Accuracy of Ultrasound in Diagnosing Pneumothorax taking CT Chest as Gold Standard

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ABSTRACT

Objective: To determine the accuracy of ultrasound in diagnosing pneumothorax taking CT chest as gold standard.

Design: It was a cross sectional survey.

Study Settings: This study was carried out at Department of Diagnostic Radiology and Thoracic Surgery at Children Hospital & Institute of Child Health, Lahore over 12 months from 13-08-2019 to 12-08-2020.

Patients and Methods: This study involved 235 both male and female patients aged between 18-75 years referred from thoracic surgery department with clinical suspicion of pneumothorax. Ultrasound of all these cases was carried out and pneumothorax was labeled on negative lung sliding and comet tail artifacts and absence of seashore sign and presence of barcode sign. Later CT chest was performed and diagnosis of pneumothorax was confirmed. Results of CT scan were considered as gold standard while the diagnosis of pneumothorax on chest sonography was adjudged consequently as true/false and positive/negative. An informed written consent was obtained in each case.

Results: There was a male predominance (M:F; 4:1) with mean age of 46.3±13.1 years among patients with pneumothorax. Ultrasound diagnosed pneumothorax in 148 (63.0%) cases while pneumothorax was confirmed in 164 (69.8%) cases on CT chest Ultrasound was found 88.4% sensitive, 95.8% specific and 90.6% accurate with negative and positive predictive values of 78.2% and 98.0% respectively.

Conclusion: Chest sonography was established as an exceedingly sensitive and specific modality for the evaluation of pneumothorax. Its non-invasive and portable nature and lack of radiation risk further make it idyllic for the diagnostic evaluation of pneumothorax in suspected cases in future clinical practice.

Keywords: Pneumothorax, Ultrasound, CT Chest, Diagnostic Accuracy

INTRODUCTION

Pneumothorax is described by the presence of air outside the normal lung cavity with in the pleural space.[1] It can result from chest trauma resulting in wound exposing the pleural cavity to external environment or breach in the lung parenchyma causing leakage of air into the pleural space. Other common causes include chronic lung diseases and iatrogenic such as mechanical ventilation, central venous catheter insertion, thoracocentesis and lung biopsy.[1,2]

Whatever the cause might be, this air in the pleural cavity disturbs the physiological negative pressure gradient responsible for insufflation of the lung on inspiration and causes lung collapse in severe cases.[1,3] A timely and accurate diagnosis of pneumothorax is crucial as early recognition and anticipated management proves lifesaving in such patients.[3,4] A high index of suspicion is followed by plain X-ray of the chest where a collapsed lung is usually evident and suggests intervention without further investigation.[1,2]

However at many occasions, the pneumothorax may not be substantial and evident on routine chest X-ray. Also in critically ill and bed ridden patients, inability to take an erect x-ray chest also decreases like likelihood of an appropriate diagnosis.[1,2] In such circumstances, CT chest is usually performed to confirm the diagnosis. However, CT scan is an expensive investigation and requires a substantial amount of time for the test and its reporting and thus delays the management of patient. It also exposes the patient to unwanted radiations.[5,6] Therefore there has always been a quest for more handy and accurate investigation for the diagnosis of pneumothorax.

A few recent studies investigated the diagnostic performance of ultrasound in the diagnosis of pneumothorax due to its portability and bedside availability and low cost and radiation free nature.[8-11] The results remained controversial though, where some found it accurate[8-13] while others reported it even less reliable than X-ray chest.[14] Owing to this controversy in the existing literature and lack of local such published material need for the current study was felt.

PATIENTS AND METHODS

It was a cross sectional survey carried out at the study was carried out at Department of Diagnostic Radiology and Thoracic Surgery at Children Hospital & Institute of Child Health, Lahore over 12 months from 13-08-2019 to 12-08-2020. Sample size of 235 cases was estimated with 5% margin of error and 95% confidence level with an expected sensitivity and specificity of ultrasound as 86.1% and 97.4% respectively[14] with prevalence of pneumothorax as 79.4%[10]. 235 adult patients of both genders with ages in the range of 18-75 years who were referred to department of radiology from department of thoracic surgery with clinical suspicion of pneumothorax were included after informed written consent. Patients with tension pneumothorax and those with hemodynamic instability were excluded. Chest sonography of all these cases was performed in supine position with 38 mm, 8-12 MHz

broadband linear US probe. First a B-mode and then M-mode ultrasound was performed and pneumothorax was diagnosed upon negative lung sliding and comet tail artifacts and absence of seashore sign and presence of barcode sign. Later CT chest was performed and diagnosis of pneumothorax was confirmed. Results of CT scan were considered as gold standard and those of chest sonography were adjudged consequently as true/false and positive/negative. An informed written consent was obtained from each subject. A pre-designed performa was utilized to note patient's demographic details as well as sonographic and CT chest diagnosis of pneumothorax.

Numerical variables such as age have been described as mean ±SD whereas categorical variables such as gender and ultrasound and CT chest diagnosis of pneumothorax have been described as frequency and percentage. 2x2 table has been produced to conclude the diagnostic performance of chest sonography considering CT scan as gold standard.

RESULTS

The mean age of the subjects was 46.3±13.1 years. Majority (n=131, 55.7%) of the cases were aged between 40-60 years followed by 31.5% patients aged between 18-39 years and 12.8% aged above 60 years. There were 189 (80.4%) male and 46 (19.6%) female cases with a male to female ratio of 4:1 as described in Table 1.

Table 1: Demographic characteristics

Characteristics	Participants n=235
Age (years)	46.3±13.1
• 18-39 years	74 (31.5%)
• 40-60 years	131 (55.7%)
• >60 years	30 (12.8%)
Gender	
• Male	189 (80.4%)
• Female	46 (19.6%)

Table 2: Frequency of pneumothorax on ultrasound and CT chest

	Frequency (n)	Percent (%)
Ultrasound Chest	148	63.0%
CT Chest	164	69.8%

Ultrasound diagnosed pneumothorax in 148 (63.0%) cases while pneumothorax was confirmed in 164 (69.8%) cases on CT chest as depicted in Table 2. When cross tabulated diagnosis of pneumothorax on chest sonography and CT, it yielded sensitivity, specificity and accuracy of 88.4%, 95.8% and 90.6% respectively for ultrasound with positive and negative predictive values of 98.0% and 78.2% respectively as shown in Table 3.

Table 3: 2x2 contingency table between ultrasound and CT chest diagnosis

Ultrasound Diagnosis	CT Diagnosis		Total
	Pneumothorax	No	
Pneumothorax	145[a]	3[c]	148
No	19[b]	68[d]	87
Total	164	71	235

a=true positive, b=false negative, c=false positive, d=true negative

Statistic	Formula	Value
Sensitivity	$\dfrac{a}{a+b}$	88.4%
Specificity	$\dfrac{d}{c+d}$	95.8%
Accuracy	$\dfrac{a+d}{a+b+c+d}$	90.6%
Disease prevalence	$\dfrac{a+b}{a+b+c+d}$	69.8%
Positive Predictive Value	$\dfrac{a}{a+c}$	98.0%
Negative Predictive Value	$\dfrac{d}{b+d}$	78.2%

DISCUSSION

Pneumothorax is one of the most common thoracic conditions requiring clinical visit and hospital admission and intervention.[1] It can be spontaneous (occurring without trauma), secondary to trauma most frequently road traffic accidents or iatrogenic resulting from various forms of medical interventions such as mechanical ventilation, central venous catheter insertion, thoracocentesis and lung biopsy.[1,2] The clinical presentation of pneumothorax is highly variable ranging from no symptoms to severe dyspnea, tachycardia and hypotension.[3,4] An accurate and timely diagnosis is crucial which is frequently made on X-Ray chest but often requires sophisticated investigations like CT-Scan which are however time consuming and waste the precious time in the management of such cases.[5,6] Therefore there has always been a quest for more handy and accurate investigation for the diagnosis of pneumothorax. The aim of the current study was to assess the diagnostic performance of ultrasound in this regard.

In the present study, we observed a relative male predominance with male to female ratio of 4:1 and mean age of 46.3±13.1 years in patients with pneumothorax. Our observation is in line with that of Hussain et al.[15] (2019) who reported a similar male predominance (M:F; 3.7:1) and mean age of 46±17.8 years among such patients at The Aga Khan University Hospital, Karachi. Majeed et al.[16] (2017) observed comparable male predominance among patient presenting with pneumothorax at Combined Military Hospital Lahore and reported a male to female ratio of 1.5:1. They described similar mean age of 43.3±17.1 years among such patients. Our observation is also in line with an Indian study, where Dhua et al.[17] (2015) observed mean age of 48.9±.2 years and male to female ratio of 4:1 among such patients. In another study, Ramouz et al.[18] (2018) reported similar mean age of 48.9±9.4 years and male to female ratio of 6:1 among Iranian patients with pneumothorax. In a recent study, Kapicibasi et al.[19] (2020) reported comparable mean age of 44.1 years among

Turkish patients with pneumothorax. They also reported similar male predominance (M:F; 4:1) among such patients. A similar observation was made by Nam et al.[20] (2019) in Korea. They reported similar mean age of 47.6±8.9 years among such patients. They also reported a male to female ratio of 3:1 in line with the present study. In a similar study involving Sri Lankan patients with chest trauma and pneumothorax, Mathangasinghe et al.[21] (2020) reported a comparable mean age of 45.8±17.9 years and male to female ratio of 2.6:1.

In the present study, we observed that ultrasound was 88.4% sensitive, 95.8% specific and 90.6% accurate in the diagnosis of pneumothorax with positive and negative predictive values of 98.0% and 78.2% respectively. In a similar local study conducted at Combined Military Hospital, Lahore, Imran et al.[13] (2017) observed similar diagnostic performance of chest sonography and reported comparable sensitivity (78.3%), specificity (96.8%) and diagnostic accuracy (95.3%). Our observation is also in line with that of Abdalla et al.[14] (2016) who observed a comparable sensitivity, specificity and diagnostic accuracy of chest sonography in the diagnosis of pneumothorax and reported it to be 86.1%, 97.4% and 95.3% respectively in Egypt. In an Italian study, Corsini et al.[8] (2018) reported similar sensitivity of 80.0% and specificity of 100.0% for chest sonography while Abbasi et al.[12] (2013) reported similar sensitivity of 86.5% and specificity of 100.0% for chest sonography in Iran.

Thus pneumothorax predominantly affected middle aged males. This is in line with the mechanism of injury; road side accidents which frequently involve younger males as compared to older patients and females. We also observed that ultrasound carried a good sensitivity and specificity for the diagnosis of pneumothorax. Ultrasound is widely available at government setups as compared to CT scan. It is also portable and can be performed on bed side. This along with its radiation free nature advocates the preferred use of ultrasound in the diagnostic evaluation of such patients in future clinical practice.

An important inadequacy of the current study was that we didn't consider the diagnostic performance of chest sonography in comparison with other existing non-invasive and time saving tools like X-ray. Combining these two modalities may have further improved the diagnostic performance and may have alleviated the need for a confirmatory CT scan. Such a trial will be better useful in the selection of more appropriate diagnostic tool in clinical practice and is particularly endorsed in future medical research.

CONCLUSION

Chest sonography was established as an exceedingly sensitive and specific modality for the evaluation of pneumothorax. Its non-invasive and portable nature and lack of radiation risk further make it idyllic for the diagnostic evaluation of pneumothorax in suspected cases in future clinical practice.

REFERENCES

1. Papagiannis A, Lazaridis G, Zarogoulidis K, Papaiwannou A, Karavergou A, Lampaki S, et al. Pneumothorax: an up to date "introduction". Ann Transl Med 2015;3(4):53. doi: 10.3978/j.issn.2305-5839.2015.03.23.
2. Singh SK, Tiwari KK. Analysis of clinical and radiological features of tuberculosis associated pneumothorax. Indian J Tuberc 2019;66(1):34-8. doi: 10.1016/j.ijtb.2017.01.009.
3. Kim MJ, Park I, Park JM, Kim KH, Park J, Shin DW. Systematic review and meta-analysis of initial management of pneumothorax in adults: Intercostal tube drainage versus other invasive methods. PLoS One 2017;12(6):e0178802. doi: 10.1371/journal.pone.0178802.
4. Schnell J, Koryllos A, Lopez-Pastorini A, Lefering R, Stoelben E. Spontaneous Pneumothorax. Dtsch Arztebl Int 2017;114(44):739-44. doi: 10.3238/arztebl.2017.0739.
5. Imran JB, Eastman AL. Pneumothorax. JAMA 2017;318(10):974. doi:10.1001/jama.2017.10476
6. Hefny AF, Kunhivalappil FT, Matev N, Avila NA, Bashir MO, Abu-Zidan FM. Management of computed tomography-detected pneumothorax in patients with blunt trauma: experience from a community-based hospital. Singapore Med J 2018;59(3):150-4. doi: 10.11622/smedj.2017074.
7. Cattarossi L, Copetti R, Brusa G, Pintaldi S. Lung Ultrasound diagnostic accuracy in neonatal pneumothorax. Can Respir J 2016;2016:6515069. doi: 10.1155/2016/6515069.
8. Corsini I, Parri N, Gozzini E, Coviello C, Leonardi V, Poggi C, et al. Lung ultrasound for the differential diagnosis of respiratory distress in neonates. Neonatology 2019;115(1):77-84. doi: 10.1159/000493001.
9. Jalli R, Sefidbakht S, Jafari SH. Value of ultrasound in diagnosis of pneumothorax: a prospective study. Emerg Radiol 2013;20(2):131-4. doi: 10.1007/s10140-012-1091-7.
10. Balesa J, Rathi V, Kumar S, Tandon A. Chest sonography in the diagnosis of pneumothorax. Indian J Chest Dis Allied Sci 2015;57(1):7-11.
11. Ianniello S, Di Giacomo V, Sessa B, Miele V. First-line sonographic diagnosis of pneumothorax in major trauma: accuracy of e-FAST and comparison with multidetector computed tomography. Radiol Med 2014;119(9):674-80. doi: 10.1007/s11547-014-0384-1.
12. Abbasi S, Farsi D, Hafezimoghadam P, Fathi M, Zare MA. Accuracy of emergency physician-performed ultrasound in detecting traumatic pneumothorax after a 2-h training course. Eur J Emerg Med 2013;20(3):173-7. doi: 10.1097/MEJ.0b013e328356f754.
13. Imran M, Bhatti MA, Nazir M, Mirza TM. Diagnostic accuracy of chest ultrasonography in the early detection of pneumothorax taking chest CT scan as gold standard. Pak J Radiol 2018;28(1):1-8.
14. Abdalla W, Elgendy M, Abdelaziz AA, Ammar MA. Lung ultrasound versus chest radiography for the diagnosis of pneumothorax in critically ill patients: a prospective, single-blind study. Saudi J Anaesth 2016;10(3):265-9. doi: 10.4103/1658-354X.174906.
15. Hussain SF, Aziz A, Fatima H. Pneumothorax: a review of 146 adult cases admitted at a university teaching hospital in Pakistan. J Pak Med Assoc 2019;49(10):243-9.
16. Majeed FA, Mehmood U, Imtiaz T, Zafar U. Clinical assessment compared with chest-x-ray after removal of chest tube to diagnose pneumothorax. Pak Armed Forces Med J 2017;67(4):641-5.
17. Dhua A, Chaudhuri AD, Kundu S, Tapadar SR, Bhuniya S, Ghosh B, et al. Assessment of spontaneous pneumothorax in adults in a tertiary care hospital. Lung India 2015;32(2):132-6. doi: 10.4103/0970-2113.152622.
18. Ramouz A, Lashkari MH, Fakour S, Rasihashemi SZ. Randomized controlled trial on the comparison of chest tube drainage and needle aspiration in the treatment of primary spontaneous pneumothorax. Pak J Med Sci 2018;34(6):1369-74. doi: 10.12669/pjms.346.16126.
19. Kapicibasi HO. Uniportal VATS technique for primary spontaneous pneumothorax: an analysis of 46 cases. Pak J Med Sci 2020;36(2):224-8. doi: 10.12669/pjms.36.2.1556.
20. Nam SH, Kim KW, Kim SW, Kim SW, Hong JM, Kim D. Fate of spontaneous pneumothorax from middle to old age: how to overcome an irritating recurrence?. J Thorac Dis 2019;11(11):4782. doi: 10.21037/jtd.2019.10.30.
21. Mathangasinghe Y, Pradeep IH, Rasnayake D. Demographic, clinical features and outcome determinants of thoracic trauma in Sri Lanka: a multicentre prospective cohort study. Can Respir J 2020;2020:1219439. doi: 10.1155/2020/1219439.