Management of penetrating neck injury in the emergency department: a structured literature review

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ABSTRACT

Objective: The management of patients with penetrating neck injuries in the prehospital setting and in the emergency department has evolved with regard to the necessity for spinal immobilisation and the use of multidetector computed tomographic (MDCT) imaging. Questions also arise as to choices of securing a threatened or compromised airway. A structured review of the medical literature was conducted to provide current recommendations for the management of patients with penetrating neck injury.

Methods: Databases for PubMed, MEDLINE, CINAHL and Cochrane EBMs were electronically searched using the subject headings “penetrating neck injury”, “penetrating neck trauma”, “cervical immobilization”, “multi-detector CTA” and “airway management”. The results generated by the search were limited to English language articles and reviewed for relevance to the topic.

Results: 122 citations were identified that met the criteria for emphasis on emergency department care, cervical spine immobilisation, use of multidetector CT angiography or airway management. After excluding case series, non-peer reviewed articles and editorials, 20 articles were identified and reviewed.

Conclusions: The current literature suggests that prehospital cervical immobilisation may not be necessary unless the patient has focal neurological deficits. Studies show that patients with penetrating neck trauma who are haemodynamically stable and exhibit no “hard signs” of vascular injury may be evaluated initially by MDCT imaging even when platysma violation is present. Airway management is evolving, but traditional laryngoscopy continues to be the mainstay of airway stabilisation.

Penetrating neck injuries (PNI) are an intimidating encounter for any prehospital provider or emergency medicine physician. In the USA, 1% of all trauma patients present with PNI, and up to one-third of these are accompanied by other moderate to severe injury that requires urgent medical attention. In addition, the mortality from such injuries ranges from 3% to 6%, with most of the fatalities resulting from direct injury to the major vessels in the neck. Firearms are the causative agent in 45% of platysmal violations, with stab wounds accounting for another 40% and shotgun injury 4%.

The neck is an area of complex anatomy that contains many vital structures within millimetres of one another, and the initial treatment and stabilisation of the injured patient is paramount. The most widely accepted anatomical classification as designed by Roon and Christiansen is as follows (fig 1):

- Zone I: extending from the clavicles to the cricoid cartilage;
- Zone II: extending from the inferior margin of the cricoid cartilage cephalad to the angle of the mandible;
- Zone III: located between the angle of the mandible and the base of the skull.

It should be remembered, however, that these zones of the neck refer to the anterior neck, from the anterior border of the sternocleidomastoid to the anterior border of the other sternocleidomastoid.

The prehospital and emergency department care of these patients has evolved over the last 20 years. There is no controversy surrounding the disposition of the patient with hard signs of injury (large expanding haematomas, severe active bleeding, bruit or palpable thrill). This review is intended to address more clearly questions in the management of patients without hard signs of injury. This includes the need for cervical stabilisation for prehospital transport, the correct method of evaluating the stable patient with platysmal violation and the necessity of mandatory surgical exploration or transfer to a trauma centre for higher level of care.

METHODS

Data sources

A comprehensive literature search was conducted of the databases MEDLINE (via PubMed; http://www.pubmed.gov), CINAHL (Cumulative Index of Nursing and Allied Health Literature, 1982–; via the OVID Technologies interface; http://gateway.ovid.com) and the Cochrane Database of Systematic Reviews (also via OVID). All searches were limited to English language. The PubMed search was limited to the year range 1977–2007 and used combinations of the following Medical Subject Headings (MeSH) and textwords (tw): penetrating[tw], “wounds, penetrating”[MeSH], stab[tw], “wounds, stab”[MeSH], gunshot[tw], “wounds, gunshot”[MeSH], firearm[tw], “firearms”[MeSH], neck[MeSH], cervical[tw] and injury[tw].

The initial combined search from all three databases yielded 1059 articles, which was reduced to 989 when the search was limited to humans and adults in PubMed and CINAHL. Further review by two of the investigators (JJB and BAC) was performed to eliminate those articles that did not have significant focus on (1) “cervical
immobilisation”, (2) “multidetector CTA”, (3) “emergency department management” or (4) “airway management”. Editorials, non-peer reviewed reports and case series were excluded. The application of these limits yielded a total of 122 articles. A third author (TWB) conducted a final review and adjudicated disagreements among the first two authors. Final consensus yielded 20 references for evaluation (tables 1–4).

RESULTS

Cervical spine immobilisation

Prehospital providers evaluating and managing the patient with penetrating neck trauma must quickly assess for potential airway, breathing and circulatory compromise (table 1). Commonly, given the mechanism, the paramedic may choose to place a cervical collar in order to stabilise any potential cervical fractures secondary to the inflicted trauma. Advanced Trauma Life Support (ATLS) does not make a distinction between blunt and penetrating neck trauma, stating that any patient with a suspected spine injury must be immobilised above and below the suspected injury site. In the 1980s many medical professionals suggested that all patients with penetrating neck injuries should be immobilised in a rigid cervical collar.

Over the past two decades, studies evaluating the need for prehospital cervical spine immobilisation have had conflicting results (table 1). Data from the Vietnam conflict were retrospectively analysed and it was concluded that, in a hostile environment, only 1.4% of all casualties who were candidates for immobilisation may have benefited from this care and that, in this population, all penetrating cervical cord injury was universally fatal. In addition, Barkana et al performed a retrospective chart review and evaluated autopsy reports of military casualties in Israel and concluded that life-threatening complications due to PNI (such as expanding haematomas) may be overlooked with a rigid cervical collar in place. In fact, none of the military casualties who were not immobilised required internal surgical cervical spine stabilisation whereas 22% of casualties had life-threatening signs diagnosed by an exposed neck. These studies were limited to retrospective analysis in a hostile environment and were initially viewed as “not applicable” to the current patient population as the injuries were sustained from military weapons.

A 10-year retrospective cohort study by Klein et al reported that 33/183 patients (18%) with gun shot wounds to the neck had cervical spine injuries. The authors concluded that spine immobilisation is essential for patients with gunshot wounds to the neck until radiographic imaging is complete. However, only 1 of the 33 patients had an unsuspected spine injury, which the authors defined as a proven spine injury with no neurological finding at admission.

Medzon et al performed a retrospective chart review to determine the frequency of stable and unstable cervical spine fractures after gunshot wounds to the head and neck. They reviewed 13 years of data and identified 81 patients; 25% had documented cervical spine fractures and, of the awake alert patients without initial neurological deficit, only 5% had a fracture, none of which was unstable or required surgical intervention. In a retrospective chart review by Lanoix et al it was concluded that, after excluding patients clinically

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>
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<tbody>
<tr>
<td>Arishita et al</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 al</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 (haematomas, emphysema); none required surgical stabilisation of spine injuries</td>
</tr>
<tr>
<td>Medzon et al</td>
<td>Retrospective study</td>
<td>81 patients with gun shot wounds to the head or neck 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 al</td>
<td>Retrospective cohort study</td>
<td>2450 patients with gun shot wounds to the trunk, head or neck who survived &gt;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 al</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>
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</table>
Table 2  Results of studies investigating airway management 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>
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<tbody>
<tr>
<td>Eggen et al</td>
<td>Retrospective study</td>
<td>8-year review of all patients (114) with a diagnosis of PNI seen in the ED</td>
<td>Data reviewed for airway management complications</td>
<td>60% were intubated during their hospital course, 22% in the ED. No patient developed complications form intubation</td>
</tr>
<tr>
<td>Mandavia et al</td>
<td>Retrospective study</td>
<td>748 patients with PNI, 1993–6</td>
<td>Establish rates of successful airway management by which methods</td>
<td>11% needed emergency intubation. Of these, 67% underwent RSI with direct laryngoscopy with 100% success rate. The rest underwent fiberoptic intubation, with all failures (3) rescued with DL</td>
</tr>
<tr>
<td>Shearer et al</td>
<td>Retrospective study</td>
<td>107 patients with PNI, 1989–91</td>
<td>Data reviewed for primary intubation technique</td>
<td>6% received surgical airways; 83% had RSI with DL; 7% had awake fiberoptic intubation; 4% had blind awake nasotracheal intubations. Success was 100%, 100%, 98%, 75%, respectively</td>
</tr>
<tr>
<td>Tallon et al</td>
<td>Retrospective study</td>
<td>19 patients with PNI, &gt;16 years of age, 1994–2005</td>
<td>Data reviewed for method of ETT method of choice</td>
<td>Very small study showed variations in choice for establishing airway at one Canadian medical centre. Of those intubated, 50% underwent awake intubation and 50% underwent RSI</td>
</tr>
</tbody>
</table>

DL, direct laryngoscopy; ED, emergency department; ETT, endotracheal intubation; RSI, rapid sequence intubation.

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

Airway management in the emergency department

As the patient with penetrating trauma arrives in the emergency department, the need for airway management must immediately be assessed (table 2). The approach to the compromised airway in this delicate situation remains controversial with a general lack of literature on the topic. Shearer et al13 reviewed the records of 107 patients with PNI and found that 6% received surgical airways, 83% had direct laryngoscopy after rapid sequence intubation (RSI), 7% underwent awake fiberoptic intubation and 4% had awake blind nasotracheal intubation. The authors noted that the success rates were not statistically different with any of the four airway techniques; however, one death occurred in the awake nasotracheal intubation group and, with the technical requirements and time needed for fiberoptics, direct laryngoscopy with RSI may be the preferred method of airway control.

Tallon et al13 performed a retrospective review of patients suffering PNI at a Canadian tertiary care centre to review the method of securing the jeopardised airway. Nineteen patients met the inclusion criteria and three were not intubated. Of those intubated, five were performed in the prehospital setting, six in the emergency department and five in the operating suite. Of these, 42.1% underwent awake intubation and 42.1% underwent RSI intubation. This small study concluded that there is clear variability in airway management in PNI.13

Table 3  Results of studies evaluating physical examination (PE) for penetrating neck injury (PNI)

<table>
<thead>
<tr>
<th>Author</th>
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<th>Intervention</th>
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</tr>
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<tbody>
<tr>
<td>Atteberry et al</td>
<td>Prospective study</td>
<td>66 consecutive patients with zone II PNI, 36 meeting inclusion criteria</td>
<td>Vascular status determined on PE alone if the injury was in zone II and no signs of vascular injury. Patients admitted in first year received ultrasound of carotids</td>
<td>Patients with no hard signs of vascular injury can be safely managed on PE alone. No patients had evidence of vascular injury during hospitalisation or follow-up not anticipated on PE.</td>
</tr>
<tr>
<td>Demetriades et al</td>
<td>Prospective study</td>
<td>82 stable patients sustaining PNI</td>
<td>Objective was to evaluate PE, Doppler and angiography in detecting serious injury in PNI</td>
<td>Serious injuries were detected or suspected by PE; 6 lesions missed but did not require intervention. Excluding injuries not requiring treatment, sensitivity was 100% and specificity 91%</td>
</tr>
<tr>
<td>Gonzales et al</td>
<td>Prospective study</td>
<td>42 patients aged &gt;14 years sustaining PNI to zone II</td>
<td>Evaluate the utility of CT scanning as a diagnostic tool and adjunct to PE in identifying surgically significant PNI to zone II</td>
<td>CT scanning contributed minimally to the sensitivity of PE in the diagnosis of surgically significant PNI to zone II. All patients with carotid injury or oesophageal injury were diagnosed on PE</td>
</tr>
<tr>
<td>Sekharan et al</td>
<td>Retrospective study</td>
<td>145 patients reviewed over 9 years</td>
<td>Review of medical records 1991–9 of patients with PNI and documented vascular injury</td>
<td>Patients with zone II PNI can be safely and accurately managed by PE alone to confirm or exclude serious vascular injury with a miss rate of 0.7%</td>
</tr>
</tbody>
</table>

Mandavia et al performed a retrospective analysis of all emergency department intubations at a level I trauma centre over a 3-year period. Seven hundred and forty-eight consecutive patients with PNI were evaluated, with 11% deemed to require emergency airway control. They found that 67.2% of intubations used RSI and direct laryngoscopy with a 100% success rate, while the remaining patients underwent fibreoptic intubation in which three attempts were unsuccessful.

Grewal et al and Eggan and Jorden also retrospectively reviewed intubations of patients with PNI and demonstrated success with traditional RSI and direct laryngoscopy.

In conclusion, RSI is the preferred method of intubation for patients presenting with penetrating neck trauma, and experience dictates that this method may still be the first-line method of establishing a definitive airway. As advanced techniques including fibreoptics evolve, this issue will need to be readdressed.

### Physical examination (table 3)

Historically, those with PNI to zone II were universally brought to an operating suite for surgical exploration. Physical examination was viewed as unreliable unless hard signs of injury were present. This dogma has recently been challenged in the literature. Jarvik et al performed a retrospective chart review at a level I trauma centre and found no statistically significant difference between the sensitivities of clinical examination or angiography for the detection of vascular injury. They concluded that the physical examination alone may be sufficient to detect significant vascular lesions.

Sekhara et al reviewed 145 cases of penetrating neck trauma and found that 21% of these patients had hard signs of vascular injury and were taken to the operating suite; 90% of the patients had major arterial or venous injury requiring operative repair, yielding a false positive physical examination rate of only 10%. Of the 114 patients without hard signs of injury, only one required operative repair of vascular injury.

These conclusions are made regarding zone II injury and do not dictate the management of other zones of trauma. However, most penetrating neck trauma results in injury to zone II. The clinician should be aware that current literature dictates that any patient with hard signs of injury needs an operative intervention, and these patients may require transfer to a higher level of care if a surgeon is not readily available.

#### Imaging of the stable patient

As mentioned above, most penetrating injuries to the neck occur in zone II (table 4). Much controversy has surrounded the management of such patients. A policy of early mandatory neck exploration for zone II injuries deep to the platysma was promoted in the 1950s. This was cumbersome and costly as a surgeon was immediately needed for each patient presentation to an emergency department. In the 1980s selective arteriography was employed to evaluate vascular injury in zone II penetrating neck trauma. Rivers et al concluded in a retrospective study that no major arterial injuries were discovered during neck surgery that were missed by preoperative physical examination, and neither abnormal nor normal angiograms significantly altered the course of management of patients sustaining zone II PNI. In addition, angiography did not address concurrent injury to the aerodigestive tract which may also require surgical intervention. Mazolewski et al prospectively evaluated the utility of CT scanning in the evaluation of zone II PNI. Stable patients with PNI received a CT angiogram of the neck prior to elective surgical exploration. Before operation, surgeons were asked to predict the likelihood of significant injury. The sensitivity, specificity, positive predictive value and negative predictive value were 100%, 91%, 75% and 100%, respectively (p < 0.02).

These results spawned further research on the evaluation of zone II injury in the haemodynamically stable patient. Inaba et al prospectively assessed multidetector CT angiography (MCTA) as a stand-alone screening tool for the initial evaluation of the patients. During a 16-month period 106 injuries that penetrated the platysma presented to a level I trauma centre. Only 1/32 patients in the CTA neck group needed exploration; patients with normal CTA had higher negative explorations (22%, p < 0.001) CTA of the neck achieved 100% sensitivity and 93.5% specificity in detecting all vascular and aerodigestive injuries sustained (p < 0.001).

#### Table 4 Result of studies evaluating multidetector CT scanning 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>
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<tbody>
<tr>
<td>Gracias et al</td>
<td>Retrospective</td>
<td>23 stable patients</td>
<td>Stable patients received CTA of the neck as an initial study; outcome was</td>
<td>13 patients with CTA of the neck had no further studies as trajectory far from vital structures. 10 underwent angiography, 2 underwent endovascular or observation procedures and clinical follow-up.</td>
</tr>
<tr>
<td>Munera et al</td>
<td>Prospective</td>
<td>175 patients</td>
<td>CTA results evaluated by radiology and based on findings, either surgical,</td>
<td>Arterial lesions identified in 27 patients (15.6%). No CT evidence of injury and no surgical intervention in 84.4%. Sensitivity 100%</td>
</tr>
<tr>
<td>Woo et al</td>
<td>Retrospective</td>
<td>130 patients</td>
<td>Surgical or observation procedures and clinical follow-up.</td>
<td>Only 1/32 patients in CTA neck group needed exploration; patients with normal CTA had higher negative explorations (22%, p &lt; 0.001)</td>
</tr>
<tr>
<td>Inaba et al</td>
<td>Prospective</td>
<td>106 patients</td>
<td>Cognitive abnormalities in patients receiving CTA of the neck, then</td>
<td>CTA of the neck had a sensitivity, specificity, PPV and NPV of 100%, 91%, 75% and 100%, respectively (p &lt; 0.02)</td>
</tr>
<tr>
<td>Mazolewski et al</td>
<td>Prospective</td>
<td>14 patients</td>
<td>Cognitive abnormalities in patients receiving CTA of the neck, then</td>
<td>Cognitive abnormalities in patients receiving CTA of the neck, then</td>
</tr>
<tr>
<td>Munera et al</td>
<td>Prospective</td>
<td>60 patients</td>
<td>Cognitive abnormalities in patients receiving CTA of the neck, then</td>
<td>Cognitive abnormalities in patients receiving CTA of the neck, then</td>
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</table>

CTA, CT angiography; PPV, positive predictive value; NPV, negative predictive value.
trauma centre. MCTA achieved 100% sensitivity and 93.5% specificity in detecting all vascular and aerodigestive injuries sustained. In addition, MCTA found two tracheal and two carotid injuries requiring operative intervention or endovascular repair in asymptomatic patients.23 Gracias et al14 performed a retrospective case series with the hypothesis that CTA used as an early diagnostic tool could eliminate further studies or procedures in stable zone II neck injury. Most of this patient population had gun shot wounds, and data obtained suggested that CT scanning in stable patients with penetrating trauma to the neck appears safe and reliable. More importantly, 60% of patients had “trajectory consistent with injury” excluded by the CT scan. Thus, only 40% required formal angiography (because of proximity) and less than 10% required endoscopy.24

Many other studies have reached similar conclusions regarding the use of CTA in penetrating neck trauma as a method of eliminating mandatory surgical exploration of all platysmal penetration.12–25–33 These studies have profound implications for emergency physicians who receive and initiate treatment of this patient population. No longer must a haemodynamically stable patient with a PNI to zone II be explored. If CTA does not reveal significant injury and the patient does not demonstrate haemodynamic compromise, these victims may be observed. This eliminates the need for the presence of a surgeon in the emergency department for each patient with platysmal violation and decreases the need for transfers to a higher level of care institution if a surgeon is not readily available.

CONCLUSIONS
All emergency medicine practitioners as well as prehospital providers will encounter patients with penetrating neck trauma. Patients who do not have hard neurological signs at the scene probably do not need cervical and spinal immobilisation as this may obscure life-threatening haemotoma and potential airway compromise. If airway management is needed, traditional direct laryngoscopy appears to be safe and effective. For those patients in whom surgical exploration is warranted, most have physical examination findings that necessitate intervention. In addition, patients with no hard signs of vascular injury and stable vital signs may undergo MDCT angiography despite platysmal violation and, if no injury is found, these patients may not need transfer to a trauma centre for mandatory exploration.

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REFERENCES
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