Evaluation and Management of Penetrating Neck Injuries: No More Zones

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History

• 1552, Paré reported first carotid artery injury, ligated CCA, patient survived w/ extensive neuro deficit.

• 1802, Fleming performed same procedure in a suicidal sailor w/successful outcome.

• Controversy mandatory surgical intervention continued for 2 centuries, but now most are managed selectively.
Anatomy

- VASCULAR
- RESPIRATORY
- DIGESTIVE
- NEUROLOGIC
- ENDOCRINE
- SKELETAL
Anatomy

• VASCULAR
• RESPIRATORY
• DIGESTIVE
• NEUROLOGIC
• ENDOCRINE
• SKELETAL
Those Zones...

- Zone I: carotid, subclavian, lung, trachea, esophagus
- Zone II: carotid, jugular, larynx, hypopharynx
- Zone III: distal carotid, jugular, hypopharynx
Management of penetrating neck injury in the emergency department: a structured literature review

J J Brywczynski,¹ T W Barrett,¹ J A Lyon,² B A Cotton²

Table 1  Result of studies investigating the use of cervical spine immobilisation in penetrating neck injury (PNI)

<table>
<thead>
<tr>
<th>Author</th>
<th>Study type</th>
<th>Patient population</th>
<th>Intervention</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arishita et al⁶</td>
<td>Retrospective study</td>
<td>Vietnam casualties</td>
<td>Data from these casualties reviewed to determine benefit of cervical spine immobilisation on the battlefield</td>
<td>Patients with PNI to the cord were always fatal. Only 1.4% of casualties who were candidates for immobilisation might have benefited</td>
</tr>
<tr>
<td>Barkana et al⁶</td>
<td>Retrospective study</td>
<td>44 military casualties in Israel with PNI over 4.5 years</td>
<td>Data from these soldiers and autopsy reports reviewed; none had cervical spine immobilisation</td>
<td>8/36 patients (22%) had life-threatening complications diagnosed in the exposed neck (haematoma, emphysema); none required surgical stabilisation of spine injuries</td>
</tr>
<tr>
<td>Medzon et al⁶</td>
<td>Retrospective study</td>
<td>81 patients with gun shot wounds to the head or neck reviewed over a 10-year period</td>
<td>Data reviewed to determine frequency of stable and unstable cervical spine fractures</td>
<td>19/81 patients had cervical spine fractures (11%); of the 65 awake and alert patients without neuro deficit, 3 (5%) had a fracture, none of which was unstable</td>
</tr>
<tr>
<td>Klein et al⁶</td>
<td>Retrospective cohort study</td>
<td>2450 patients with gun shot wounds to the trunk, head or neck who survived ≥24 h reviewed over a 10-year period</td>
<td>Physical examination, radiographs, final diagnoses reviewed</td>
<td>244 (10%) had spine injuries; 66% of the spine injuries were “significant” and 13% were “unsuspected”</td>
</tr>
<tr>
<td>Rhee et al, 2006</td>
<td>Retrospective study</td>
<td>57 532 trauma patients evaluated at two level 1 trauma centres over 87 and 144 months, respectively</td>
<td>Determine the incidence of cervical spine fracture and cervical cord injury based on mechanism following blunt and penetrating assault</td>
<td>All patients, both blunt and penetrating, who had cord injury had neuro deficit on presentation. No penetrating patients with cord injury regained significant neuro function</td>
</tr>
<tr>
<td>Connell et al¹¹</td>
<td>Retrospective analysis of prospectively collected data</td>
<td>12 patients coded as penetrating trauma and spinal cord injury over 8 years without blunt mechanism</td>
<td>Identified the incidence of unstable or potentially unstable spinal column injuries in PNI patients</td>
<td>Of the 12 patients with PNI and cord injury, all had clinical neuro deficit on initial assessment or were in traumatic arrest</td>
</tr>
</tbody>
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In conclusion, many prehospital providers will continue to place patients with PNI in cervical collars. However, based on available retrospective data, the incidence of unstable cervical spine injuries is very low and the risks of obscuring an expanding neck haematoma or other hard signs of injury with a cervical collar in the prehospital setting might outweigh the benefits of spinal immobilisation in patients sustaining penetrating neck trauma.⁶–¹¹
Initial Management...

• Stable, no obvious vascular/aero-digestive injury >> dx evaluation

• UNSTABLE or obvious injury >> O.R.

• NO platysma violation >> local wound mgt
Initial Management...

- AIRWAY! AIRWAY! AIRWAY!
- ETT complicated by hemx/trach deviation
- Get GCS, neuro exam EARLY & document before ETT & paralysis
Which way do we go?

• Stable?

• Hard Signs?

• Location?
Which way do we go?

• Immediate Exploration: bleeding, expanding hematoma, stridor, extensive SQ emphysema, “blow-hole”

• Mandatory Evaluation: hoarseness, dysphonia, dysphagia, hematemesis, hemoptysis, change in voice
The Physical Exam

• 28 pts with NO “hard” or “soft” signs, found careful PE & observation safe  
  Frykberg et al, JACS 1994

• 145 pts, PE & observation in 91 pts had one false negative, no false positives  
  Frykberg et al, J Vasc Surg 2000

• Asymptomatic pt with Zone II injuries can be safely observed, 0-1% missed injury  
  Biffl et al, AJS 1997  Weigelt et al, JACS 1997
The Physical Exam

• PE: 94-100% sens for vascular injury

• Screening angiogram cost $3 mil/CNS event prevented

• 353 pts, 20% pts > immediate exploration, of 78% pts w/ NOM, <1% missed
  Demetriades et al, BJS 1993
The Physical Exam

• Zone I injury: 5 level-1 centers, no false negatives nL PE & CXR
  Eddy et al, JOT 2000

• Zone III injury: 72 patients; 73% no hard signs, no false negatives among observed, 1 out 4 angiograms (+), none required intervention, 10% exploration (all negative).
  Ferguson E et al, Vascular 2005
The Physical Exam

- Durban, South Africa, 59 GSWs to the neck
- 13 patients (+) soft signs on physical exam had vascular injury
- 10 patients with no physical exam findings had vascular injury
- Angiography is necessary

Mohammed GS et al, Eur J Vasc Endovasc Surg 2004
Non-op management

• Zone I/III : HD stable > Diagnostic W/U

• Zone II : no “hard” signs > Diagnostic W/U
Non-op management

- Zone I & II: Angiography, pharyngo-esophagoscopy (esophagography), & tracheobronchoscopy
- Zone III: Angiography, pharyngoscopy
Esophageal work-up

- Esophagoscopy or -gram: 60% sensitivity
- Combined modalities- 90% sensitivity
- PE + esophagoscopy + -gram = 100%
  Demetriades et al, WJS 1997
- Flex.Endoscopy 100% sens, 93-97% spec
  Srinivasan et al, Am J Gastro 2000
  Flowers, et al, J Trauma 1996
Trajectory determination defines anatomic injury
CT angiogram

- CTA = 100% PPV, 98% NPV
  Munera F et al, Radiology 2000 & 2002

- MD-CTA- 57 pts, blunt-pen, 3 were inconclusive, neg=neg
  Stuhlfaut JW et al, AJR 2005
CT angiogram

• CT offer little over physical exam (stab)
  Gonzales et al, J Trauma 2003

• CT allows elimination invasive studies, demonstrates trajectory, & safe obs. without mandatory exploration (GSW)
  Gracias et al, Arch Surg 2001
  Mazolewski et al, J Trauma 2001
Before and after CTA

- 130 cases: 34 with CTA, 96 without (n-CTA)
- Fewer neck explorations (3% vs 33%, p< 0.001)
- Negative neck explorations significantly higher in no-CTA group, 22 % vs 0% in CTA (P < 0.01)

Woo K et al, Am Surg 2005
Before and after CTA

• Angiogram & esophagram use significantly lower in CTA vs no-CTA (p = 0.02 and p = 0.04)

• In CTA group, 12% had angiography & 12% contrast esophagram

• In the no-CTA group, 29% had angio & 26% contrast esophagram

Woo K et al, Am Surg
Evaluation of multidetector computed tomography for penetrating neck injury: A prospective multicenter study

Kenji Inaba, MD, Bernardino C. Branco, MD, Jay Menaker, MD, Thomas M. Scalea, MD, Sean Crane, MD, Joseph J. DuBose, MD, Lily Tung, BSc, Sravanthi Reddy, MD, and Demetrios Demetriades, MD, PhD, Los Angeles, California
Selective management of penetrating neck injuries using “no zone” approach

Supparerk Prichayudh*, Jirat Choadrachata-anun, Suwit Sriussadaporn, Rattaplee Pak-art, Sukanya Sriussadaporn, Kritaya Kritayakirana, Pasurachate Samorn
86 penetrating neck injury patients

**Hard Signs (36)**
- Active Bleeding (29)
- Expanding hematoma (2)
- Massive subcutaneous emphysema/air bubbling (5)

**Soft signs (26)**
- Dysphagia (4)
- Voice change (1)
- Hemoptyis (2)
- Stable hematoma (15)
- Subcutaneous emphysema (4)

**Asymptomatic (24)**
- Close observation (24)

**Selective investigations**
- CTA* (21)

**OR (41)**
- Positive findings (6)
- Close observation (21)
- Negative findings (20)

**Angiographic embolization (1)**
- Branch of external carotid artery

*CTA: Computed Tomography Arteriography*
Preoperative Approach

- AIRWAY
- Apply PRESSURE until vascular control
- DON’T probe/explore
- LEAVE object in place until vascular control
Preoperative Prep/Evaluation
Preoperative Evaluation/Prep

• Call Blood Bank ASAP

• Give IR a “heads up” Zone I/III
OR Positioning and Prep

• Supine, arm(s) tucked, neck to the opposite side & extended

• Prep from ears to mid-abdomen & at least one groin

• Keep up the communication with blood bank, IR, & anesthesia
Zone I
Zone I Approach
Zone I Approach
Zone I Approach

- Anastomosis of subclavian a
- Hemorrhage control and ligation of subclavian a, vertebral a, and thyrocervical trunk accomplished via thoracotomy
- Intercalaneal and phrenic a.
- Ant. scalenus a.
Zone I Approaches

- “Trap door” rarely needed
- Best exposure through median sternotomy
- Right subclavian injuries - through supraclavicular or infraclavicular incision
Zone I Approaches-R subclavian
Zone I-II
Zone I-II
7-4a

Post. belly, digastric m.
Styloid process
Accessory n. (XI)
Sternocleidomastoid m.
Parotid gland
Glossopharyngeal
Masseter m.
Hyoglossus
Sulcus gl.
Internal jugular v.
Vagus n.
Internal carotid a.

Cut edge of carotid sheath

7-4c

Divided:
Digastric m.
Sternohyoid m.
Styloid process
Internal carotid a.
External carotid a.
ICA Repair

Injury, internal carotid a.

External carotid a.

Internal carotid a.

External carotid a.

Oversewn
Zone III Approach

• Incision similar to Zone II

• Cut the digastric? Subluxation of mandible?

• Get IR involved EARLY

• Watch out for the hypoglossal nerve
Zone III Approach

• Incision similar to Zone II

• Cut the digastric? Subluxation of mandible?

• Get IR involved EARLY

• Watch out for the hypoglossal nerve
Vertebral Control
Airway management following repair of cervical tracheal injuries: A retrospective, multicenter study

John A. Harvin, MD, Ethan A. Taub, DO, Bryan A. Cotton, MD, MPH, Jason Brocker, MD, Deborah M. Stein, MD, MPH, Evren Dilektasli, MD, Kenji Inaba, MD, Michael A. Vella, MD, Oscar Guillamondegui, MD, Lisa M. Kodadek, MD, Elliott R. Haut, MD, PhD, Cory R. Evans, MD, Jordan A. Weinberg, MD, Michael D. Goodman, MD, Bryce R.H. Robinson, MD, MS, and John B. Holcomb, MD, Houston, Texas
Cervical Tracheal Injuries

• Multicenter study: immediate or early extubation following cervical tracheal injury repair was common and safe.
• However, among those with more severe tracheal or extratracheal injuries, immediate tracheostomy versus prolonged intubation presents a risk-benefit decision.
• While immediate tracheostomy placement is associated with increased risk of SSI, prolonged intubation is associated with a higher risk of pneumonia and mortality and fewer ICU-free and ventilator-free days.
Damage Control in the Neck

• Esophageal injuries: small lacs may be repaired w/primary closure, covered with intercostal muscle flap, and widely drained both internally and externally.

• Destructive injuries should be excluded with a stapling device and widely drained.

• To handle oral secretions, a sumping nasal tube should be sutured to the nose with the tip just proximal to the cephalad staple line.
Damage Control in the Neck

• A gastric tube should be placed as well to allow for interval decompression and feeding.

• Cervical esophagostomy is an option to divert flow from injury.

• Cervical or pharyngeal esophagus is different than thoracic or mediastinal esophagus, and they can easily be repaired simply and if a spit fistula later forms, it will most often close spontaneously if properly drained.
Review
Damage Control in the Neck

• Similar to esophageal injuries, small tracheal injuries should undergo primary repair.

• If this is not feasible or if the injury is destructive, ETT should be advanced beyond injury to allow for continued ventilation.

• Alternatively, if this is not possible, an endotracheal tube can be placed through the wound to either be occlusive or to allow for ventilation.
Initial Management

• Remember your ABCs/ATLS principles

• Intubate EARLY, Intubate OFTEN

• Direct pressure until vascular control
Initial Management

• CXR *if HD stable*

• (+) “Hard” signs > O.R.

• HD unstable > O.R.
Diagnostic Work-up

• **Zone I, stable** > angiogram, scope+/- esophagram, bronch

• **Zone II, stable** > O.R > Zone I work-up

• **Zone III, stable** > angiogram, pharyngoscopy, DL+/-esoph

• CTA to avoid many of these
Management

• Prep/drape ears to mid-abdomen + GROINS

• Repair ALL carotids, even with neurological deficits

• For high ICA injuries, sublux jaw, utilize Fogarty catheters for distal control

• Primary repair if ?, if >2cm length, use GSV

• “Shunt” if necessary
Management

• Innominate/ prox R subclavian > sternotomy

• Proximal L subclavian > left thoracotomy

• Injuries to subclavian DISTAL to vertebral take-off > ligate if difficult to repair

• Vertebral artery injury > IR if stable
Management

• **Jugular** > if easy repair, otherwise ligate

• **Esophageal** > 2 layer repair, mucosal-interrupted, absorbable, muscular- nonabsorbable

  *no drains needed

  *SCM tissue flap if too large, too friable, too many perforations
Management

- **Esophageal** (>24 hours) > drain + debride
- **Tracheal** > single layer vicryl, buttress, trach if SEVERE
- **Laryngeal** > stabilize fx, mucosal repair
- **Thoracic Duct** > ligate it!
NEVER TRUST A MAN WHO CALLS YOU “DOC.” HE RARELY PAYS HIS BILLS.  -William Osler