# Comparative Study of National Emergency X-Radiography Utilization Study (NEXUS) Chest Algorithm and Extended Focused Assessment with Sonography for Trauma (E-FAST) Performed by Emergency Physicians in The Early Detection of Blunt Chest Injuries

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## ABSTRACT
**Background**: Observing the disparity between increased imaging utilization and a lack of proportional increase in diagnosed diseases, leading to higher resource waste and patient risks, there was always a call for developing guidelines for directing the usage of imaging in the Emergency Department.
**Objectives**: Evaluating the ability of E-FAST and NEXUS chest algorithms in the early detection of blunt chest injuries in polytrauma patients, with the goal of minimizing costs and harmful radiation exposure.
**Patients and Methods**: Sixty-one polytrauma patients with blunt chest trauma from the emergency room at Menoufia University Hospital were included in this observational cross-sectional study; we noted whether the NEXUS chest clinical criteria were present. After that E-FAST scan was performed, and then a CT was conducted for all patients. We compared the findings of the CT with those of the NEXUS algorithm and E-FAST.
**Results**: In pneumothorax cases, the NEXUS algorithm recorded 100% sensitivity and 10% specificity, whereas E-FAST recorded 87% sensitivity and 98% specificity. In hemothorax cases, the NEXUS algorithm had 100% sensitivity and 11% specificity. In contrast, E-FAST recorded a higher specificity of 100% and a lower sensitivity of 80%.
**Conclusion**: Compared to the NEXUS chest algorithm, which had higher sensitivity than E-FAST, E-FAST demonstrated a higher specificity in identifying pneumothorax and hemothorax in patients with blunt chest injuries.
**Keywords**: Chest injuries, E-FAST, Hemothorax, NEXUS algorithm, Polytrauma, Pneumothorax.

## INTRODUCTION

Trauma is recognized as a significant global burden, accounting for a high number of deaths and disability [1,2]. Trauma is the leading cause of death in Africa among young, productive individuals, and the number of deaths resulting from it is greater than in other parts of the world [3].

One of the most significant and frequent injuries that needs to be diagnosed right once is chest trauma [4]. contributing to 25–50% of trauma-related deaths worldwide [5]. Chest trauma has a very important golden hour, when careful treatment is usually necessary to avoid death [6].

Due to limited access to computed tomographic scans, which are considered the gold standard, diagnosing chest injuries can be difficult in low-income nations. Additionally, easily available chest radiographs come at a high cost, particularly when considering the radiation exposure of many injuries and longer wait times that lead to overcrowded emergency rooms [7].

It has been demonstrated that thoracic ultrasonography (US) is a useful instrument and bedside procedure [8].

When compared to conventional radiographic scanning, it offers several benefits, including dynamic imaging, radiation-free operation, and greater accessibility [6]. U.S can be done quickly, cheaply, and without interfering with resuscitation or exacerbating injuries during transport [9]. Observing the disparity between increased imaging utilization and a lack of proportional increase in diagnosed diseases, leading to higher resource waste and patient risks, there was always a call for developing guidelines for directing the usage of imaging in the Emergency Department [1].

These guidelines must demonstrate near-perfect sensitivity for severe injuries in order to be widely accepted in trauma cases [10]. A multicenter, prospective cohort validated research conducted at nine US level I trauma centers between December 2009 and January 2012 showed that the NEXUS chest algorithm has an excellent sensitivity for diagnosing chest injuries. It included patients who were above 14 years, had blunt trauma within 24 hours of presenting to the emergency room, and had received CT chest or chest X-ray as part of the evaluation of blunt trauma. Intra-thoracic injury cannot be ruled out when one or more of the criteria are met, in which case a CT scan is required. When a trauma patient does not meet all of the criteria, there is very little chance of an intra-thoracic injury, and chest imaging is not recommended [10,11]. The NEXUS Chest decision tool has seven clinical variables: Age > 60, rapid deceleration mechanism (fall > 20 feet or MVC > 40 mph), intoxication, abnormal mental state, distracting painful injury, chest pain, and tenderness while palpating the chest wall [10,11].

So, in this study, we aimed to reduce the costs and radiation risks of unnecessary polytrauma imaging, and to improve the management process of polytrauma patients by evaluating the accuracy of the NEXUS chest algorithm compared with E-FAST in detecting blunt chest injuries in Menoufia University Hospital.



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## PATIENTS AND METHODS

Between June 2024 and March 2025, 61 patients with blunt chest injuries were enrolled in this observational cross-sectional comparative study at Menoufia University Hospital's Emergency Department. Every patient was chosen based on the inclusion and exclusion criteria. the inclusion criteria were: Adult patients (18 years of age and above), patients who had blunt trauma within 24 hours of presentation, and patients who underwent chest CT scan in the Emergency Department as a part of blunt trauma evaluation. Exclusion criteria were: Patients' age less than 18 years old, patients who were transferred from or to other hospitals, patients who were discharged on their demand and patients who underwent any imaging scan before presenting to the criteria. Clinical evaluations of the patients were conducted on arrival to the Emergency Department, which included demographic and clinical data. Then, hemodynamic vital measurement by the ABCDE approach (airway, breathing, circulation, dysfunction, and exposure). Followed by a detailed chest examination to identify the type of chest injuries,

Then we noted whether the NEXUS chest clinical criteria were present, which include: age > 60 years, rapid deceleration mechanism, chest pain, intoxication, abnormal alertness/mental status, distracting painful injury, and tenderness to chest wall palpation.

Then the E-FAST was conducted by a fixed staff Emergency specialist and was reviewed by a fixed staff emergency consultant, both had received training on POCUS and were internationally certified.

It was carried out by the Sonoscape S30 device made in China in 2022, available in the Emergency Department most of the time. The whole process took less than one minute for each side and didn't interfere with the resuscitation process. Pneumothorax was diagnosed by the high-frequency linear probe by the presence of the following signs: Absence of pleural (lung) sliding. (barcode" sign) In M-mode, the presence of A lines, the absence of comet-tail artefacts, also referred to as B-lines, the absence of a lung pulse, and presence of one or more lung points. Hemothorax was diagnosed by the curvilinear or phased array probe by loss of mirror image and the presence of a dark, anechoic area within the dependent portion of the chest cavity.

After that, the emergency physician ordered a chest CT scan for each patient, which is regarded as the gold standard. Non-contrast computed tomography (CT) was done on a GE Bright Speed 16 scanner at the computed tomography unit, Emergency Department, Menoufia University Hospital, which is available 24 h every day. Then, a radiology specialist noted the reports of each chest CT.

The E-FAST was conducted prior to the step of the CT to make sure that no bias of being influenced by the result of the CT. The outcomes of the E-FAST and NEXUS chest algorithms were then compared with the results of chest CT scans and recorded.

**Ethical consideration:**

**Menoufia University Faculty of Medicine's Local Research and Ethics Committee gave its approval. (IRB n: 9/2023 SURG). Written informed consent was taken from all the participants or their legal surrogates. The study adhered to the Helsinki Declaration throughout its execution.**

***Statistical analysis***

IBM SPSS Statistics (Statistical Package for the Social Sciences) software version 22.0, IBM Corp., Chicago, USA, 2013, was used to code, tabulate, and statistically analyze the gathered data. Qualitative data were expressed as numbers and percentages, and the Kappa test was used to assess how well they agree. When the P value was less than 0.05, it was considered significant; otherwise, it was considered non-significant. The diagnostic characteristics, such as sensitivity, specificity, accuracy, predictive positive value, and predictive negative value were calculated.

## RESULTS

A total of 61 polytrauma patients with blunt chest trauma, who presented within 24 h from the time of trauma to Menoufia Emergency Hospital, from September 2024 to June 2025, were enrolled in this study. The age < 30 years was the most frequent in the studied cases, followed by the age from 30-40 years. Nearly 13% of cases were aged > 60 years. Among the studied cases, males were more than females (60.7% vs. 39.3%), and RTA was the most frequent trauma reason. As regards clinical characteristics, the majority of cases had a heart rate < 100 beats/minute (72.1%), systolic blood pressure ≥ 90 (90.2%), respiratory rate ≥ 24 cycles/minute and oxygen saturation ≥94 (90.2%), as shown in table 1.

**Table (1):** Demographic and clinical characteristics of the studied cases

| Demographic and clinical characteristics | The studied cases (n=61) | |
|---|---|---|
| | No | % |
| Age (years): | | |
| < 30 | 26 | |
| 30-40 | 15 | 42.6 |
| 41-50 | 7 | 24.6 |
| 51-60 | 5 | 11.5 |
| >60 | 8 | 8.2 |
| Mean ± SD | 37.08±17.50 | 13.1 |
| Range | 18-86 | |
| Sex | | |
| Male | 37 | 60.7 |
| Female | 24 | 39.3 |
| Mode of trauma: | | |
| Assault | 8 | 13.1 |
| Fall | 10 | 16.4 |
| Local trauma | 8 | 13.1 |
| RTA | 35 | 57.4 |
| Heart rate (beat/min): | | |
| <100 | 44 | 72.1 |
| ≥ 100 | 17 | 27.9 |
| Systolic blood pressure (mmHg): | | |
| < 90 | 6 | 9.8 |
| ≥ 90 | 55 | 90.2 |
| Respiratory rate (cycle/min) | | |
| <24 | 45 | 73.8 |
| ≥ 24 | 16 | 26.2 |
| Oxygen saturation (%): | | |
| <94 | 6 | 9.8 |
| ≥94 | 55 | 90.2 |

RTA: road traffic accident.

The most frequent NEXUS criteria were tenderness to chest wall palpation (44.3%), followed by chest pain (42.6%) and distracting painful injury (27.9%). E-FAST findings were positive in 27 cases (44.3%), including 6.6% as hemopneumothorax, 23% as pneumothorax and 14.8% as hemothorax. CT findings were positive in 30 cases (49.2%), including 8.2% as hemopneumothorax, 24.6% as pneumothorax, and 16.4% as hemothorax (Table 2).

**Table (2):** Diagnostic findings by NEXUS, E-FAST and CT in the studied cases

| Items | The studied cases (n=61) | |
|---|---|---|
| | No | % |
| NEXUS: | | |
| • Age > 60 years, | | |
| • Rapid deceleration | 8 | 13.1 |
| • Chest pain | 15 | 24.6 |
| • Intoxication | 26 | 42.6 |
| • Abnormal | 2 | 3.3 |
| alertness/mental status | 10 | 16.4 |
| • Distracting painful injury | 17 | 27.9 |
| • Tenderness to chest wall | 27 | 44.3 |
| palpation | 56 | 91.8 |
| • All positive cases. | | |
| E-FAST | | |
| Hemopneumothorax | 4 | 6.6 |
| pneumothorax | 14 | 23.0 |
| Hemothorax | 9 | 14.8 |
| Negative | 34 | 55.7 |
| CT | | |
| Hemopneumothorax | 5 | 8.2 |
| pneumothorax | 15 | 24.6 |
| Hemothorax | 10 | 16.4 |
| Negative | 31 | 50.8 |

There was a slight agreement between NEXUS with CT findings in the studied cases (Kappa= 0.159; p 0.022) with sensitivity 100%, specificity 16% and accuracy 57%. Pneumothorax was detected with 100% sensitivity and 10% specificity using the NEXUS chest algorithm, hemothorax was detected with 100% sensitivity and 11% specificity, and hemopneumothorax was detected with 100% sensitivity and 9% specificity (Table 3).

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**Table (3):** Diagnostic accuracy of NEXUS in diagnosis of each of hemopneumothorax, pneumothorax and hemothorax in reference to CT diagnosis.

| Values | NEXUS finding in the studied cases (n=61) | | | | | |
|---|---|---|---|---|---|---|
| | Hemopneumothorax | | Pneumothorax | | Hemothorax | |
| | % | (95% CI) | % | (95% CI) | % | (95% CI) |
| Sensitivity | 100% | 0.46-0.98 | 100% | 0.66-0.99 | 100% | 0.75-0.99 |
| Specificity | 9% | 0.03-0.20 | 10% | 0.04-0.22 | 11% | 0.04-0.24 |
| Accuracy | 16% | 0.09-0.29 | 25% | 0.15-0.38 | 33% | 0.22-0.46 |
| Predictive value of +ve result | 9% | 0.03-0.20 | 18% | 0.09-0.31 | 27% | 0.16-0.41 |
| Predictive value of -ve result | 100% | 0.46-0.98 | 100% | 0.46-0.98 | 100% | 0.46-0.98 |

There was a significant agreement between E-FAST with CT findings in the studied cases (Kappa= 0.836; p<0.001) with sensitivity 87%, specificity 97% and accuracy 92%. E-FAST detected pneumothorax with an 87% sensitivity and a 98% specificity. Additionally, it has an 80% sensitivity and a 98% specificity in identifying hemothorax. Additionally, it has an 80% sensitivity and 100% specificity in identifying hemopneumothorax (Table 4).

**Table (4):** Diagnostic accuracy of E-FAST in diagnosis of each of hemopneumothorax, pneumothorax and hemothorax in reference to CT diagnosis.

| Values | E-FAST finding in the studied cases (n=61) | | | | | |
|---|---|---|---|---|---|---|
| | Hemopneumothorax | | Pneumothorax | | Hemothorax | |
| | % | (95% CI) | % | (95% CI) | % | (95% CI) |
| Sensitivity | 80% | 0.30-0.99 | 87% | 0.58-0.98 | 80% | 0.44-0.96 |
| Specificity | 100% | 0.92-1.00 | 98% | 0.87-1.00 | 98% | 0.88-1.00 |
| Accuracy | 98% | 0.90-1.00 | 95% | 0.85-0.99 | 95% | 0.85-0.99 |
| Predictive value of +ve result | 100% | 0.40-0.98 | 93% | 0.64-1.00 | 89% | 0.51-0.99 |
| Predictive value of -ve result | 98% | 0.89-1.00 | 96% | 0.84-0.99 | 96% | 0.86-0.99 |

Nexus was a more sensitive but less specific tool compared to E-FAST in blunt chest injury early identification. Therefore, Nexus was a good negative tool (had high negative predictive value) but a poor positive tool (had poor positive predictive value). While E-FAST was more specific but less sensitive than NEXUS so E-FAST was good positive tool (had high positive and negative predictive value) (Table 5).

**Table (5):** Diagnostic accuracy of Nexus and E-FAST in diagnosis of pneumothorax, hemothorax and hemopneumothorax in reference to CT diagnosis.

| Value | Pneumothorax | | Hemothorax | | Hemopneumothorax | |
|---|---|---|---|---|---|---|
| | Nexus | E-FAST | Nexus | E-FAST | Nexus | E-FAST |
| Sensitivity | 100% | 87% | 100% | 80% | 100% | 80% |
| Specificity | 10% | 98% | 11% | 98% | 9% | 100% |
| Accuracy | 25% | 95% | 33% | 95% | 16% | 98% |
| Predictive value of +ve result | 18% | 93% | 27% | 89% | 9% | 100% |
| Predictive value of -ve result | 100% | 96% | 100% | 96% | 100% | 98% |
| Kappa | 0.159 | 0.844 | 0.159 | 0.844 | 0.159 | 0.844 |
| P value | 0.022 | <0.001 | 0.022 | <0.001 | 0.022 | <0.001 |

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## DISCUSSION

This study is one of the very few studies that have compared the diagnostic validity of both E-FAST and NEXUS chest algorithms in identifying blunt chest injuries.

In this study, the mean age of the patients was 37.08±17.50 years, the age < 30 years was the most frequent age in the studied cases, followed by the age from 30-40 years. This finding comes in agreement with the study of **Akoglu *et al.*** [12], in which the median age of the study population was 38 years, also **Kozaci *et al.*** [6] study in Turkey 2018, showed the mean age of the study population was 38±20 years. This might be since people in their middle years drove cars more frequently than others and at risk of workplace accidents or other traumatic injuries [13].

Among the studied cases, males were more than females (60.7% vs 39.3%). may be because Men are more likely to engage in risky behaviors like driving and working in dangerous environments [14]. This result is in line with the research performed by **Kithinji *et al.*** [15]**,** in which 59.6% were men, also with **Akoglu *et al.*'s**[12] study in which 79.1% were male.

In our study, the most frequent cause of trauma was road traffic accidents, which were accountable for 57.4% of the total cases, followed by falls (16.4%) then assault 13.1%. According to the WHO report in 2023, every year, approximately. 1.19 million people die, and an estimated 20 to 50 million people sustain non-fatal injuries because of road accidents. Many factors contribute to this, like speeding, unsafe roads, unsafe vehicles, driving under the influence of alcohol, and non-use of seat belts [16].

This result comes in agreement with **Abdulrahman *et al.*'s**[17] study, which showed that the majority of injuries were caused by motor vehicle crashes (46.6%) and falls from height (22.6%). **Narayanan *et al.*** [18]**,** a study in 2018 in India, reported that vehicular crashes were the most frequent cause of chest injuries, accounting for 59.7% of cases, with assault being the next most common cause. **Saeed *et al.*** [19] also found that road traffic accidents (RTAs) were the most common cause of injuries, accounting for 73% of cases. **Ayman *et al.*** [20] in Saudi Arabia found that road traffic accidents were responsible for 81.25% of chest injuries.

But this result contrasts with the study of **Shaban *et al.*** [21]**,** which was performed at Al-Hussein Hospital, Al-Azhar University in 2021, who reported that trauma to the chest was most frequently caused by assaults (42%), with road and motor vehicle accidents being the second most common cause (31%). This could be attributed to the nature and activities of the local people living around the Hospital. Also, in contrast with **Ali and Gali** [22] **and Albadani and Alabsi** [23] who said that the primary cause of chest injuries was assault. They linked Yemen's widespread possession and usage of firearms and combat equipment to the prevalence of assault-related chest injuries.

The NEXUS chest algorithm was developed and validated to reduce unimportant chest imaging to blunt chest trauma in a multicenter prospective cohort research that was carried out at nine US level I trauma centers between December 2009 and January 2012. The study included a sample of 9905 patients, and the sensitivity and specificity in detecting chest injuries in general were found to be 99.7% and 13.3%, respectively [10].

In our study, we found that the NEXUS chest algorithm had a sensitivity of 100% and a specificity of only 16% in detecting both pneumothorax and hemothorax together in all studied cases. These results were compared with those of the study of **Attia *et al.*** [24], which was conducted in Suez Canal University Hospital, that demonstrated that the NEXUS chest algorithm detected both hemothorax and pneumothorax simultaneously with a sensitivity of 96.7% and a specificity of just 15%.

As a result, the NEXUS chest algorithm finds a very low-risk group of blunt trauma patients who don't need chest imaging. Therefore, the NEXUS Chest algorithm was developed to rule out injuries, not to rule them in. That is to say, you do not have to C.T scan that patient just because you detect one or more NEXUS Chest criteria. Therefore, it is advised to utilize NEXUS Chest to determine if imaging may be avoided safely [10,11].

It has been demonstrated that thoracic ultrasonography (US) is a useful instrument and bedside procedure [8]. In our study, we found that E-FAST had a sensitivity of 87%, a specificity of 98%, in identifying pneumothorax, a sensitivity of 80%, a specificity of 98%, in identifying hemothorax, and a sensitivity of 80%, a specificity of 100%, in detecting hemopneumothorax. The sensitivity and specificity of E-FAST in identifying both pneumothorax and hemothorax together were 87% and 97%, respectively. This outcome is in line with research by **Subramaniam *et al.*** [25] that found ultrasonography had a 100% specificity and a very good sensitivity of 72.41%. Our results are also comparable with those of **Kithinji *et al.*** [15]**,** who reported that E-FAST detects hemothorax with a very high sensitivity of 96.1% and a specificity of 100%. In a different cross-sectional research, **Vafaei *et al.*** [9] found that E-FAST had a sensitivity of 75.9% and a specificity of 95.9% for hemothorax identification.

In our research, among 61 patients, only 15 patients had pneumothorax on CT of these 13 pneumothorax cases (86.6%) were identified by E-FAST, with one false positive case. it was a case of subcutaneous emphysema, which appeared as a horizontal hyper-echoic line (artefact from air) without lung sliding; so, misdiagnosed as pneumothorax. This is what happened in **Soldati *et al.*'s**[26] study, which showed pneumothorax on CT in 25 out of 218 trauma patients, lung US detected 23 out of 25 cases of pneumothorax (92%) with one false positive (sensitivity: 92%; specificity: 99.4%). Subcutaneous emphysema, along with other conditions like bullae, adhesions, and contusions, can lead to false-positive results on E-FAST when assessing for pneumothorax. These findings can mimic the absence of lung sliding, a key indicator of pneumothorax, on ultrasound [27].

Also, those of **Ojaghi Haghighi *et al.*** [28] in Tabriz, Iran, in 2014 reported that ultrasonography had a sensitivity of 96.15% and a specificity of 100%, in the diagnosis of pneumothorax. The sensitivity for ultrasonography in the diagnosis of a hemothorax was 82.97%, with a specificity of 98.05%. Those findings are similar to our study. In almost all studies of E-FAST, a high specificity and moderate sensitivity were reported. This is crucial since it's a common misconception that a negative E-FAST test excludes serious injuries. But in fact, a negative FAST exam lacks the sensitivity to exclude chest injuries. False negatives in eFAST exams can be due to the presence of small amounts of fluid or air. This could occur when the amount of fluid or air is less than the minimum requirement for visualization [29]. Also, the patient factor presence of obesity, pleural effusion can sometimes be misinterpreted [30].

## LIMITATIONS

There were fixed qualified emergency specialist, a consultant and a U.S machine for the examination of all cases, and also a fixed radiologist for reporting all CTs for standardization of all cases, because not all of these conditions were available for every single case, which made it difficult to collect some cases. Also, we focused in this study on detecting only hemothorax and pneumothorax, because of the time factor.

Further studies, including other injuries like lung contusion, great vessel injury and rib fracture, would be recommended. Finally, the sample size was relatively small, so it is difficult to generalize the results.

## CONCLUSION

The NEXUS chest algorithm can identify a very low-risk group of individuals with blunt trauma for whom chest imaging can be avoided because of its great sensitivity in detecting chest injuries. As a rule-out tool, it may thus be applied efficiently. When it comes to detecting chest injuries, E-FAST had a higher level of specificity than the NEXUS chest algorithm, which had the lowest level. Therefore, E-FAST is a useful triaging technique for patients with blunt chest trauma that may be used in conjunction with resuscitation in the emergency department to quickly examine potentially fatal injuries without delaying or even interrupting resuscitation.

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| **Abbreviation** | |
|---|---|
| **C.T** | Computed tomography |
| **E-FAST** | Focused assessment with sonography for trauma |
| **NEXUS** | National Emergency X-Radiography Utilization Study |
| **U.S** | Ultrasonography |

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