

Value of clinical examination in the assessment of penetrating neck injuries: a retrospective study of diagnostic accuracy test

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Abstract

Background: There are many high-volume trauma centers in limited resource environments where a thorough clinical examination of patients may contribute to a more economic, accurate, and widely applicable method of determining the proper management of patients with penetrating neck injuries. The purpose of this study was to validate thorough physical examination as a reliable diagnostic tool in these patients. **Methods:** We performed an observational retrospective study of a diagnostic accuracy test where we compared clinical findings (symptoms and soft signs on admission of the patient) with the definitive findings according to the gold standard test for each particular situation (selective studies, clinical observation and surgical exploration). The study was conducted at Hospital Occidente Kennedy (HOK) between August 2009 and June 2010. **Results:** The sample consisted of the clinical records of 207 (n=207) patients who went to the emergency room for penetrating neck wounds at Hospital Occidente Kennedy (HOK). Of the total sample, 36.2% (n=75) of patients were considered “asymptomatic” as they didn’t present with any soft signs of injury. Vascular soft signs were present in 57% (n=118) of the patients, soft signs of the airway and the upper gastrointestinal tract were present in 15.9% (n=33) and 21.3% (n=44) of the patients respectively. The sensitivity and negative predictive value (NPV) of any soft sign to determine injuries which require surgical repair was 97.4% [CI] [86.5%-99.5%] and 98.7% [CI] [92.8%-99.8%] respectively, with a range of confidence [CI] of 95%. **Conclusions:** Our study’s main findings suggest that patients with neck injuries and no vascular, airway, or gastrointestinal soft sign can be safely managed with a conservative approach. It is important to emphasize the value of the clinical examination since there are many contexts in the modern world where a considerable amount of the population is afflicted by neck trauma and treated under conditions where technological resources are limited.

Background

The neck has a dense concentration of vital structures confined in a small space. Any intrusion may result in life threatening penetration of the trachea or larynx, the esophagus, major blood vessels, cervical nerve roots, cervical nerves or the spinal cord (1,2). Penetrating neck injury (PNI) constitutes 5–10% of traumatic injuries in adults and has a mortality rate ranging from 10% to 15% (1,2). Different characteristics of neck trauma are usually related to the social and cultural conditions of the population. Penetrating neck injuries are more likely to occur in highly populated areas where there is more interpersonal violence and more gun and knife crime between young men (3). Additionally, the rise of global terrorism and continuing wars in the Middle East has perpetuated head and neck injuries in the civilian population leading to elevated morbidity and mortality rates. (4,5)

Previously many centers advocated for mandatory surgical exploration irrespective of signs or symptoms. Such policies are associated with a high incidence of unnecessary operations, ranging from 30%–89% (6). Different studies suggest operative management is required more frequently with gunshot wounds than with stab wounds, even though the majority of PNIs are caused by stab wounds, with only a minority by gunshot injuries (7, 8). In recent years, selective management of penetrating neck trauma

based on clinical examination has been recommended, which seems to reduce, on the one hand, the percentage of negative examinations, and on the other hand, a significant number of costly diagnostic tests, many of which are not available in some institutions, which also generate unnecessary prolongation of hospital stays (6).

However, management of PNI remains controversial. Over the last decade, most trauma centers have now adopted the approach of selective management based on a combination of clinical examination and the use of diagnostic tools (9). In particular, developments in computed tomography angiography (CTA) have provided a fast, accurate, non-invasive method for evaluating patients with penetrating neck injuries (9).

Although, in settings where resources are limited and this technology is not yet available, other types of studies (angiography, bronchoscopy and/or esophagoscopy) still hold high sensitivity for detecting injuries. These exams are also invasive for the patient and carry a small but serious risk of complications (10). The high incidence of PNIs due to interpersonal violence within cities and due to the continuation of wars in the Middle East raises questions as to whether patients should be managed by using CTA as the gold standard diagnostic approach or if efforts must be focused on the rational use of technology. This being even more so when the value of the clinical examination plays a very important role defining the management of the patient (9,10).

The current trend in literature is to argue the selective use of different diagnostic methods depending on the clinical findings upon admission (11). High-volume trauma centers are more frequently turning to the selective non-operative management (SNOM) approach when treating PNIs. This type of management is based on clinical examination or other additional examinations. Together, they have shown to be reliable indicators of clinically significant injury, with a sensitivity of 93–95% and a negative predictive value of 97% (11,12).

Bearing in mind the changes in the management of PNIs, our study aims to provide information on the value of the clinical examination in the assessment of penetrating neck wounds, in scenarios where there is a high volume of trauma and there are limited resources for decision making. To this end, a diagnostic accuracy test study was designed to evaluate the diagnostic value of clinical findings in neck trauma (to identify the presence of lesions that warranted further study or surgical intervention). Our research shows the experiences within a trauma referral center with limited resources in Bogotá, Colombia. When information was gathered, approximately 2000 trauma patients were admitted in Hospital Occidente Kennedy's (HOK) facilities annually, where 8% of the cases were associated with penetrating neck injuries. The present diagnostic accuracy study aims to highlight the importance of thorough physical examination in patients with penetrating neck injury admitted to the emergency department.

Methods

We performed an observational retrospective study to compare the diagnostic accuracy of clinical findings (symptoms and soft signs on admission of the patient) with the definitive findings according to the gold standard test for each particular situation in patients with PNI admitted to the HOK emergency

department from August 2009 until and including June 2010. We aimed to calculate the diagnostic accuracy of clinical findings following the Standards for Reporting Diagnostic accuracy studies (STARD) 2015 guidelines (13).

Patients admitted to the HOK emergency department with neck wounds that extended deep to the platysma were considered for inclusion. The selected group was between 14 and 65 years of age. They underwent an interview and a complete physical examination, and a form was filled out by the surgeon on duty, where he/she focused on soft signs and symptoms that would lead the physician to suspect lesions in the upper gastrointestinal tract, airway lesions in the neck and/or vascular lesions. Patients with penetrating neck trauma who were initially resuscitated according to the Advanced Trauma Life Support guidelines and remained hemodynamically unstable were excluded from the study (14). Patients were also excluded and taken immediately to the operating room if they presented "hard signs" including signs of vascular injury (active severe bleeding, expanding hematoma, absence of peripheral pulse, arterial bruit, thrill, and unexplained hypotension) and aerodigestive injury (respiratory distress, massive subcutaneous emphysema, air bubbling through the neck wound and massive hemoptysis) (14). Additionally, patients were excluded if they were dead on arrival (DOA), those with insufficient data in the clinical record or without clinical follow-up, and patients with cranioencephalic and/or spinal cord trauma of whom, due to their clinical condition, necessary information couldn't be collected.

After a comprehensive clinical evaluation, patients included in the research were categorized into 2 groups according to their signs and symptoms. The first group consisted of patients with "soft signs" including signs of vascular injury (minimal bleeding, mild to moderate bruising, hypotension that responds to resuscitation, and murmur fluids) and aerodigestive injury (hoarseness, stridor, minimal hemoptysis, subcutaneous emphysema, odynophagia, dysphagia and hematemesis) (14). The second group was comprised of patients who did not present any hard or soft signs upon clinical examination, and so were considered "asymptomatic" (however still presenting with PNI) and would undergo close observation and series of physical examinations for 24 hours.

To determine whether patients required any kind of surgical repair, we used three gold standard tests. The surgeon on duty decided between three different types of patient management according to the initial clinical findings: 1. Request selective studies: Fibrobronchoscopy (airway), arteriography and/or duplex studies (vascular), upper digestive endoscopy (upper Gastrointestinal tract). 2. Surgical exploration: intraoperative findings. 3. Clinical observation: patients that the surgeon on duty left in clinical observation for 24 hours in the emergency service and hereafter were discharged. Subsequently, a follow-up was carried out by external consultation or a telephone call 30 days after the trauma where a questionnaire was carried out to determine if the patient presented late signs or symptoms that required complementary studies, or if they were asymptomatic, at which point the patients were considered to be fully recovered.

Clinical findings were compared using two-by-two contingency tables, the accuracy of the soft signs of vascular, airway and digestive injury was estimated comparing patients who required surgery with

patients who didn't (according to the gold standard in each patient). Additionally, 95% confidence intervals (CI) were calculated. Data was collected in a pre-established format and analyzed with the statistical packages STATA version 9 and SPSS version 17. A descriptive analysis of the variables was carried out, and sensitivity, specificity, positive and negative predictive values of clinical examination were calculated.

Results

The sample consisted of the clinical records of 207 (n = 207) patients who were admitted for penetrating neck wounds at HOK between August 2009 and June 2010 and met the inclusion criteria. The majority were male 87.9% (n = 182) and the mean age was 29.22 years (SD:11.92). The median time elapsed between the time of injury and their admission to the hospital was 60 minutes (IQR: 30–180) and the median blood pressure upon admission 110/70 MmHg (IQR:100/65- 120/75.75).

The most frequent neck injuries were caused by stab wound in 176 (85%) cases, followed by gunshot wounds in 24 (11.6%) patients, and shotgun injury in 7 (3.4%) patients. Neck zone II was compromised in 123 (59%) of the cases; 61 (29.5%) in Zone I and 23 (11.1%) cases in Zone III.

Vascular soft signs were present in 118 (57%) patients, 87 (42%) patients presented minimal bleeding, followed by 54 (26%) patients who presented non-expansive hematomas. The soft signs of the airway and the upper gastrointestinal tract were present in 33 (15.9%) and 44 (21.3%) patients respectively. In the airway and in the upper gastrointestinal tract, the most frequent sign was subcutaneous emphysema present in 29 (14.1%) patients. Hemoptysis occurred in only 7 patients and stridor in 4 patients. Dysphagia occurred in 21 (10.1%) patients and odynophagia in 14 (6.8%).

Regarding the diagnostic and/or therapeutic approach of the 207 patients, 95 (45.9%) underwent the set of selective studies: Upper digestive tract endoscopy was performed in 95 patients and did not show evidence of any lesion.; only one patient had an abnormal fibrobronchoscopy, underwent surgical exploration and required surgical repair of the trachea. Carotid duplex was performed in 80 patients and only one patient needed surgical repair (internal carotid stent). Of 22 arteriographic studies performed, 2 showed evidence of lesions that required surgical repair (internal carotid stent and vertebral artery thrombosis).

Of the 83 (40.1%) patients who underwent surgical exploration, 60 (72.3%) patients showed no lesions of vital structures. Some type of vascular lesion was identified in 23 (27.7%) patients (total or partial section of the anterior or external jugular veins; in three cases evidence was found of injuries to the internal carotid and the internal jugular). Airway injury was identified in 16 (20%) patients, all cases were characterized by perforations of the trachea. No injury of the upper gastrointestinal tract was identified in this series of patients. From the 75 (36.2%) patients categorized in the "asymptomatic" group (as they didn't present any soft sign of injury), 37 (49.3%) had complementary studies where only one needed surgical repair (internal carotid stent). Additionally, 11 (14.6%) patients were taken to surgery and none

needed any kind of repair. Of the 207 patients, only 30 (14.5%) patients had clinical follow-up and none required further assessment.

Of the 207 patients, only 38 (18.4%) had injuries that required surgical repair: 23 (11.1%) of the patients presented vascular lesions and 16 (7.7%) airway lesions. Only one patient needed repair of a vascular and airway injury (external jugular and trachea).

Analytical Statistics

The validation analysis showed in Table 1 demonstrates that the clinical finding of any soft sign has a sensitivity of 97.37%, with a specificity 43.79%, a positive predictive value (PPV) of 28.03% and a negative predictive value (NPV) of 98.67% to determine which patients required surgical repair. Additionally, clinical findings of vascular and airway soft signs demonstrated high diagnostic value to identify injuries that require surgical repair. Diagnostic accuracy was calculated with a range of confidence of 95% (CI).

Discussion

Our study's main findings suggest that patients with PNI and no vascular, airway or gastrointestinal soft sign can be safely managed with a conservative approach, which hold high negative predictive values in the absence of soft signs (NPV: 93%–99%). Our findings also demonstrate that adequate identification of soft signs represents a good screening tool for patients with PNIs, as it shows high sensitivity (97.4%) in determining patients who require surgical repair. Many high-volume trauma centers are using the Selective Non-operative Management Approach (SNOM) in which by determining the soft signs of vascular injury, airway injury and upper gastrointestinal tract lesion, they are able to suspect vital structure lesions and identify the need to carry out complementary studies (8). Similar to our results, the study of Inaba et al. with 453 patients at two Level 1 trauma centers demonstrate that using physical examination to triage patients into those with hard signs, soft signs, and no signs of vascular and aerodigestive tract injuries was highly effective at minimizing the need for invasive imaging and the rate of negative surgical exploration (19). Different studies validated the practice of SNOM as a safe and appropriate management strategy (8,15).

Identification of vascular soft signs evidenced high sensitivity (95.6%) and NPV (98.9%) in order to determine patients who require surgical repair. The possibility of requiring surgical repair if one does not present any vascular soft sign is very low. While some authors advocate mandatory vascular imaging following PNIs according to mechanism or zone, many studies have demonstrated the reliability of physical examination alone to exclude clinically relevant vascular injuries (12, 18). A prospective observational study with 203 patients showed a negative predictive value (NPV) and specificity of 88.6%–95.5% and 90.7% respectively, for all signs and symptoms mandating angiography (18). Additionally, in a study conducted with 216 patients in Indiana the sensitivity and negative predictive value of physical examination for detecting vascular injuries requiring operative management were both 100% (12). Moreover, the research of Menawat et al. conducted with 110 patients evidenced that 42

patients were determined to have no vascular injury based on lack of any physical findings (16). According to our findings and evidence shown in literature it is safe to say that routine angiography may be unnecessary for patients with penetrating neck injuries and negative physical examination.

Taking into account soft signs of airway injury, our study showed a sensitivity of 93.8%, a specificity of 90.6%, and a NPV of 99.4% to diagnose airway injuries that required surgical repair. Patients presenting airway soft signs may be evaluated with bronchoscopy, esophagogram and esophagoscopy (12). Nevertheless, new technologies such as CTA have demonstrated to hold high diagnostic accuracy when compared to the vascular and airway diagnostic gold standards. Different studies showed nearly 100% sensitivity and specificity of CTA in detecting clinically significant vascular or aerodigestive injuries (19, 20, 21, 22).

As shown, any vascular or airway soft sign identified in patients should impact the management received. Different diagnostic studies (Arteriography, duplex of four vessels of the neck, bronchoscopy, esophagogram, esophagoscopy and more recently CTA) have shown high sensitivity and negative predictive values to determine injuries patients with PNI (12,21). Although, we should bear in mind the significant resource implications associated with unnecessary utilization of diagnostic tools (19). The loss of resources in unnecessary procedures may be interpreted as the loss of opportunity in the care of many patients in a resource-limited environment, which is why the confirmation of the safety and accuracy of physical examination in patients with PNI represents a paradigm shift towards a simpler, more economic, accurate, and widely applicable method of determining the proper management of these patients (17).

A consensus regarding the management of penetrating neck injuries has been sought around the world. It is clear that immediate neck exploration is warranted in unstable patients with "hard signs" of neck injury after optimal airway has been obtained (14). In accordance to international literature, our study showed higher incidence of stab wounds than gunshot wounds as a result of interpersonal violence within city limits (7,8,15,16,17). Nevertheless, higher incidence of gunshot wounds is evidenced in scenarios of war and armed conflict. Also, according to literature there's a higher prevalence of PNIs in men, and the most affected zone of the neck is usually zone II(15–18). However, the type of management of the PNI shouldn't be determined by the mechanisms of assault but by the signs and symptoms presented by the patient (4,7,12,18).

There are some limitations to this study that need to be emphasized. Primarily, this was an observational retrospective study, and if we wish for there to be a future paradigm shift towards a SNOM approach in scenarios of low resources, a prospective study would be more appropriate. Additionally, the hospital where the study was conducted did not have available CTA imaging. As different studies showed a nearly 100% accuracy in detecting vascular and aerodigestive injuries, it would have been important to count on this diagnostic tool as a gold standard.

Conclusions

It is important to emphasize the value of clinical examination since there are many contexts in the modern world where the population is subjected to neck trauma and technological resources are limited. Taking into account that the loss of resources in unnecessary procedures may be interpreted as the loss of opportunity of caring for many other patients in a resource-limited environment, the results of the present study indicates that physical examination is a reliable diagnostic tool that is simpler, more economic, accurate, and widely applicable. Furthermore, it can be specifically implemented and used systematically to diagnose the patient's signs and/or symptoms related to lesions of the digestive tract, vascular system, airway, and nervous system in contexts where more sophisticated technologies are not yet available.

Abbreviations

PNI: Penetrating Neck Injury; CTA: Computed Tomography Angiography; HOK: Hospital Occidente Kennedy; SNOM: Selective Non-Operative Management; PPV: Positive Predictive Value; NPV: Negative Predictive Value; SD: Standard Deviation; IQR: Interquartile Range; CI: Confidence Interval

Declarations

Ethics approval and consent to participate:

This work did not involve direct interventions on the patients since the data was taken from the clinical records and the defined behaviors for the diagnosis and treatment were those that the surgeons of the service decided according to the criteria of their current practice. The conducts used to carry out arteriographies, endoscopies, fibrobronchoscopies, or explorations and / or surgical treatments are those that are usually taken in the emergency service for the management of penetrating injuries in the neck by the different surgeons of the service in Hospital Occidente Kennedy. There was no direct intervention on patients as part of the present investigation. The protocol of treatment of patients in HOK to perform any invasive examination or surgical procedure, includes that all patients must demonstrate their compliance with said behavior by signing a pre-established Informed Consent form for each service. The data was collected under the numbers of their clinical histories and the presentation of the results kept the anonymity of the patients and did not allow them to be identified in any way. The research project was submitted and approved by the Clinical Research Ethics Committee of the Universidad del Rosario. The planning and conduct of the project was carefully developed following the ethical guidelines contemplated in the Declaration of Helsinki and Resolution 8430 of 1993 of the Ministry of Health, and in accordance with this resolution was considered a risk-free study.

Consent for publication: Not applicable

Availability of data and material: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Authors' contributions: AIR, JQ, AMRS conceived and designed the study, developed the theory, draft the manuscript and designed the tables. JQ, AMRS and JED preformed the analytic calculations, contributed to the interpretation of the results and were in charge of overall direction and planning. AIR, JED, and AMRS helped in interpreting the results and worked on the manuscript. All authors discussed the results and contributed to the final version of the manuscript.

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Table

| Table 1: Diagnostic accuracy of soft signs to determine patients who require surgical repair. | | | | | | |
|---|--------------------|-------------|------------------|-------------|---------------|-------------|
| | Vascular soft sign | | Airway soft sign | | Any soft sign | |
| | % | CI 95% | % | CI 95% | % | CI 95% |
| Sensitivity | 95.6% | 79.0%-99.2% | 93.8% | 71.7%-98.9% | 97.4% | 86.5%-99.5% |
| Specificity | 47.8% | 40.7%-55.0% | 90.6% | 85.6%-94.0% | 43.8% | 36.5%-51.3% |
| Positive Predictive Value | 18.6% | 12.6%-26.6% | 45.4% | 29.8%-62.0% | 28.0% | 21.1%-36.2% |
| Negative Predictive Value | 98.9% | 93.9%-99.8% | 99.4% | 96.8%-99.9% | 98.7% | 92.8%-99.8% |