic/miniplate.jpg

http://img.medcape.com/pi/emed/ckb/clinical_procedures/834279-853246-537tn.jpg
Larynx/Cricoid Repair

Endolaryngeal stents used if larynx fracture repair is unstable or anterior commissure laceration present


Larynx/Cricoid

Tracheal Injury

• Small injuries may be repaired primarily without placing tracheostomy
  – 3-0 or 4-0 vicryl to approximate, including tracheal rings above and below injury
• Larger defects → tracheostomy needed
• May need to mobilize trachea to repair larger defects
  – Take care to avoid recurrent laryngeal nerve injure
  – Large defects of 5-6 rings may require intrathoracic tracheal mobilization
  – May use 2-0 prolene as retention sutures for reanastomosis
• Consider 0 prolene chin-to-chest suture to prevent neck extension while healing
Hypopharynx/Esophagus Injury

• 10% of penetrating neck trauma patients have pharyngoesophageal injury
• Occult esophageal injury may occur in up to 25% of asymptomatic patients da→ may lead to mediastinitis
• Signs include: crepitus, dysphagia/odynophagia, hematemesis
• Treatment
  – Hypopharyngeal→ observe with NG tube, IV antibiotics, NPO
  – Esophageal→ primary repair

Errington Thompson 2002
Esophageal Repair

• Expose via same SCM incision as for blood vessels
• If side of lesion known, place incision on that side
  – If unknown, place on left as esophagus is left of midline
• Retract contents of carotid sheath laterally
• Divide omohyoid mm for adequate access
• May place esophageal dilator to identify injury
  – Or may use an NG tube proximally-placed to localize injury
    - saline or methylene blue
Esophageal Repair

• Use two-layered closure with absorbable suture (3-0 or 4-0 Vicryl)
• Avoid injury recurrent laryngeal near in the tracheoesophageal groove
• Place penrose or closed drain
• Place on IV antibiotics
• 55

Wu et. Al 2007
Debridement and primary repair of esophageal perforation

Figure A depicts the exposed mucosa and muscular layer of the perforated esophagus. Devitalized tissue is sharply debrided.
Figure B depicts the longitudinal extension of the muscular defect to completely expose the mucosal defect. The extension of the muscularis can be performed superior and inferior to the perforation.
Figure C depicts the primary repair of the debrided esophageal perforation. The closure is performed in two layers.
Nerve Repair- End-to-End Neurorrhaphy

- Perform under loupe magnification
- Dissect tissue surrounding nerve to aid in tension-free repair
- Make fresh cut at each end
- Nylon suture 8-0 to 10-0 to approximate
- Suture placement
  - Epineurium 2-5 mm from the end
- Place simple interrupted circumferential sutures
  - Approx 3 to 6 sutures depending on nerve diameter

Facial Plastic Surgery: The Essential Guide by Stephen Park
Neurorrhaphy
ANASTOMOSING A SEVERED NERVE

For the sake of clarity, the sutures have been drawn larger than in reality.

ends trimmed
inserting the stay sutures
leave the sutures long

stay sutures in front

stay sutures in the back

complete anastomosis

vessel aligned

stay sutures pulled tight

sutures pass through epineurium only

Figure 2. In general, exposure of structures in the anterior areas of the neck is best done through an incision oriented along the anterior border of the sternocleidomastoid muscle.
Blood Vessels - Arteries

- External carotid and branches → suture-ligate due to good collateral
- Internal and common carotid → vessel repair preferred
- Obtain distal and proximal control → vessel loops
Blood Vessels- Arteries

• Use simple interrupted or running suture pattern
  – Young patients $\rightarrow$ interrupted to prevent stenosis from growing
• Utilize monofilament non-absorbable suture of size 5-0, 6-0, or 7-0 (Prolene/Nylon)
• Defects longer than 1-2 cm $\rightarrow$ venous or synthetic patch
  – Saphenous vein from groin or ankle preferable
• Admit to ICU $\rightarrow$ monitor for hematoma, neuro status, labile BPs from carotid body manipulation
For interposition grafting, need post operative arteriography
Post-Operative Management

• Blood vessel repair → hematoma monitoring
• Esophageal perforation repair
  – Leave penrose in for 1 week and keep NPO
  – Get swallow study at 1 week and then advance to clear diet if (-); may remove penrose at this time
• Esophageal strictures → endoscopic dilations
• All require antibiotics, length varies
In Summary

• Knowledge of projectile types and injury patterns helpful to determine treatment
• Remember the ABC’s of stabilization
• Hemodynamic instability/stroke $\rightarrow$ OR immediately regardless of zone
• Asymptomatic patients without obvious deep-structure injury may be observed
  – Zone II injuries do not necessarily require trip to OR
Questions ?
Bibliography

- Up To Date: "Surgical management of esophageal perforation." Updated 2014. Accessed October 2014

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