# Is chest ultrasonography a reliable tool for the emergency diagnosis of traumatic pneumothorax. An Updated Meta-Analysis

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**Abstract**

Aims: A commonly encountered problem in emergency care is pneumothorax, identified by air present in pleural space, occurring spontaneously, principally because of trauma or pathogenic factors like a central venous catheter, mechanical ventilation, and biopsy. Employing Chest ultrasound for diagnosing pneumothorax in an emergency is currently investigated by many researchers. The present meta-analysis aimed to assess Chest ultrasound's diagnostic accuracy in diagnosing the pneumothorax during emergencies. Material and Methods: Literature search of published articles in MEDLINE, Embase, Ovid, Scopus, and Journal on web databases from 2000 up to November 2020 were reviewed for the pre-described outcomes. Results: 12 articles were finally chosen for quantitative analysis. The overall sensitivity of ultrasound scan in pneumothorax diagnosis was 89% (95 % CI – 86 – 91%). Specificity was 96% (CI – 95% – 97%). The diagnostic odds ratio was 193.94 (59.009 – 637.40) at 95% CI, thus demonstrating greater chest ultrasound accuracy in diagnosing pneumothorax. Conclusion: A definite evidence of chest ultrasound accuracy was noted in pneumothorax.

## Introduction:

Traumatic injuries have posed severe public health consequences of mountable proportions globally, accounting for death's principal cause in the early years of life. Chest injuries make up to 25% of all trauma-induced causalities.[1,2]

Pneumothorax makes up 85% of chest trauma-related cases. It results in greater mortality frequency and morbid conditions, resulting in an extended hospital stay burdened with health service expenditure and decreased productivity.[3]

It is vital to diagnose pneumothorax patients quickly, as drainage of the chest may be lifesaving. The first diagnostic technique is the Chest X rays if clinical examination does not point towards thoracostomy. But literature evidence demonstrates lesser sensitivity of this method, along with other demerits like exposure to radiation and requiring patient mobilisation.[4-6]

Chest ultrasound has gained popularity off late owing to its portability, speed, and easy reproducibility. Additionally, it carries the advantage of not using radiation and allowing real-time scanning and interpretation. It is successfully used in diagnosing Pneumothorax in recent years in case of emergency demands.[7,8]Additionally, ultrasound has emerged as an alternative to chest radiographs because of its high specificity and sensitivity. Hence, this review and analysis were undertaken to evaluate chest ultrasound diagnostic accuracy in the pneumothorax patients' emergency diagnosis.

## Material and Methods:

The present review and analysis followed the PRISMA guidelines.[9]

Information Sources: Eligible studies were searched in MEDLINE, Embase, Ovid, Scopus, Web of Science and Journal on web databases, through EBSCO. All relevant articles were identified. Only studies obtained in full, through electronic and other search methods, were reviewed.

Search Strategy: MeSH phrases and open phrases were entered into unique search strategies.

Keywords: Key terms employed for the search: 1) Pneumothorax; 2) Chest ultrasound; 3) specificity; 4) sensitivity; 5) diagnostic accuracy; 6) ultrasonography; and 7) Chest trauma.

Boolean Operators: The Boolean operator 'OR' was employed to complement truncated synonyms in each search theme. The Boolean operator 'AND' makes up the sum of each four main search themes to specifically output papers that give at least one result for each time.

Search Limits: The search limit for literature ranged from the year 2000 up until 2020 as the concluding year, and the literature published only in the English language with full text was chosen.

Process of Study Identification: Endnote X8soft ware was used to import the search data results and remove the duplicates. Abstracts were screened for eligibility criteria, and the full text was extracted when an article was selected. Following inclusion into the review, data was extracted.

Data collection: All the titles and the extracts were screened independently by the reviewers and upon a detailed review of the full-text articles, the data were extracted and documented in a data extraction table, elaborating data items evaluated for the review.

Eligibility criteria: Studies investigating the accuracy of chest ultrasound in diagnosing pneumothorax, conforming to the diagnostic criteria of pneumothorax and met quality criteria set by QUADAS 2 was included. Data items: The data extraction table included Study ID, sample size, location, criteria of the condition, ultrasound type, machine made, and personnel involved.

Risk of bias in individual studies: QUADAS – 2 criteria evaluated risk of bias of included studies which is a tool for evaluating diagnostic accuracy[10]. It includes patient selection – random sequencing, index test – detection of the condition, reference evaluation – comparison with flow and timing of the study. However, if there is a non-agreement between the two reviewers for quality evaluation, the mutual agreement was reached through a discussion & consultation with a senior expert in the field.

Statistical analysis:

A 2 X 2 table was made, based on which pooled sensitivity, specificity, and diagnostic odds ratio were calculated using the DerSimonian Lair technique. The diagnostic odds ratio calculated demonstrates the chest ultrasound capacity (test) to detect the condition (Pneumothorax). A higher DOR value indicates better diagnostic accuracy of the test. Moreover, the Cochran Q statistic and $I^2$ index evaluated the heterogeneity of the studies included. Meta disc software was used for the creation of forest plots.

**Results:**

Study selection: 12 studies were included for the quantitative analysis, out of 593 titles screened. Figure 1 depicts the process of studies included.

Study characteristics: Characteristics of each study are enlisted (Table 1). Studies reviewed encompassed global locations, including Italy, India, Pakistan, Canada, and France.

Risk of bias : The quality of studies included was assessed using QUADAS – 2 criteria and is depicted (Table 2).

Sensitivity analysis: The overall sensitivity of ultrasound scan in pneumothorax diagnosis was 89% (95 % CI – 86 – 91%), and specificity was 96% (CI – 95% – 97%). The diagnostic odds ratio was 193.94 (59.009 – 637.40) at 95% CI, thus demonstrating greater chest ultrasound accuracy in diagnosing pneumothorax.

SROC plot demonstrated an estimate of sensitivity versus specificity and area under the SROC curve (Figure 2, 3, and 4).

**Discussion:**

Chest ultrasound in the diagnosis of Pneumothorax was reported first in 1986 in a veterinary journal. Several researchers have explored its usage since then. The principal method for diagnosing employed an absent sliding lung sign in the air presence between visceral and parietal pleura.[26] The presence of sliding lung signs acts as an accurate negative predictor for pneumothorax detection. Dulchavsky et al. [27] described a 100% true negative rate compared to conventional chest radiographs in Pneumothorax diagnosis, with sensitivity ranging from 90% to 100%.

Most of the studies used focused assessment with sonography for trauma (FAST) technique for diagnosing pneumothorax. Literature has shown accurate and fast results. Standard FAST protocols assess four locations (pericardial, perihepatic, perisplenic, and pelvis). Still is more feasible and simpler to widen the scanned regions to assess the chest for haemothorax formally. [28,29]

The present systematic review and meta-analysis showed a better performance of chest ultrasound in detecting pneumothorax and can be used as an alternative to CT and MRI.

Pneumothorax diagnosis can be made based on physical examination and symptom presentation. Confirmation is generally via radiography or C.T. scanning. Radiographs taken in the later stages pose difficulty in diagnosing pneumothorax because of the patient's condition, distance and other considerations. Also, chest radiograph reliability is questionable, and a wrong diagnosis may be expected in 30% of cases.[23]. The metanalytic study of Ebrahimi et al[29] showed ultrasound accuracy in detection of pneumothorax, with sensitivity of 0.87 (95% CI: 0.81–0.92;$I^2 = 88.89$; $P < 0.001$) and specificity of 0.99 (95% CI: 0.98–0.99;$I^2 = 86.46$, $P < 0.001$). Our study results are also in similar lines with a sensitivity of 0.89 and specificity of 0.96.

The present study included both adult and neonate populations, and the diagnostic accuracy was good. The results of Hamid Dahmarde et al. [30] also support this statement. The sensitivity, specificity, and odds ratio of the chest ultrasound in the diagnosis of pneumothorax in neonates was 96.7% (88.3%–99.6%), 100% (97.7%–100%), and 1343.1% (167.20–10788.9), respectively, depicting superior results.

The study has certain limitations. Firstly, it should be borne in mind that the test characteristics merely a part of evaluation of diagnostic test function, and extent of each test depends on its effect on patient. The second factor which can affect the course of meta-analysis is the chest ultrasound operator's accuracy. The training quality and nature of training are not considered in several studies. The heterogeneity of studies included was also higher; thus, the random-effects model was employed to obtain better results.

**Conclusion:**

Chest ultrasound has demonstrated results that are accurate and reliable. Besides, it also aids in timely diagnoses of pneumothorax. In emergencies, it becomes a valuable adjunct. Utilizing this method carries the advantage of facilitating the therapy process, reduces the cost, lack of ionizing radiation, and easy operation.

Acknowledgment: None Declared.

Statement of Ethics: All procedures performed in the study were in accordance with the institutional and/or national research committee's standards and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Conflict of Interest Statement: The authors declare that they have no competing interests.

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Author Contributions: HT: Concept and designed the study, TZ.: analyzed data and drafting of the manuscript; YZ.: Collected the data and helped in data analysis; SR and RC.: Proofreading and final editing along with guarantor of the manuscript. "All authors read and approved the final version of the manuscript".

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**Figure Legends**

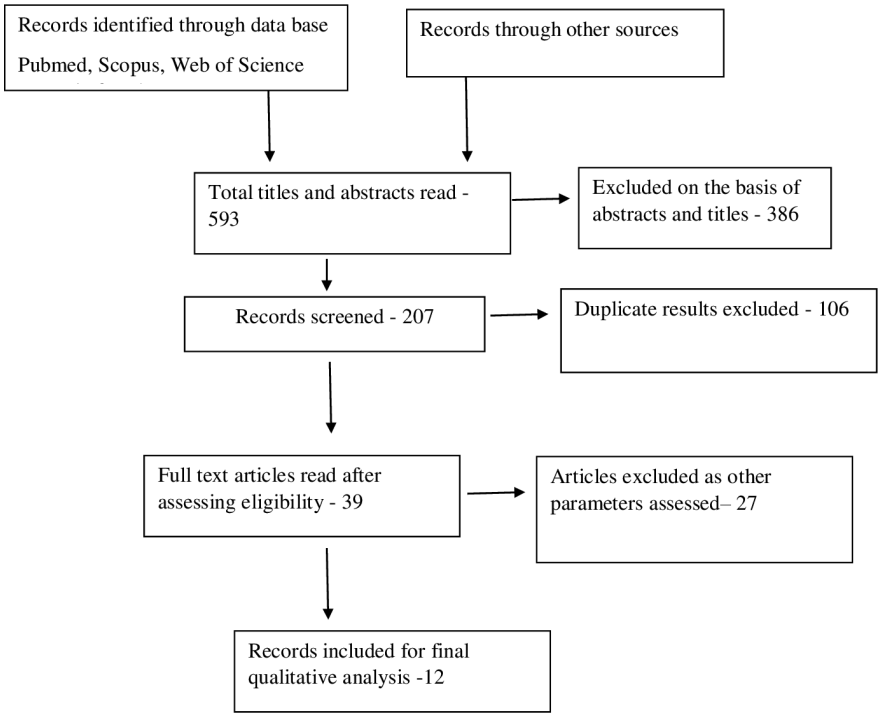
**Figure 1: Flow chart diagram for article inclusion**

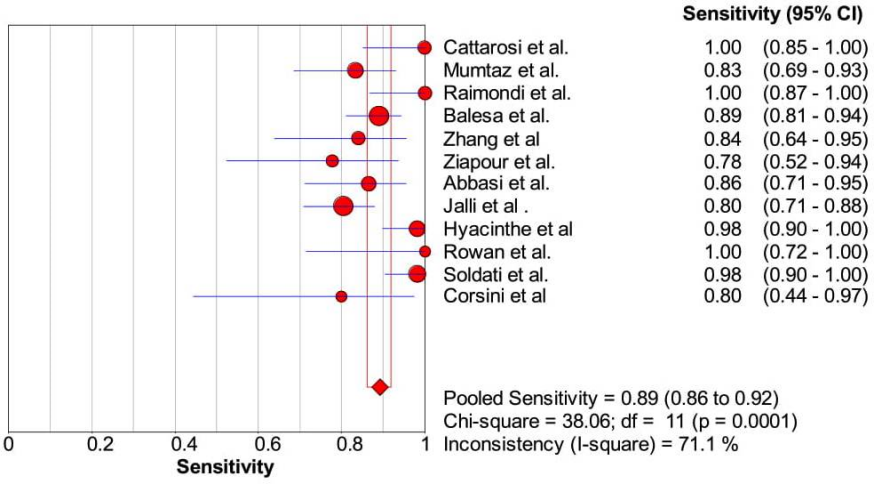
**Figure 2: Sensitivity of Chest ultrasound in diagnosis of pneumothorax patients.**

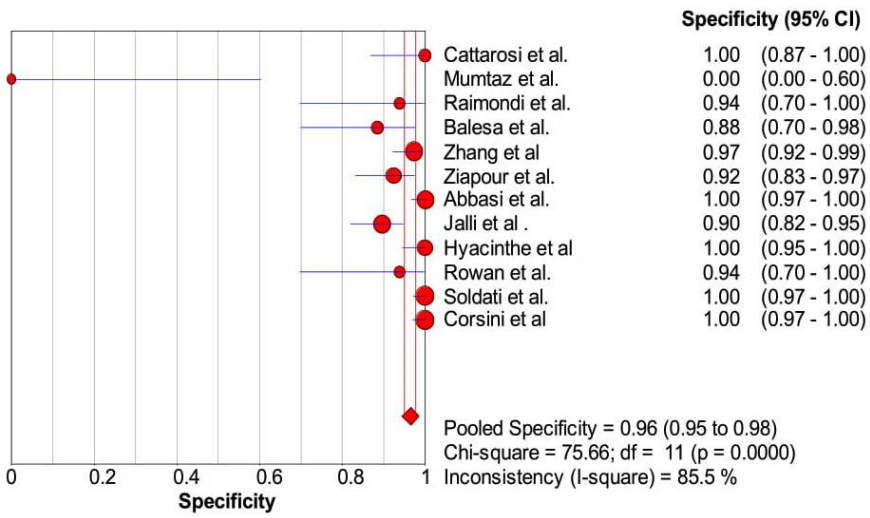
**Figure 3: Specificity of Chest ultrasound in diagnosis of pneumothorax patients.**

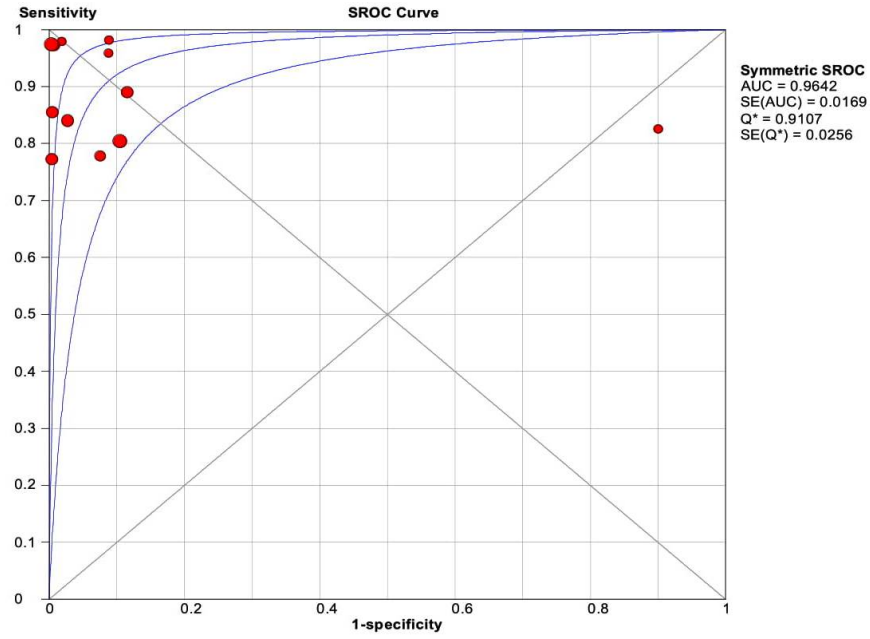
**Figure 4: Summary-ROC (SROC) curve for diagnostic accuracy of chest ultrasound in pneumothorax diagnosis**

**Figure 1: Flow chart diagram for article inclusion**






Heterogeneity chi-squared = 96.58 (d.f.= 12) p = 0.000
Inconsistency (I-square) = 87.6 %
Estimate of between-study variance (Tau-squared) = 0.7837

## Hosted file

Tables (1) (2).docx available at https://authorea.com/users/415660/articles/523491-is-chest-ultrasonography-a-reliable-tool-for-the-emergency-diagnosis-of-traumatic-pneumothorax-an-updated-meta-analysis