



## **Neck Trauma: Don't Put Your Neck on the Line When Treating These Injuries**

Few emergencies are as difficult to manage as neck injuries. The risk of airway compromise, as well as vascular, neurologic, and esophageal injuries, leads to many difficult decisions. Through the use of case presentations, the lecturer will demonstrate an approach to patients with trauma to the neck, including alternatives for airway management and a selective approach to the surgical exploration of neck wounds.

- Describe the indications and techniques of airway management in patients with neck injuries.
- Describe the steps for determining when to surgically explore neck wounds.
- Discuss the management of the near-hanging victim.
- Review the different presentations and the diagnosis of traumatic dissection of the arteries of the neck.

TH-194  
Thursday, October 14, 1999  
8:00 AM - 8:55 AM  
Room # N204  
Las Vegas Convention Center

### **FACULTY**

Jeffrey J Schaidt, MD, FACEP

Assistant Professor, Emergency Medicine, Rush Medical College; Vice Chairman, Department of Emergency Medicine, Cook County Hospital; Chicago, Illinois

# Neck Trauma: Do not put your neck on the line when treating these injuries

## **PENETRATING NECK INJURY**

### **Case Presentation**

30 year old male with single gun shot wound to right anterior neck. Small amount of blood lost at scene. Bandage applied, two lines started in field and transported to the emergency department.

BP = 120/90                      RR = 24                      HR = 100

HEENT – PERRL, EOMI, no blood from oropharynx

Neck – single GSW to right anterior neck at level just above cricoid cartilage, small amount of swelling around wound

Lungs – clear, BBS =

Heart – RRR, S1, S2 normal

Abdomen – normal

Neurologic exam – intact

### **Prehospital**

- Airway
  - Fraught with hazards and unforeseen complications
    - Hematomas
    - Laryngotracheal injuries
  - Bag-valve-masking (BVM) may cause dissection of air into surrounding tissues
  - Indications for intubation
    - Long transport times with stridor or severe respiratory compromise
    - Apneic or pulseless
    - Impending or full cardiopulmonary arrest
- Avoid upper extremity intravenous lines on the same side as the injury.
- Cervical spine precautions rarely necessary unless neurologic signs or symptoms present.
- Evaluate for tension pneumothorax with severe respiratory / cardiovascular compromise.
- Trendelenburg position if air sucking or bubbling through site to decrease chance for air embolism.
- Apply direct pressure to actively bleeding wounds.

### **Airway Management**

#### ***Timing***

- *Earlier intubation leads to easier intubation*
  - Less anatomical distortion
  - Decreases need for later crash intubation
- Immediate airway management for evidence airway compromise
- Elective prophylactic for minimally symptomatic if suspected progressive airway compromise

#### ***Liberal Indications***

- Gun shot wounds
- Deep stab wounds
- Neck hematoma
- Voice changes
- Pharyngeal bleeding
- Prolonged transport or diagnostic testing

- *Recommendations* (Walls)
  - Stab wound that violates platysma and demonstrates clinical evidence of vascular or direct airway injury
  - Gun shot wound to neck regardless of external evidence of vascular or direct airway injury.

### ***Difficult Airway to Secure***

- Retrospective analysis of 114 penetrating neck trauma (Eggen)
  - 26 / 69 intubation attempts unsuccessful
  - 6 required alternative to endotracheal intubation to secure airway
- Retrospective review of airway management of 107 patients with penetrating neck trauma (Shearer)

<i>Technique</i>	<i>Number of Cases</i>	<i>Success rate</i>
Direct laryngoscopy after RSI	89	98%
Awake Fiberoptic	8	100%
Surgical	6	100%
Blind Nasotracheal	4	75%

- Comments:
  - Two failed direct laryngoscopy patients required surgical airway
  - Long technical time required for fiberoptic intubation
- *Preferred modalities*
  - Rapid sequence induction (RSI) of anesthesia with direct laryngoscopy or surgical airway
- Retrospective analysis of 57 patients with penetrating laryngotracheal injuries (Grewal)
  - Airway management in 32 (56%)
    - Oral endotracheal intubation – 14
    - Cricothyrotomy – 3
    - Tracheostomy – 15 (7 in OR)
  - *Preferred modalities*
    - Oral intubation attempted with RSI when minor to moderate laryngeal injury

### ***Techniques***

- *Do not paralyze if cannot bag or perform surgical airway quickly*
- Radiographic clearance of C-spine not essential before airway manipulation if patient is neurologically intact.
- Initial attempt should be orotracheal intubation whenever possible
- *Management Options*
  - Rapid sequence intubation
    - Ultimate relaxation – best shot at cords
    - Must be able to bag
    - No contraindications to cricothyrotomy
  - Oral intubation with sedation
    - Reversible agents or ketamine best
      - Fentanyl – high dose 4-10 ug/kg with versed 2.5-5 mg
      - Ketamine 2-3 mg/kg (airway / respiratory drive maintained)
    - Combine with direct airway local anesthesia
  - Local airway anesthesia
    - Maintains airway
    - Technically difficult airway due to patient movement.
  - Blind nasotracheal (NT)
    - May dislodge clot
    - Distorted anatomy may complicate.
  - Fiberoptic
    - Effective but requires time and skill

- Retrograde
  - Time consuming
  - Difficult
- Cricothyrotomy
  - Quick and easy if no anatomical distortion
  - Use horizontal incision only if landmarks easily palpable
  - Use vertical if landmarks distorted
    - Allows for incision to be extended if initial approach inadequate.
  - Contraindicated if expanding hematoma over cricothyroid membrane
- Tracheostomy
  - More difficult / time consuming than cricothyrotomy
  - Perform if cannot do cricothyrotomy
- **Conclusions: Airway approach depends on clinical presentation**
  - No airway distortion / easy to bag-valve-mask
    - Rapid sequence intubation
  - Minimal airway compromise / anticipated easy to bag-valve-mask
    - Rapid sequence intubation or oral intubation with sedation / local airway anesthesia
  - Airway distortion complicating oral tracheal intubation / anticipated difficult to bag-valve-mask
    - Sedation / local airway anesthesia
    - NT intubation if wound has not penetrated airway
    - Fiberoptic
    - Surgical
    - Retrograde
  - Expanding hematoma over cricothyroid membrane
    - Avoid paralytics since bag-valve-mask difficult and cricothyrotomy relatively contraindicated
    - NT intubation if wound has not penetrated airway
    - Fiberoptic best
    - Tracheostomy
  - Suspected transection of trachea near suprasternal notch
    - Avoid oral / NT intubation – may complete transection and push proximal segment into chest
    - Fiberoptic best
    - Tracheostomy through wound
    - Be prepared for emergent median sternotomy to retrieve proximal segment if proximal trachea is pushed into chest

### **Wound Examination**

- Control bleeding with pressure not clamps
- Separate wound edges and inspect
  - Do not probe due to risk of interrupting hemostasis and worsening injury

### **Initial Radiographs**

- AP / lateral neck
  - Findings
    - Subcutaneous emphysema
    - Prevertebral emphysema
    - Location / trajectory of missile
  - Presence of subcutaneous or prevertebral air are indications for surgical exploration
- CXR
  - Findings
    - Pneumothorax
    - Hemothorax
    - Mediastinal air
    - Widened mediastinal structures

- Location of missile fragments
- Of 110 bullet wounds to neck, 48 positive CXR findings (Orgog)
  - 6 hemothoraces
  - 9 pneumothoraces
  - 4 hemopneumothoraces

### **Immediate Operative Therapy**

#### **Selective vs Mandatory Exploration of Zone II Injuries**

##### ***Mandatory Exploration***

- Mandatory Exploration of Zone II injuries arose from decreased wartime mortality of penetrating injuries when all wounds that penetrated the platysma were surgically explored. Advantages of mandatory exploration:
  - Negative neck exploration quick (mean time 44 minutes)
  - Simple operation
  - Disastrous complications of delayed treatment
  - Short hospital stay after negative exploration – 0.8-1.5 hospital days (Golueke)
- Mandatory Exploration results in high negative exploration rate

##### ***Selective Exploration***

- Ancillary diagnostic testing excludes injury
- Safe
- Decrease negative exploration rate
- Standard of care in the 90's

##### ***Safety of Selective Exploration (Asensio)***

- Review of 26 studies
  - 10 mandatory exploration
  - 16 selective exploration

- Explorations rates

	<b>Mandatory</b>	<b>Selective</b>
Total # Patients	1653	2540
Exploration # / %	1492 / 90.2%	1596 / 62.8%
Observation # / %	161 / 9.8%	944 / 37.2%
Observation requiring re-exploration # / %	3 / 1.86%	20 / 2.11 %

- Operative Findings

	<b>Mandatory</b>	<b>Selective</b>
Total # Patients	1492	1596
Positive Exploration # / %	803 / 52.8%	1117 / 70%
Negative Exploration # / %	689 / 46.2%	479 / 30%

- Mortality

	<b>Mandatory</b>	<b>Selective</b>
Mortality	5.85%	3.75%
Range	0.8-11%	0-9.8%

##### ***Conclusions***

- Selective operative approach to penetrating neck injuries is safe
- Selective approach decreases rate of negative exploration

### **Indications for Operative Therapy**

- Vascular
  - History of substantial blood loss
  - Persistent bleeding
  - Enlarging hematoma
- Respiratory
  - Hemoptysis
  - Crepitation
  - Dysphonia
- Digestive
  - Hematemesis
  - Dysphagia
  - Crepitation
- Nervous system
  - Neurologic deficit
- Transcervical GSW (controversial)
  - Retrospective review of 41 patients with transcervical GSW (Hirshberg)
    - 83% positive for injury
    - Recommend exploration
  - Prospective review of 33 patients with transcervical GSW (Demetriades/1996)
    - 21% required surgery
    - Recommend selective approach with PE and diagnostic testing

### **Vascular Injury**

#### **Clinical Findings**

- Shock with or without active bleeding
- Expanding or pulsatile hematoma
- Brisk bleeding from wound site
- Airway compromise
- Decreased pulse (radial, ulnar, carotid, temporal, facial arteries)
- Carotid bruit / thrill
- Hemothorax
- Air embolism
- Cerebral vascular accident

#### **Neck Zones**

- Zone I
  - Inferior to cricoid cartilage
  - Suspect great vessel and intrathoracic injuries
- Zone II
  - Cricoid cartilage to angle of mandible
  - Easy access for operative repair
- Zone III
  - Superior to angle of mandible
  - Difficult surgical anatomical exposures
  - Embolization may be used for vascular injuries

### **Vascular Imaging**

#### ***Is Physical Examination alone sufficient to Exclude Injury?***

##### ***Pro***

- Demetriades/1993 from South Africa
  - 335 patients with penetrating neck injuries

- 60 patients to OR due to signs and symptoms of significant injury
- 6 patients to OR due to positive angio or esophageal studies
- Emergency angiography in 3 patients
  - Two with widened mediastinum
  - One with knife embedded at base of skull
- 269 patients observed without vascular studies
  - 2 required surgery for vascular lesions detected during hospitalization
- Conclusions
  - PE reliable for detecting significant injuries
  - Emergency angiography rarely necessary
- Demetriades / 1997 from USC/LA County
  - Prospective
  - 223 patients
  - 176 underwent angiography
    - 34 abnormalities with 14 requiring treatment
  - None of 160 patients without clinical signs of vascular injury required treatment for vascular injury
- Atteberry from Jacksonville, Florida
  - Prospective
  - None of the 28 patients with “asymptomatic” Zone II penetrating injuries without definite signs of vascular injuries had evidence of vascular injury during the hospital stay or during follow up.
- Jarvik from University of Washington
  - Retrospective
  - 111 patients with Zone II injuries
  - Follow up time only mean of 13.3 days
  - 45 of 48 patients with vascular injuries had abnormal physical findings
  - None of remaining 3 patients with vascular injuries but with normal physical findings would have had their treatment altered by angiography.
- Rivers from Albert Einstein
  - Retrospective
  - 61 patients with angiography due to penetrating neck trauma
  - 6 abnormal angiograms
  - No significant arterial injuries were identified in absence of suggestive physical findings
- Beitsch from Parkland
  - Retrospective
  - 178 patients with zone II penetrating neck injuries
  - 71 patients asymptomatic patients underwent angiography
    - 5 abnormal angiograms with one requiring surgical exploration
  - Physical examination - 92% sensitivity and 99% NPV for vascular injury

#### Con

- Meyer from Cook County Hospital
  - 120 consecutive penetrating neck injuries
  - 7 patients to OR immediately
  - 113 patients underwent arteriography, laryngotracheoscopy, esophagoscopy and esophagography followed by neck exploration
  - Clinical Assessment alone ability to detect injury
    - Accuracy = 68%
    - PPV = 47%
    - NPV = 86%
- Apffelstaedt from South Africa
  - 393 consecutive stab wounds to neck
  - Mandatory neck exploration policy

- Clinical signs of injury absent in 30% of positive neck exploration
- Velmahos from South Africa
  - 755 patients reviewed
    - 613 explored due to clinical findings
    - 142 observed
  - 13/142 patients had injuries missed on clinical evaluation
    - 2 with vascular injuries requiring surgery
    - 11 with missed pharyngoesophageal injuries (4 died of mediastinitis)
- Sclafani from Kings County
  - Retrospective
  - 72 consecutive patients (56 GSW)
  - Of 46 asymptomatic patients, 9 injuries were identified on angiography
  - Conclusion
    - Physical examination had poor sensitivity (61%) and specificity (80%) for vascular injuries of neck
- Stahl from Bronx
  - 429 penetrating injuries
  - Angiogram for all observed patients
  - 7 / 38 carotid injuries not diagnosed clinically

#### *Conclusions regarding Accuracy of Physical Examination*

- Ancillary diagnostic testing required to supplement physical exam to exclude vascular imaging

#### *Angiography vs. Carotid Duplex Scanning (CDS)*

- Advantages of CDS
  - Angiography invasive
  - Angiography 4-6 times more costly
  - Angiography in “asymptomatic patients” has a low yield and rarely changes management (Demetriades)
- Studies comparing angiography and Carotid Duplex Scanning

<i>Study</i>	<i># Patients</i>	<i>Sensitivity</i>	<i>Specificity</i>	<i>Comment</i>
Ginzburg	55	100%	85%	+CDS followed by Angio Zone I, II, III
Fry	100	100%	100%	Angio for +CDS in Zone III since many injuries extend to carotid siphon Zone II, III
Demetriades/ 1995	82	91%	98.5%	100% sensitive / specific for clinically important lesions
Demetriades/ 1997	99	91.7%	100%	100% sensitive / specific for injuries requiring therapy
Kuzniec	47	90.5%	100%	For both neck and extremity arterial trauma One neck and one femoral injury missed by CDS Missed one asymptomatic ICA pseudoaneurysm

- *Recommendations*
  - Qualified personnel should employ CDS to exclude carotid injuries in asymptomatic zone II and III penetrating injuries.
  - Positive CDS should be followed by angiography prior to surgical intervention.
  - For zone III injuries, angiography with embolization may provide therapeutic as well as diagnostic role.



**Helical CT**

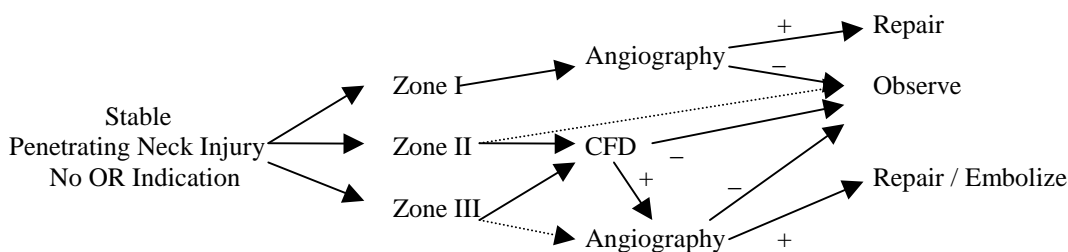
- Prospective study of 35 patients (30 GSW) undergoing helical CT of neck with results compared to angiography (29), surgery (3), ultrasound (2) and local inspection (1) (LeBlang)
  - Two injuries were only identified with indirect signs of injury (< 3mm non-obstructing flap, 1mm pseudoaneurysm)
    - These injuries received surgical repair in this study but others question the need for surgery in these types of injury.
  - Using direct signs of injury
    - Sensitivity = 80%
    - Specificity = 100%
    - NPV = 91%
    - PPV = 100%
  - Using direct and indirect signs of injury
    - Sensitivity = 100%
    - Specificity = 97%
    - PPV = 71%
- **Conclusions**
  - Helical CT may be an appropriate screening tool but more and larger studies are needed.

**Diagnostic Approach to Injury Zones**

*Stable Patients without Indication for Operative Therapy (see above)*

- Zone I
  - Angiography to determine integrity of thoracic outlet vessels (Narrod, Jurkovich, Golueke, Massac, Miller, Roden, Grewal)
- Zone II
  - Color flow Doppler imaging as screening tool with angiography if positive
  - Clinically asymptomatic patients with significant carotid injuries requiring repair:
 

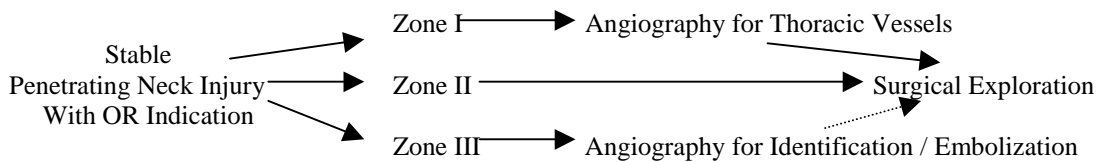
Study	Clinically Asymptomatic Patients	Number with Vascular Injuries Requiring Repair
Klychkin	24	2 (9%)
Sofianos	35	1 (3%)
  - Some recommend close, inpatient observation for asymptomatic patients without any imaging modality (Narrod, Jurkovich, Golueke, Rivers, Atteberry, Biffl, Demetriades, Menawat)
- Zone III
  - Angiography or CFD for integrity of internal carotid artery and intracerebral circulation (Jurkovich, Golueke, Massac, Sclafani, Velmahos, Miller, Roden, Grewal)
  - Some recommend close, inpatient observation for asymptomatic patients without any imaging modality (Biffl, Demetriades)



*Stable Patients with Indication for Operative Therapy*

- Zone I
  - Angiography to determine need for thoracotomy prior to neck exploration to repair thoracic outlet vessels (Narrod, Jurkovich, Golueke, Massac, Miller, Roden, Grewal)

- Zone II
  - Multiple zone II injuries (Narrod)
- Zone III
  - Angiography indicated (Miller, Roden, Sclafani/1996, Jurkovich, Grewal)
  - High internal carotid injuries are difficult to visualize at operation.
  - May require carotid artery ligation and concomitant extracranial / intracranial bypass
  - Embolization (Sclafani/1985/1995/1996) as an alternative therapy when arterial ligation anticipated for
    - Expendable vessels such as external carotid artery whose rich collateral flow from its paired vessel makes embolectomy a safe alternative to ligation
    - Poorly accessible vessels such as the vertebral artery and the internal maxillary artery where repair of these vessels is rarely possible and ligation is usually performed
    - Active arterial extravasation or arteriovenous fistula in association with an absence of prograde intracranial flow
    - Transected, thrombosed internal carotid artery with no prograde flow in a comatose patient



#### **Possible Criteria for Non-Operative Management of Carotid Injuries**

- Clinically occult injury
- Low velocity injury (stab wound)
- < 5 mm intimal defect
- < 5 mm pseudoaneurysm
- Intact distal circulation
- Compliant patient who will continue follow up

#### **Esophageal Injury**

##### **Aggressive diagnostic approach warranted**

- Recognition of esophageal injuries difficult
  - Uncommon injury
  - Associated injuries to vascular / respiratory systems mask esophageal trauma
    - 11/57 penetrating laryngotracheal injuries had associated esophageal injuries (Grewal)
    - Of 48 penetrating esophageal GSW, 9 patients had 3 other injuries, 14 had 2 other injuries, and 12 had 1 other injury. (Symbas)
- Delayed operative repair results in high morbidity and mortality due to early contamination of paraesophageal space

##### **Clinical Signs of Esophageal Injury**

- Neck pain
- Neck tenderness
- Resistance of neck to passive motion
- Crepitation
- Dyspnea
- Dysphagia
- Bleeding from mouth or nasogastric tube
- *Clinical signs often non diagnostic*

**Diagnostic Imaging Difficult due to Low Sensitivity***Plain radiographs*

- Anterior / posterior and lateral cervical
  - Subcutaneous emphysema
  - Increased prevertebral shadow
- CXR
  - Pleural effusion
  - Pneumothorax
  - Mediastinal air
  - Widening of superior mediastinum
- Normal plain radiographs do not exclude esophageal injury
  - 6 of 17 with penetration esophageal trauma had normal cervical and chest radiographs (Glatterer)

*Esophageal Contrast Studies*

- Do not rely on as sole means to exclude esophageal injury (Biffl, Symbas, Shama, Sheely, Spenler)
- Low sensitivity
  - 50-90% (Weigelt, Jurkovich)
  - 80% (Ordog)
  - 62% (Armstrong)
    - 4/5 inaccurate studies in intubated patients
- Use Gastrografin initially since it causes less irritation than barium with extravasation followed by barium if negative Gastrografin study (Grewal).

*Esophagoscopy*

- Perform if negative contrast study
- Rigid esophagoscopy has higher diagnostic yield than flexible esophagoscopy (Armstrong)
- Flexible endoscopy
  - Sensitivity 100% / specificity 96% / accuracy 97% in 31 patients (Flowers)
  - Sensitivity 100% / specificity 83% in 13 patients (Horwitz)

***Combination of Esophageal Contrast study plus Esophagoscopy required to exclude injury***

- Combined Diagnostic Yield (Weigelt):

	Sensitivity	Specificity	Accuracy
Physical Exam	80%	64%	72%
Barium Swallow	89%	100%	94%
Rigid endoscopy	89%	95%	94%

- *Combination of all three missed no injuries*

***Indications for Diagnostic Testing***

- Positive clinical findings (Demetriades/1997)
- When projectile is in proximity to or crosses the midline (Symbas, Glatterer)
- If missile has traveled beyond the limits of surgical exploration
- Presence of subcutaneous air on cervical or chest radiographs
- Some authors (Narrod, Jurkovich)
  - Surgically explore all patients with abnormal soft tissue air without performing esophagography or esophagoscopy due to low sensitive of these tests
  - Perform esophageal contrast studies and endoscopy in Zone I penetrating injuries of the wound approaches the mediastinum
  - Do not perform esophageal contrast studies on Zone II and Zone III injuries due to overlying bony shadows and contractions of cricopharyngeus muscle which make the study technically difficult

## Management

- Surgical repair and adequate drainage of deep neck spaces required for cervical esophageal and lower hypopharyngeal injuries
  - Earlier repair decreases complications (Asensio)
- Non surgical management for injuries to upper portion of hypopharynx (Stanley)

## Conclusions

*Diagnosis of esophageal injury must be combination of:*

- Physical examination
- Plain radiographs
- Contrast radiographs
- Endoscopy (rigid better than flexible)
- Surgical exploration may required in some patients to exclude injury

## Laryngeal Injury

### Clinical Signs of Laryngeal Injury

- Voice alteration
- Airway compromise
- Subcutaneous emphysema
- Crepitus
- Hemoptysis
- Bubbling wound

### Diagnostic Evaluation

- Visualization of endolarynx via indirect or direct laryngoscopy (Thompson, Miller, Schaefer)
  - Mainstay for diagnosis of injury
  - Visualization should be standard part in evaluation of penetrating neck trauma
- Radiographic evaluation serves adjunctive role
  - Soft tissue cervical radiographs
    - Subcutaneous or prevertebral air
    - Fractured larynx possible when calcified
  - CT
    - Accurately identifies location and extent of laryngeal fracture (Thompson, Schaefer)
    - Perform when the diagnosis of laryngeal fracture is suspected even in the presence of negative endolarynx examination
    - Perform when endolarynx cannot be visualized (intubated patient)

## Management

- Early airway management for significant fractures
  - If a severely fractured larynx is present, a tracheostomy is preferred method for airway management.
- Prompt surgical repair when displaced fractures identified (Thompson)
- Non surgical management for minimal intralaryngeal injuries and nondisplaced fractures (Demetriades/1996)

## **BLUNT NECK INJURY**

### **Case Presentation**

30 year old male unrestrained passenger in a deceleration motor vehicle collision where his neck and right clavicle struck the dash. The patient only complains of pain in right clavicular area.

BP = 120/80

RR = 18

HR = 90

HEENT – PERRL, EOMI, no blood from oropharynx

Neck – mild tenderness and swelling over anterior and right side of neck, no crepitus

Lungs – clear, BBS =

Heart – RRR, S1, S2 normal

Chest – tenderness over right clavicle with deformity

Abdomen – normal

Neurologic exam – intact

### **General**

- Often subtle injuries due to concomitant injuries of chest, abdomen and head
- Common mechanisms
  - Motor vehicle crash in unrestrained passenger (padded dash syndrome)
  - Shoulder harness creates shearing injury to neck as it decelerates
- Early airway management mandatory

### **Vascular Injury**

#### **Mechanism of Carotid Injury**

- Direct blow to neck with compression of carotid
- Blow to head causing rotation and hyperextension of head stretch the carotid artery across the bodies of C1 and C2 or across the transverse process of C3
- Blunt oral trauma
- Basilar skull fracture

#### **Incidence (Alimi, Rogers)**

- After closed head injury
  - 0.08% - 1 %
- Neurologic deficits unexplained by CT findings, spinal cord injury or peripheral nerve injury
  - 21%

#### **Difficult diagnosis**

- 25-50% have no external signs of neck trauma (Opeskin)
- Delayed neurologic deficits frequent - >90% have lucid interval extending hours to weeks from the onset on injury to development of symptoms
  - 10% have TIA / CVA within one hour
  - 17% develop symptoms days / weeks post injury
- Many patients with co-existing injuries (head) that mask clinical signs of dissection

#### **Clinical Findings**

- Neurologic findings incongruent with head CT
- Lucid interval between trauma and symptoms with negative head CT
- *Carotid Artery Injury*
  - Hematoma lateral neck
  - Bruit over carotid circulation
  - Horner's syndrome
  - TIA
  - Aphasia
  - Hemiparesis

- *Vertebral Artery Injury*
  - Ataxia
  - Vertigo
  - Nystagmus
  - Hemiparesis
  - Dysarthria
  - Diplopia
- 66 cases of blunt carotid artery injury (Fabian)
  - 34% diagnosed by incompatible neurologic and CT findings
  - 43% by new onset neurologic deficits
  - 23% by physical exam (neck injury, Horner's syndrome)

### **Diagnostic Imaging**

- Institutional specific depending on availability and skill of radiology investigators
- Indications (Fakhry)
  - Neurologic findings incongruent with head CT
  - Monoparesis or hemiparesis with normal mental status
  - Signs or history of significant external cervical trauma in patient with altered mental status
  - Basilar skull fracture in patient with altered mental status
  - Focal neurologic deficit inconsistent with head CT
- Angiography
  - Study of choice in acutely injured and symptomatic patient (Fabian)
  - 93% of lesions at the bifurcation of carotids or higher
  - Multiple vessel injuries occur in 40%-80% (Alimi, Fabian)
    - Four vessel angiography recommended
  - Findings in 66 patients with blunt carotid injury (Fabian)
    - 54 intimal dissections
    - 11 pseudoaneurysms
    - 17 thromboses
    - 4 carotid cavernous fistulas
    - 1 transected internal carotid artery
- Color Flow Doppler ultrasound
  - Provides rapid identification and quantification of arterial dissection
  - Unable to assess distal upper extracranial and intracranial internal carotid artery (Rogers, Fabian)
  - Most operator dependent
  - Possible screening role in lower risk patients (Fabian)
- Helical CT angiography
  - Used as a screening modality for patients at risk for blunt carotid injury
  - Significant decrease in time to diagnose from 156 hours to 5.9 hours (Rogers)
  - Increased detection rate cervical arterial injury (Rogers)
- MR angiography
  - Accurately detects carotid and vertebral artery injuries (Friedman, Stahmer, Bok)
  - Best for follow up or for stable patients since it is difficult to perform MR in acutely injured unstable patients (Fabian).

### **Management**

- Depends on size of lesions and clinical picture
- Options (Okada, Eachempati, Fabian)
  - Observation
  - Anticoagulation
  - Antiplatelet agents
  - Arterial reconstruction
  - Ligation

**Laryngeal Injury****Mechanism**

- Sharp blow to anterior neck that compresses thyroid and cricoid cartilages against the cervical spine.

**Clinical Findings**

- Voice changes due to:
  - Intrinsic injuries
    - Laryngeal fractures
    - Laryngotracheal separation
    - Displaced arytenoid
    - Intralaryngeal hematoma
    - Vocal cord tears
  - Extrinsic injuries
    - Recurrent laryngeal nerve injury
    - Extra-laryngeal hematoma
- Respiratory compromise / Stridor
  - Intralaryngeal hematoma and edema may not reach maximum until several hours post-injury.
- Pain / Tenderness
- Dysphagia
- Hemoptysis
- Subcutaneous emphysema
- Abrasion over neck
- Inability to palpate a normal larynx

***Laryngeal Injury Classification*** (Schaeffer, Grewal)

Group	Findings
1	Minor endolaryngeal hematoma or lacerations, absence of detectable laryngeal fractures and minimal airway compromise
2	Edema, hematoma or minor mucosal disruption without exposed cartilage, varying degrees of airway compromise
3	Massive edema, large mucosal lacerations, exposed cartilage, displaced fractures, vocal-cord immobility, varying degrees of airway compromise
4	As in group 3 with disruption of the anterior larynx or unstable laryngeal cartilaginous skeleton

**Diagnostic Evaluation**

- Visualization of endolarynx via indirect or direct laryngoscopy (Camnitz, Reece)
  - Determines function and status of internal soft tissue defects
- CT (Gussack, Spiro, Guertler, Schild)
  - Determines status of cartilage
    - particularly useful in Group 1 and 2 patients (Schaeffer)
    - Nondisplaced fracture – no operation needed
    - Preoperative planning in significantly displaced fractures
  - Helpful when laryngoscopy cannot be performed (intubated patient)
- Plain Radiographic evaluation serves adjunctive role
  - Soft tissue cervical radiographs
    - Subcutaneous or prevertebral air
    - Fractured larynx possible when calcified
  - CXR
    - Mediastinal air

**Management**

- Early aggressive airway management
  - Oral endotracheal intubation for group 1 and 2 suspected injuries
  - Tracheostomy (Reece)
    - Awake under local anesthesia while the patient is ventilating is optimal.
  - Cricothyrotomy relatively contraindicated when significant disruption to larynx
- Early surgical repair for injuries

**Pharyngoesophageal Injury****General**

- Exceedingly rare (Jacobs)
- Classic clinical findings (subcutaneous air / chest pain) found in more common cervical and chest injuries.
- Often associated with laryngotracheal injuries

**Diagnostic Imaging**

- Soft tissue cervical / CXR for
  - Cervical or mediastinal air
  - Pneumothorax
  - Pleural effusion
- Esophagography
  - High false negative rate
  - 6 false negative esophagrams of 43 blunt esophageal injuries (Beal)
  - Combine with endoscopy for patients with high index of suspicion

**Management**

- Surgical therapy for esophageal or large (>2 cm) pharyngeal perforations
- Medical therapy for small (< 2 cm) pharyngeal perforations (Niezgoda, Jacobs)

**Strangulation Injury****Definition**

- Compression of neck
- Mechanisms (Iserson)
  - Hanging
    - Victims body is either totally or partially suspended by a ligature
    - Fracture rare in non-judicial hangings
    - Transverse intimal tears at bifurcation of common carotid artery common in judicial hangings
  - Postural strangulation
    - Victims neck is stretched over an object and then compressed by the pressure of his own body
  - Ligature strangulation
    - Ligature is pulled around neck – body weight plays no part in mechanism
    - Hyoid and laryngeal injuries found 50% of time in forensic studies
  - Manual strangulation
    - Ligature is a pair of hands
    - In forensic studies, associated with fracture of larynx including hyoid bone and thyroid cartilage

**Mechanism of death**

- Cerebral ischemia and hypoxia caused by compression of blood vessels in the neck
  - First – pressure on neck obstructs venous circulation causing stagnant hypoxia and loss of consciousness.
  - Second – body goes limp due to loss of consciousness.
  - Third – decreased muscle tone in neck allows for occlusion of arterial circulation.
- Total blockage of the airway is rare.



**Treatment**

- Cervical spine immobilization only if mechanism of injury is consistent with a significant drop from a height as in judicial hanging. (Howell)
- Aggressive respiratory management since high risk for:
  - pulmonary edema
  - ARDS
  - congestion and edema of uvula, epiglottis, larynx and vocal cords
- Prevent further neurologic deterioration by decreasing intracranial pressure if elevated.
- Control seizures.
- Treat associated blunt vascular, laryngeal and esophageal injuries (see above).

**Bibliography**

1. Alimi Y, Di Mauro P, Tomachot L et al. Bilateral dissection of the internal carotid artery at the base of the skull due to blunt trauma: incidence and severity. *Ann Vasc Surg* 1998;12:557-65.
2. Apffelstaedt JP, Muller R, Results of mandatory exploration for penetrating neck trauma. *World J Surg* 18;917-920, 1994
3. Asenio JA, Valenziano CP, Falcone RE, Grosh JD, Management of penetrating neck injuries. The controversy surrounding zone II injuries. *Surg Clin North Am* 1991 Apr;71(2):267-96
4. Asensio JA, Berne J, Demetriades D, Murray J et al. Penetrating esophageal injuries: time interval of safety for preoperative evaluation – how long is safe? *J Trauma* 1997;43:319-24.
5. Atteberry LR, Dennis JW, Menawat SS, Frykberg ER, Physical examination alone is safe and accurate for evaluation of vascular injuries in penetrating zone II neck trauma. *J Am Coll Surg* 1994 Dec;179(6):657-62
6. Ayuyao AM, Kaledzi YL et al: Penetrating neck wounds: mandatory versus selective exploration, *Am Surg* 202:563, 1985
7. Back MR, Baumgartner FJ, Klein SR, Detection and evaluation of aerodigestive tract injuries caused by cervical and transmediastinal gunshot wounds. *J Trauma* 1997 Apr;42(4):680-6
8. Beitsch P, Weigelt JA, Flynn E, Easley S, Physical examination and arteriography in patients with penetrating zone II neck wounds, *Arch Surg* 1994;129:577-581
9. Belinkie SA, Russell JC, DaSilva J, Becker DR, Management of penetrating neck injuries. *J Trauma* 1983;23(3):2357
10. Betitsch, P, Weigelt JA, Flynn E, Easley S, Physical examination and arteriography in patients with penetrating zone II neck wounds. *Arch Surg* 1994 June;129:577-581
11. Biffi WL, Moore EE, Rehse DH, Offner PJ, Franciose RJ, Burch JM, Selective management of penetrating neck trauma based on cervical level of injury, *Am J Surg* 1997 Dec;174(6):678-82
12. Bishara RA, Pasch AR, Douglas DD, et al; The necessity of mandatory exploration of penetrating zone II neck injuries. *Surgery* Oct 1986; 100(4):655-660
13. Blank-Reid, C. Strangulation. *Trauma* 1999;62:32-35.
14. Blickenstaff KL, Weaver FA, Yellin AE, et al; Trends in the management of traumatic vertebral artery injuries. *Am J Surg* Aug 1989;158:101-106
15. Bok AP, Peter JC. Carotid and vertebral artery occlusion after blunt cervical injury: the role of MR angiography in early diagnosis. *J Trauma* 1996;40:968-72.
16. Calcatera TC, Holt GP: Carotid artery injuries, *Laryngoscope* 82:321, 1972
17. Camnitz PS, Shepherd SM, Henderson RA, Acute blunt laryngeal and tracheal trauma. *Am J Emerg Med* Mar 1987;5(2):157-162
18. Carducci B, Lowe RA, Dalsey W, Penetrating neck trauma: consensus and controversies. *Ann Emerg Med* Feb 1986;15:208-215
19. Catala J, Puig J et al: Perforation of the pharynx caused by blunt external neck trauma. *Eur Radiol* 1998;8:137-140.
20. Catala J, Puig J, Munoz JM, Vivancos J, Llopart JR, Perforation of the pharynx caused by blunt external neck trauma. *Eur Radiol* 1998;8(1):137-40
21. Caubet-Biayna J, Olabe-Jauregui et al. Blunt internal carotid artery trauma: report of two cases and review of the literature. *Acta Stomatologica Belgica* 1993;4:155-158.

22. Chedid MK, Deeb ZL, Rothfus WE, et al; Major cerebral vessels injury caused by a seat belt shoulder strap: case report. *J Trauma* 1989; 29(11):16013
23. Chen FH, Fetzer JD, Complete cricotracheal separation and third cervical spinal cord transection following blunt neck trauma: A case report of one survivor. *J Trauma* July 1993;35(1):140-2
24. Clark CG, Lim RC, Rosenberg JM, Cerviothoracic vascular injuries: presentation, management, and outcome. *Am Surg* Sep 1991; 57(9):582-7
25. Crissey MM, Bernstein EF, Delayed presentation of carotid intimal tear following blunt craniocervical trauma. *Surgery* Apr 1974; 75(4):543-9
26. Day JD, Levy ML, Giannotta SL, The management of penetrating vascular injuries. *Neurosurg clin of N Am* 1995 Oct;6(4):799-808
27. Demetriades A, Theodorou D, Cornwell E III et al, Penetrating injuries of the neck in patients in stable condition: physical examination, angiography, or color flow doppler imaging. *Arch Surg* Sep 1995;130:971-5
28. Demetriades D, Asensio JA, Velmahos G, Thal E, Complex problems in penetrating neck trauma. *Surg Clin North Am*, 1996 Aug;76(4):661-83
29. Demetriades D, Charalambides D, Lakhoo M, Physical examination and selective conservative management in patients with penetrating injuries of the neck. *Br J Surg* 1993 Dec;80:1534-36
30. Demetriades D, Theodorou D, Cornwell E 3<sup>rd</sup>, Weaver F, Yellin A, Velmahos G, Berne TV, Penetrating injuries of the neck in patients in stable condition. Physical examination, angiography, or color flow Doppler imaging. *Arch Surg* 1995 Sep;130(9):971-5
31. Demetriades D, Theodorou D, Cornwell E, Asensio J, Belzberg, Velmahos G, Murray J, Berne TV, Transcervical gunshot injuries: Mandatory operation is not necessary. *J Trauma* 1996 May;40(5):758-760
32. Demetriades D, Theodorou D, Cornwell E, Berne TV, Asensio J, Belzberg H, Velmahos G, Weaver F, Yellin A, Evaluation of penetrating injuries of the neck: prospective study of 223 patients. *World J Surg* 1997 Jan;21(1):47-8
33. Deo S, Knottenbelt J, Management of penetrating injuries of the anterior triangle of the neck. *Injury* 1995;26(6):427-8
34. Deo S, Knottenbelt J. Comment on: Management of penetrating injuries of the anterior triangle of the neck. *Injury* 1995 Jul;26:427-8.
35. Dunbar LL, Adkins RB, and Waterhouse G: Penetrating injuries to the neck—selective management, *Am Surg* 50:198, 1984
36. Eachempati SR, Vaslef SN, Sebastian MW et al. Blunt vascular injuries of the head and neck: is heparinization necessary? *J Trauma* 1998;45:997-1004.
37. Eggen JT, Jorden RC: Airway management, penetrating neck trauma. *J Emerg Med* 1993;11:381-385.
38. Fabian TC, Patton JH Jr, Croce MA, Minard G, Kudsk KA, Pritchard FE, Blunt carotid injury. Importance of early diagnosis and anticoagulant therapy. *Ann Surg* 1996 May;223(5):513-22; discussion 522-5
39. Fakhry SM, Jaques PF, Proctor HJ, Cervical vessel injury after blunt trauma. *J Vasc Surg* 1988;8:501-8
40. Feliciano DV, Bitonda CG, Mattox KL, Combined Tracheoesophageal injuries. *Am J Surg* Dec 1985; 150:710-715
41. Fitchett VH, Pomerantz M, Butsch AW et al: Penetrating wounds of the neck. *Arch Surg* 119:574, 1984
42. Flowers, JL, Graham SM, Ugarte MA, Sartor WM, Rodriguez A, Gens DR, et al; Flexible endoscopy for the diagnosis of esophageal trauma. *J Trauma* 1996 Feb; 40(2):261-265
43. Fogelman MS, Stewart RD: Penetrating wounds of the neck, *Am J Surg* 91:581, 1956
44. Friedman D, Flanders A, Thomas C, Millar W, Vertebral artery injury after acute cervical spine trauma: rate of occurrence as detected by MR angiography and assessment of clinical consequences. *AJR Am J Roentgenol* 1995 Feb;164(2):443-7; discussion 448-9
45. Fry WR, Dort JA, Smith RS, Sayers DV, Morabito DJ, Duplex scanning replaces arteriography and operative exploration in the diagnosis of potential cervical vascular injury. *Am J Surg* 1994 Dec;168(6):693-5; discussion 695-6
46. Fuhrman GM, Stieg FH, Buerk CA, Blunt laryngeal trauma: classification and management protocol. *J Trauma* Jan 1990;30(1):87-90

47. Gaskill-Shipley MF, Tomsick TA: Angiography in the evaluation of head and neck trauma. *Neuroimaging Clinics of NA* 1996;6:607-624.
48. Ginzburg E, Montalvo B, LeBlang S, Nunez D, Martin L, The use of duplex ultrasonography in penetrating neck trauma. *Arch Surg* 1996 Jul;131(7):691-3
49. Glatterer MS, Toon RS et al: Management of blunt and penetrating external esophageal trauma. *J Trauma* 25:784, 1985
50. Golueke PJ, Goldstein AS, Sclafani Sja et al: Routine versus selective exploration of penetrating neck injuries: a randomized prospective study, *J Trauma* 24:1010, 1984
51. Grewal H, Rao PM, Mukerji S, Ivatury RR: Management of penetrating laryngotracheal injuries. *Head Neck* 1995 Nov-Dec;17(6):494-502.
52. Guertler AT, Blunt laryngeal trauma associated with shoulder harness use. *Ann Emerg Medicine* Aug 1988; 17:8,838-9
53. Gussack DS et al, Treatment dilemmas in laryngotracheal trauma. *J Trauma* 1988;28(10):1439-44
54. Hall DE, Boydston W, Pediatric neck injuries. *Pediatr Rev* 1999 Jan;20(1):13-9; quiz 20
55. Hall JR, Reyes HM, Meller JL, Penetrating zone-II neck injuries in children. *J Trauma*;31(12):1614-17
56. Hatzitheofilou C, Strahlendorf C, Kakoyiannis S, CharalambidesD, Demetriades D. Penetrating external injuries of the oesophagus and pharynx. *Br J Surg* 1993;80:1147-9.
57. Haworth CS, de Villiers JC, Stab wounds to the temporal fossa. *Neurosurgery* 1988;23(4):431-5
58. Hirshberg A, Wall MJ, Johnston RH Jr, Burch JM, Mattox KL, Transcervical gunshot injuries. *Am J Surg* 1994 Mar;167:309-12
59. Horwitz B, Krevsky B, Buckman RF Jr, Fisher RS, Dabezies MA, Endoscopic evaluation of penetrating esophageal injuries. *J Gastroenterology*; 88(8):1249-1253
60. Howell MA, Guly HR. Near hanging presenting to an accident and emergency department. *J Accid Emerg Med.* 1996;13:135-6.
61. Irish JC, Hekkenberg R, Gullane PJ, Brown DH, Rotstein LE, Neligan P, Ali J, Penetrating and blunt neck trauma: 10-year review of a Canadian experience. *Can J Surg* 1997 Feb;40(1):33-8
62. Iserson KV: Strangulation: A review of ligature, manual, and postural neck compression injuries. *Ann Emerg Med* March 1984;13:179-185
63. Jacobs I, Niknejad G, Kelly K et al. Hypopharyngeal perforation after blunt neck trauma: case report and review of the literature. *J trauma* 1999;46:957-8.
64. James CA. Magnetic resonance angiography in trauma. *Clinical neuroscience.* 1997;4:137-145.
65. Jarvik JG, Phillips GR III, Schwab CW, Schwartz JS Grossman RI, Penetrating neck trauma: Sensitivity of clinical examination and cost-effectiveness of angiography. *AJNR Am J Neuroradiol*1995 Apr;16:647-654
66. Jurkovich GJ, Zingarelli W, Wallace J et al: Penetrating neck trauma: diagnostic studies in the asymptomatic patient. *J Trauma* Sep 1985;25(9):819-822
67. Kelly M, Trauma to the neck and larynx. *CRNA* 1997 Feb;8(1):22-30
68. Kendall JL, Anglin D, Demetriades D, Penetrating neck trauma. *Emerg Med Clin North Am* 1998 Feb;16(1):85-105
69. Klyachkin ML, Rohmillere M, Charash WE, Sloan DA, Kearney PA, Penetrating injuries of the neck: selective management evolving. *Am Surg* 1997 Feb;63(2):189-94
70. Knightly JJ, Swaminathan AP, Rush BF Jr, Management of penetrating wounds of the neck. *Am J Surg* Oct 1973; 126:575-580
71. Knudson MM, Lewis FR, Atkinson K, Neuhaus A, The role of duplex ultrasound arterial imaging in patients with penetrating extremity trauma. *Arch Surg* 1993 Sep;128:1033-7
72. Kuzniec S, Kauffman P et al: Diagnosis of limbs and neck arterial trauma using duplex ultrasonography. *Cardiovascular surg* 1998;6:358-366.
73. Laitt RD, Lewis TT, Bradshaw JR, Blunt Carotid arterial trauma. *Clin Radiol* 1996 Feb;51(2):117-22
74. Leblang SD, Nunez DB, Rivas LA, Falcone S, Pogson SE, Helical computed tomographic angiography in penetrating neck trauma. *Emer Radiol* 1997 July/Aug; 4(4):2—206
75. Line WS Jr, Stanley RB Jr, Choi JH, Strangulation: a full spectrum of blunt neck trauma. *Ann Otol Rhino Laryngol* 94:1985;542-546
76. Massac E, Siram SM, and Leffall LD: Penetrating neck wounds, *Am J Surg* 145:263, 1983
77. McConnell DB, Trunkey DD. Management of penetrating trauma to the neck. *Advances in Surgery.* 1994 27:97-127.
78. McHugh TP, Staut M. Near-hanging. *Ann Emerg Med* 1983;12:774-776.

79. McInnis WA, Cnz AB, and Aust JB: Penetrating injuries to the neck, *Am J Surg* 130:416, 1975
80. McNab AA, Fabinyi GCA, Milne PY, Blunt trauma to the carotid artery. *Aust NZ J Surg* 1988, 58, 651-656
81. Menawat SS, Dennis JW, Laneve LM, Frykberg ER, Are arteriograms necessary in penetrating zone II neck injuries? *J Vasc Surg* 1992 Sep;16(3):397-400; discussion 400-1
82. Metzдорff MT, Lowe DK: Operation or observation for penetrating neck wounds? *Am J Surg* May 1984;147:646-9
83. Meyer JP, Barrett JA, Schuler JJ, et al; Mandatory vs selective exploration for penetrating neck trauma. *Arch Surg* 1987;122:592-7
84. Miller RH, Duplechain JK, Penetrating wounds of the neck. *Otolaryng Clin N Am* 1991 Feb;24(1):15-29
85. Mitchell RO, Heniford BT, Traumatic retropharyngeal hematoma—a cause of acute airway obstruction. *J Emerg Med* 1995 Mar-Apr;13(2):165-7
86. Montalvo BM, LeBlang SD, Nunez DB Jr, Ginzburg E, Klose KJ, Becerra JL, Kochan JP, Color Doppler sonography in penetrating injuries of the neck. *AJNR Am J Neuroradiol* 1996 May;17(5):943-51
87. Mooney RP, Bessen HA, Delayed hemiparesis following non-penetrating carotid artery trauma. *Am J Emerg Med* 1988;6:341-345
88. Mutabagani KH, Beaver BL, Cooney DR, Besner GE, Penetrating neck trauma in children: a reappraisal. *J Pediatric Surg* 1995 Feb;30(2):341-44
89. Narrod JA, Moore EE: Initial management of penetrating neck wounds—a selective approach, *J Emerg Med* 2:14, 1984
90. Narrod JA, Moore EE: Selective management of penetrating neck injuries, *Arch Surg* May 1984; 119:574-578
91. Nemzek WR, Hecht ST, Donald PJ, et al, Prediction of major vascular injury inpatients with gunshot wounds to the neck. *AJNR* 1996 Jan;17:161-7
92. Niezgoda JA, McMenamin P, Graeber, GM. Pharyngoesophageal perforation after blunt neck trauma. *Ann Thorac Surg* 1990;50:615-17.
93. Nunez D Jr, Rivas L, McKenney, LeBlang S, Zuluaga A, Helical CT of traumatic arterial injuries. *AJR Am J Roentgenol* 1998 June;170(6):1621-6
94. Obeid FN, Haddad GS, et al; A critical reappraisal of a mandatory exploration policy for penetrating wounds of the neck. *Surg, Gynecol & Ob* June 1985;160:517-522
95. Okada Y, Shima T, Nishida M et al. Traumatic dissection of the common carotid artery after blunt injury to the neck. *Surg Neurol* 1999;51:513-520.
96. Opeskin K, Burke MP. Vertebral artery trauma. *Am J of Forensic Med and Pathology*. 1998;19:206-217.
97. Opeskin K. Traumatic carotid artery dissection. *Am J of Forensic Med and Pathology*. 1997;18:251-257.
98. Ordog GJ Albin D et al: 110 bullet wounds to the neck, *J Trauma* 25:238, 1985
99. Pretre R, Reverdin A et al: Blunt carotid artery injury: difficult therapeutic approaches for an underrecognized entity. *Surgery* 1994;115:375-81.
100. Pringle MB, Charig MJ, Radiology in focus: The use of digital subtraction angiography in penetrating neck injury—a very instructive case. *J Laryngology & Otology* June 1994;108:522-524
101. Rao PM, Bhatti MF, Gaudino J et al: Penetrating injuries of the neck: criteria for exploration, *J Trauma* 23:47, 1983
102. Reece GP, Shatney CH, Blunt injuries of the cervical trachea: review of 51 patients. *S Med J Dec* 1988; 81(12):1542-1548
103. Richardson DJ, Simpson C, Miller FB, Management of carotid artery trauma. *Surgery* 1988;104:673-80
104. Rivers SP, Patel Y, et al; Limited role of arteriography in penetrating neck trauma. *K Vasc Surg* 1988;8:112-6
105. Roden DM, Pomerantz RA, Penetrating injuries to the neck: A safe, selective approach to management. *Roden and Pomerantz*; 11:750-753

106. Rogers FB, Baker EF, Osler TM, Shackford SR, Wald SL, Vieco P, Computed tomographic angiography as a screening modality for blunt cervical arterial injuries: preliminary results, *J Trauma* 1999 Mar;46(3):380-5
107. Roon AJ, Christensen N, Evaluation and treatment of Penetrating Cervical Injuries. *J Trauma* 1979;19(6):391-7
108. Rostomily RC, Newell DW, Grady MS, Wallace S, Nicholls S, Winn HR, Gunshot wounds of the internal carotid artery at the skull base: Management with vein bypass grafts and a review of the literature. *J trauma* Jan 1997;42(1):123-133
109. Saletta JD, Folk FA, Freeark RJ, Trauma to the neck region. *Surgical Clin N Am* 1973;53(1):73-86
110. Schaefer SD, Primary management of laryngeal trauma. *Am otol Rhino Laryngol* 1982;91:399-402
111. Schaefer SD, Use of CT scanning in the management of the acutely injured larynx. . *Otolaryng Clin N Am* 1991 Feb;21(1):31-35
112. Schild JA, Denny EC, Evaluation and treatment of acute laryngeal fractures. *Head & Neck* 11:491-496, 1989
113. Sclafani AP, Sclafani SJA, Angiography and transcatheter arterial embolization of vascular injuries of the face and neck, *Laryngoscope* 1996 106:168-173
114. Sclafani SJ, Cavaliere G, Atweh N, Duncan AO, Scalea T, The role of angiography in penetrating neck trauma. *J Trauma* 1991 Apr;31(4):557-62; discussion 562-3
115. Sclafani SJA, Panetta T, Goldstein AS, et al; The management of arterial injuries caused by penetration of zone III of the neck. *J Trauma* 1985;25(9):871-81
116. Sclafani SJA, Scalea TM, et al, Interventional Radiology in the Treatment of Internal Carotid Artery Gunshot wounds. *J Vascular Interventional Radiol* 1995;6(6):857-61
117. Seelig M, Becker DP, Miller JD, et al; Traumatic acute subdural hematoma: major mortality reduction in comatose patients treated within four hours. *N Engl J Med* 1981;304:1511-8
118. Senkowski CK Kim U, Clinically Occult Carotid Injury: A case for operative management. *J Trauma*;41(5):530-9
119. Shama DM, Odell J, Penetrating neck trauma with tracheal and esophageal injuries. *Br J Surg* 1984;71, July,534-535
120. Shearer VE, Giesecke AH, Airway management for patients with penetrating neck trauma: a retrospective study. *Anesth Analg* 1993;77:1135-8
121. Sheely CH, Mattox KL, et al; Penetrating wounds of the cervical esophagus. *Am J Surgery* Dec 1975; 130:707-711
122. Sofianos C, Degiannis E, Van den Aardweg Ms, Levy Rd, Naidu M, Saadia R, Selective surgical management of zone II gunshot injuries of the neck: a prospective study. *Surgery* 1996 Nov;120(5):785-8
123. Spenler CW, Benfield JR, Esophageal disruption from blunt and penetrating external trauma. *Arch Surg* 111:663-667, 1976
124. Spira R, Bolanos R, Perforation of the Hypopharynx: Demonstration by computerized tomography. *Southern Medical J* May 1988, 81(5):658-9
125. Stahl, WM. Comment on: The role on angiography in penetrating neck trauma. *J Trauma* 1991 31:564-565.
126. Stahmer SA, Raps EC, Mines DI, Carotid and vertebral artery dissections. *Emerg Med Clin North Am* 1997 Aug;15(3):677-98
127. Stanley RB, Armstrong WB, Fetterman BL, Shindo ML. Management of external penetrating injuries into the hypopharyngeal-cervical esophageal funnel. *J Trauma.* 1997;42:675-9.
128. Sweeney TA, Marx JA, Blunt neck injury. *Emerg Med Clin North Am* 1993Feb;11(1):71-9
129. Symbas PN, Hatcher CR et al: Esophageal gunshot injuries, *Am Surg* 1980;191:703.
130. Thal ER, Meyer DM: Penetrating Neck Trauma. *Curr Probl Surg* Jan 1992:4-55
131. Thompson JN, Strausbaugh PL, Koufman JA, Kohut RI, Penetrating injuries of the larynx. *S Med J* Jan 1984;77:41-5
132. Uzan M, Cantasdemir M, Seckin MS et al. Traumatic intracranial carotid tree aneurysms. *Neurosurgery* 1998;43:1314-20.
133. Velmahos GC, Souter I, Degiannis E, Mokoena T, Saadia R, Selective surgical management in penetrating neck injuries. *Can J Surg* 1994 Dec;37(6):487-91

134. Walls RM, Wolfe R, Rosen P: Fools rush in? Airway management in penetrating neck trauma. *J Emerg Med.* 1993;11480-481.
135. Wallace SR, Cohen WA, Stern EJ, Reay DT, Judicial hanging: postmortem radiographic, CT, and MR imaging features with autopsy confirmation. *Radiol* 1994 Oct;193(1):263-7
136. Weaver AW, Fromm SH, And Wah AJ: The management of penetrating wounds of neck. *Surg Gynecol Obstet* 133:49, 1971
137. Weaver FA, Yeltin AE, Wagner WH, et al; The role of arterial reconstruction in penetrating carotid injuries. *Arch Surg* Sep 1988; 123:1106-11
138. Weigelt, JA, Thal ER, Snyder WH III et al, Diagnosis of penetrating carotid arterial injury. *Am J Surg* 1987;154:619-622
139. Whiteford MH, Abdulla F, Vernick JJ, Rabinovici R, Thoracic duct injury in penetrating neck trauma. *Am Surg* 1995 Dec;61(12):1072-5
140. Williams SR, Airway management for a retropharyngeal hematoma. *J Emerg Med* 1995 Mar-Apr;13(2):243-4
141. Wood J, Fabian TC, Mangiante EC, Penetrating neck injuries: recommendations for selective management. *J Trauma* 1989;29(5):602-6
142. Yamada S, Kindt GW, et al; Carotid artery occlusion due to non-penetrating injury. *J Trauma* 1967; 7(3):333-342
143. Yee, LF, Olcott EW, Knudson MM, Lim RC: Extraluminal, transluminal, and observational treatment for vertebral artery injuries. *J Trauma* 1995 Sept; 39(3):480-7