Original Research Paper

Volume-8 | Issue-5 | May-2018 | PRINT ISSN No 2249-555X

Surgery

THORACIC ULTRASONOGRAPHY IN COMPARISON WITH CHEST RADIOGRAPHY AS A DIAGNOSTIC MODALITY IN CHEST TRAUMA

Dr. V. Sowmya Ramanan	M.S MRCS. General Surgery
Dr Sreejayan M.p*	Dip.NB.,Ph.D., FRCS (Edin)., FRCS (Glasg) Professor Of Surgery, Calicut Medical College, *Corresponding Author
Dr. Kuriakose	MS., MCh Professor And Head Of The Department, Cardiothoracic Surgery, Calicut Medical College

KEYWORDS :

INTRODUCTION

Patients with blunt or penetrating thoracic and abdominal trauma are at risk for a wide variety of injuries. Though therapeutic techniques have improved considerably, chest injuries remain a significant problem. Clinical assessment and radiological evaluation in the form of x-rays forms the usual evaluation of chest trauma. There is no simple method to detect all clinically important torso injuries. The primary problem in this is the diversity of organ and skeletal injuries and the variability of clinical manifestations. There are numerous publications describing missed injuries in patients incurring blunt and penetrating trauma.

Rib fractures form 70% of cases with chest trauma that may be isolated or associated with underlying injury, which is more serious. Other significant conditions following chest trauma include sternal fractures, pneumothorax, hemothorax, lung contusions, diaphragmatic injury, cardiac injury in the form of contusions, tamponade, great vessel injury etc. Estimates suggest that approximately 20-25% of all trauma related deaths are due to chest injury. Fifty percent of patients who die from multiple injuries have a significant chest trauma.

Many chest injuries including tension pneumothorax, myocardial tamponade and massive hemothorax present with imminent threat to life. These injuries require rapid diagnosis and immediate treatment. In addition, chest trauma can lead to significant late morbidity and mortality.

In our experience, patients presented 24-48 hours later with persistent pain and repeat x-ray revealing fracture ribs. Patients initially evaluated in other hospitals with negative findings on x-rays reporting to us 4-5 days later with breathlessness and a subsequent x-ray finding of pneumothorax.

In a study of 709 patients,14 patients developed delayed pneu mothorax(2%) at 24-48 hrs,52 patients presented up to 14 days later with delayed hemothorax (7.4%).All the patients with the delayed hemothorax had at least one rib fractured.

Clinical examination or admission chest radiography missed small pneumothoraces initially in 30% to 50% of trauma patients. Studies highlight need for better screening tests in chest trauma.

X rays form the initial evaluation procedure in our college. Recent studies have reported increasing use of thoracic ultrasonography EFAST Extended Focused Assessment in Trauma as a first line method for evaluation of chest trauma, especially as FAST for abdominal trauma has become a routine investigation. USG does not enable visualization of the entire lung because of the high acoustic impedance of air. However, a high-frequency linear USG probe (7.5-10Hz) applied to an intercostal space enables visualization of the echogenic interface between the chest wall soft tissues and the aerated lung. The presence of lung sliding and comet-tail artifacts at the pleural interface indicates apposition of the pleural surfaces. These US features are absent when air within the pleural space separates the pleural surfaces.

The aim of our study was to find the utility of thoracic ultrasonography over chest x-ray as a first line diagnostic modality for evaluation of chest trauma.

MATERIALS AND METHODS

A hospital based prospective study was performed from the period September 2004 to June 2006. The source of data was patients attending our casualty who fulfilled our inclusion and exclusion criteria. The inclusion criteria applied was blunt / penetrating trauma patents attending casualty service. Patients were excluded from the study when the predominant problem was head injury (GCS<10) / the predominant problem clinically was blunt injury abdomen / hemodynamically unstable / severe respiratory distress/ flail chest requiring emergency tube thoracostomy.

METHOD OF COLLECTION OF DATA

Patients were enrolled based on the history of injury, clinical examination findings and on the fulfillment of the inclusion and exclusion criteria. Each enrolled patient underwent detailed examination to detect chest injury clinically, chest x-ray and ultrasound thorax.

Clinically fracture of ribs was diagnosed from the findings of tenderness over the rib, presence of crepitus being a definite sign of complete fracture. Decreased chest expansion and decreased air entry on the affected side gave suspicion of pleural injury and the presence of hyper-resonance or dullness on percussion was taken as suggestive of pneumothorax or hemothorax respectively.

High frequency linear probes 7.5-10 MHz was used for the performance of thoracic US.

Usg detects rib fractures and sternal fractures by the presence of cortical discontinuity. The absence of lung sliding and comet-tail artifacts at the pleural interface was taken for detection of pneumothorax. The diagnosis of hemothorax was made by the presence of echogenic fluid in the pleural space. Contusions are diagnosed by the presence of fluid in the inter tissue planes.

Chest radiography was performed preferably in the erect posture in patients. However, in patients who were unable to assume erect posture supine x-rays were used. The feature used to detect rib fractures was the break in cortical outline of the rib in PA views. Detection of sternal fractures requires both AP/PA views and lateral views. The diagnosis of pneumothorax was detection of a deep sulcus sign, sharp delineation of the pericardial silhouette, or large asymmetric area of hyperlucency in one of the hemi thoraces. A hemothorax was diagnosed based on the findings of blunting of the cardiophrenic angle and the costophrenic angles and the presence of the S shaped curve. In the presence of hemo-pneumothorax, the hemi thorax shows a definite air fluid level.

Management was based on the clinical and radiological evaluation for each diagnosed clinical entity. This included performing CT scan as an additional investigation if there was a strong clinical suspicion of underlying injury but radiological or sonological findings were non-contributory. Tube thoracostomy was performed for patients with either definite radiographic / sonological findings for hemothorax or pneumothorax or when they were symptomatic in the absence of positive diagnostic test results.

Statistical analysis

Fisher's exact test was used to compare the proportion of significant injuries by clinical assessment, chest radiography and thoracic ultrasonography. The measurement of agreement between the findings of clinical assessment, chest radiography and thoracic ultrasonography was assessed in terms of kappa value.

OBSERVATIONS

All the 80 patients enrolled for the study were men. The mean age was 47.43 yrs (25 - 65 yrs). 77 patients had blunt injury and 3 had penetrating injury. Most patients were victims of road traffic accidents. The three patients who suffered from penetrating injury were stab injury victims. Maximum number of patients presented 2 hours since injury (22 patients). The longest time at presentation was 312 hours (2 patients). 12 patients presented within 1 hour. There was no significant time delay between performance of ultrasound and chest x ray.

Breathlessness was a symptom with which 43 patients presented. Twenty-nine of these patients had a hemothorax, pneumothorax or a combination of both. Thirty-four patients had rib fractures.

It was decided to exclude patients with a GCS<10, which meant their predominant problem was head injury and thereby not, cooperate for the changes in position required to do a thoracic ultrasonography. All patients finally included in the study had a GCS of 15.

The range of recorded pulse was 78 – 110 per minute (average rate - 94 / mt). The range of systolic B.P was 80- 160 mm of Hg (average - 110 mm of Hg). The range of diastolic B.P. was 40-110 mm of Hg (average - 80 mm of Hg).

Paradoxical respiration is a feature of flail chest and this was found in six cases.

None of the cases studied showed an elevation in the jugular venous pressure, a feature of underlying cardiac injury in the form of tamponade or a feature of tension pneumothorax.

Movement of the chest wall was compared.55 patients had decreased chest wall movement of either hemi thorax on respiration.

The presence of surgical emphysema is always an ominous indicator of underlying chest injury. This feature was noted in our study also. Only 20 patients had surgical emphysema but all of them had an underlying injury. 13 patients had both hemothorax and pneumothorax, 7 patients had hemothorax.

The clinical feature of rib tenderness was analyzed for the number and location, site and whether unilateral or bilateral. Rib tenderness was found in 61 cases. Thirty patients had tenderness in 3 ribs. Three patients had tenderness in 8 ribs. Most of the patients had rib tenderness anterior to the mid axillary line. All patients had suspected unilateral rib fractures.

Sternal tenderness was found in ten patients but only one patient had definite sternal fracture as proved by X-ray, USG and CT thorax.

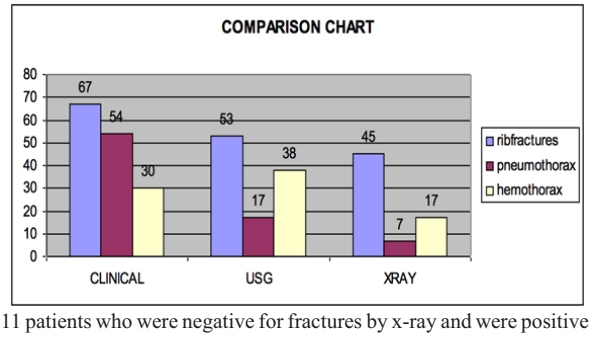
A decreased air entry on auscultation could mean decreased respiratory effort due to pain or a hemothorax or pneumothorax.48 patients had decreased air entry as a finding.37 patients had rib fractures. 17 patients had pneumothorax. 40 patients had hemothorax.

CLINICAL DIAGNOSIS AND OUTCOME

A provisional diagnosis was made based on the clinical findings. The three most common diagnosis made was rib fractures (67cases), hemothorax (30cases) and pneumothorax (54cases). A diagnosis of sternal fracture was made in 1 patient. Diaphragmatic injury was suspected in 3 cases.

The findings of X-ray, Usg thorax, CT and tube thoracostomy are summarized in table 1

Clinical evaluation	
Chest wall excursion decreased on side of injury :	55
Air entry equal on both sides:	48
Rib tenderness	61
Sternal tenderness:	10
Surgical emphysema:	20
X ray findings:	
Rib fractures :	45 cases
Pneumothorax:	7 cases
Hemothorax :	17 cases
Diaphragmatic injury:	3 cases
Sternal fracture:	1 case
Usg findings:	
Rib fractures :	53 cases
Pneumothorax:	17 cases
Hemothorax :	38 cases
Diaphragmatic injury :	3 cases
Sternal fracture :	1 cases
CT findings:	39 cases
Rib fractures :	24 cases
Hemothorax :	8 cases
Pneumothorax :	14 cases
Bilateral pneumothorax :	4 cases
Lung contusions :	28 cases
Complete diaphragmatic injury :	5 cases
Mediastinal shift due to hemothorax:	3 cases
Tube thoracostomy:	56 cases
Hemothorax :	15 cases
Hemo-pneumothorax :	26 cases
Pneumothorax :	12 cases



11 patients who were negative for fractures by x-ray and were positive by usg for fractures were followed up with x-rays. After a 72-hour period, 5 of these patients showed evidence of early callus formation suggestive of missed fractures. 7 of these patients had undergone a CT scan for other indications and diagnosed to have rib fractures and 5 had mediastinal shift due to hemothorax.

56 patients underwent tube thoracostomy based on an x-ray diagnosis of hemothorax (17 cases) and pneumothorax (7), usg diagnosis of hemothorax (38 cases) and pneumothorax (17 cases). 24 cases found to be negative by x-ray for hemothorax turned out to have hemothorax in a tube thoracostomy.3 cases found to be negative by usg for hemothorax had hemothorax in tube thoracostomy.

13 cases negative by all investigations for chest injury had an uneventful hospital course.

DATA ANALYSIS FOR RIB FRACTURES, PNEUMOTHORAX AND HEMOTHORAX.

The Fisher's exact test was used to compare the ultrasonological findings with the clinical and x-ray findings. The measure of agreement of the findings kappa value was also estimated. The ultrasonological findings were also compared with the findings of CT scan and tube thoracostomy in those cases when these were performed.

The findings in clinical study and usg for rib fractures agreed in 53 (79%) of the 67 cases with clinical suspicion of fracture. 13 cases who were clinically negative for rib fractures where also negative by usg.

X rays and usg agreed in 42 cases (93.3%) of the 45 cases detected by x-rays for rib fractures.3 cases detected by x rays were negative for rib fractures by ultrasound. There was a disagreement in 11(32.4%) cases detected by usg as positive for rib fracture and the x ray findings. X-rays and usg ruled out rib fractures in 24(67.6%) of the cases. Of the 11 patients who were negative by X-rays but positive by USG, CT was done for 7 patients (for other indications). CT could detect fracture ribs in these 7 patients. The Fisher value was 0.00. The measurement of agreement (kappa value) between x-ray and usg findings for rib fracture was 0.628.

Clinical examination and USG for pneumothorax showed an agreement in 17 (100%) cases for presence of pneumothorax and 26(41.3%) cases for absence of pneumothorax.

Chest X-ray and USG for pneumothorax showed an agreement in 7 (41.2%) cases for presence of pneumothorax and 63(100%) cases for absence of pneumothorax. USG could detect 10 (58.8%) more cases of pneumothorax than X-Ray. Of these 10 cases, 2 cases underwent CT scan and they were positive for pneumothorax. Of the 62 cases negative by x-ray and usg, 7 cases underwent CT and these were positive for pneumothorax. 3 of the cases had bilateral minimal pneumothorax. Fisher value (0.000), Measurement of agreement kappa value (0.524).

Clinical examination and USG for hemothorax showed an agreement in 22 (41.5%) cases for presence of hemothorax and 19(70.3%) cases for absence of hemothorax.

Chest X-Ray and USG for hemothorax showed an agreement in 17 (32.1%) cases for the presence of hemothorax and 27(100%) cases for absence of hemothorax. USG could detect 36 (67.9%) more cases of hemothorax. Of these 36 cases, 16 cases were positive by CT. Of the 26 cases negative by both investigations, CT detected 5 cases of hemothorax. Fisher value (0.001), Measurement of agreement kappa value (0.237).

DISCUSSION

Clinically significant parameters were time since injury, breathlessness, presence of abrasions, rib tenderness, chest wall excursion, deceased air entry and presence of surgical emphysema.

The presence of surgical emphysema was 100% indicator of underlying chest injury in most cases a pneumothorax. In a similar study conducted by Murat Kara, Erkan Dikmen, Haydar Huseyin Erdal et al, on 37 patients, age,gender, type of etiology, duration of pain and site of trauma did not appear as significant predictors for these rib fractures. However, the involved part of the rib showed a significant correlation with either ageor duration of pain [5].

The sensitivity of clinical findings in the diagnosis of rib fractures in comparison with usg was 100% and a specificity of 46.15% (95% CI =67.9-87.12). The sensitivity of clinical assessment in a similar study done to detect rib fractures and sternal fractures was 26.0% (95% CI, 15.8-36.3). The sensitivity of clinical assessment in a similar studies done by Murat Kara, Erkan Dikmen, Haydar Huseyin et al[5] and by Rainer TH, Griffith JF, Lam E, et al[6] to detect rib fractures and sternal fractures was 26.0% (95% CI, 15.8-36.3) 67 of 80 cases were found to have some form of chest injury.

In comparison with a conventional study x ray, usg showed

- Agreement in 79.2% of cases for the presence and 88.8% for the absence of rib fractures.
- Agreement in 41.2% for the presence and 100 % of cases for the absence of pneumothorax.
- Agreement in 41.5 % for the presence of and in 70.3% for the absence of hemothorax.

The disagreement rates turned out to be in favor of ultrasound on further evaluation. Between x-rays and thoracic ultrasonography, there was not much of statistical difference in the diagnosis of rib fractures though usg had a better pick up rate than chest x-ray. Our finding was that the detection of posterior upper rib fractures by ultrasonography was difficult because of the presence of scapula. For the same reason it was easier to detect lower rib fractures.

Similar studies conducted by Dulchavsky SA *et al*, 2001, and by Knudston JL *et al*, 2004, used CXR as gold standard against which USG was compared for the detection of pneumothorax. The findings of these studies respectively were 82 patients Usg had Sensitivity 95%(89–95) & Specificity 100% (99–100)) and of 328 patients Usg had Sensitivity 92.3%(74.4–97.9)Specificity 99.7%(98.9–99.9).

In comparison with tube thoracostomy/CT findings, this study showed

- Sensitvity and specificity of x-ray for pneumothorax 18.42% and 100%
- Sensitvity and specificity of usg for pneumothorax 44% and 100%
- Sensitvity and specificity of x-ray for hemothorax 41.46% and 86.66%
- Sensitvity and specificity of usg for hemothorax 92.68% and 86.66%

Rowan KR *et al*, 2002 and Kirkpatrick AW *et al*, 2004 compared USS *v* CT diagnosis or escape of air on thoracostomy. The findings respectively were of 27 patients usg showed Sensitivity 100% (82.6–100) & Specificity 94% (82-94) and of 225 patients Sensitivity 58.9%(45.0–71.9) & Specificity 99.1% (97.6–99.8) for the presence of pneumothorax.

Sternal tenderness was found in ten patients but only one patient had definite sternal fracture as proved by X-ray, USG and CT thorax.

Three cases had suspected diaphragm injury with usg and x-ray, CT scan confirmed these as partial diaphragm injury. The sample size of the study was small for these two injuries to be statistically analyzed. However, they definitely highlight the ability of ultrasound to diagnose these injuries.

CONCLUSION

The results from the 80 cases of our hospital based prospective study were that there were certain findings strongly suggestive of underlying chest injuries these, being the presence of breathlessness, rib tenderness, decreased chest wall movements, decreased air entry and surgical emphysema. The presence of surgical emphysema was an almost certain indicator of underling injury.

The results of study showed that majority of the patients detected to have a clinical suspicion of pneumothorax had a hemothorax or a hemopneumothorax on radiological and ultrasonological evaluation. That ultrasonography was better in the diagnosis of hemothorax had already been well established, the findings of this study were that ultrasound was better in the diagnosis of pneumothorax also.

As the pickup rates with ultrasound were better, more number of patients underwent definite treatment for their injuries in the form of tube thoracostomy for hemopneumothorax.

In conclusion, for injuries such as fractures for ribs and sternum, hemothorax and pneumothorax, thoracic ultrasonography had better pick up rates than chest x-rays. Ultrasonography could also detect other significant injuries like diaphragmatic injury and sternal fractures. We recommend the use of thoracic ultrasonography as a time and cost effective and a less hazardous tool for the confirmation of diagnosis of chest injuries like fractures, hemothorax and pneumothorax in lieu of CT thorax.

REFERENCES

1. JAMES R MACHO, WILLIAM C. KRUPSKI, FRANK R. LEWIS Management of Injured Patient, CSDT-11 TH EDITION.
2. DAVID B HOYT, RAUL COIMBRA, ROBERT J. WINCHELL Management of Acute Trauma, Sabiston Text Book of Surgery, 16th Edition.
3. BUDHANG, MCRITCHIE DI Missed Injuries in Patients with Multiple Trauma. J trauma -2000; 49:600-605.
4. LAUPLAND KB, KIRKPATRICK, AW SIROIS M ET AL, Hand-held thoracic sonography for detecting post-traumatic pneumothoraces: the Extended Focused Assessment with Sonography for Trauma (EFAST). J Trauma. 2004 Aug;57(2):288-95.
5. MURAT KARA, ERKAN DIKMEN, HAYDAR HUSEYIN ERDAL, ILKNUR SIMSIR, SIMAY ALTAN KARA Disclosure of unnoticed rib fractures with the use of ultrasonography in minor blunt chest trauma Eur J Cardiothorac Surg 2003;24:608-613
6. RAINER TH , GRIFFITH JF, LAM E ET AL, Comparison of thoracic ultrasound, clinical acumen, and radiography in patients with minor chest injury. J Trauma. 2004 Jun;56(6):1211-3.
7. KNUDSTON J L, DORT J M, HELMER SD, SMITH RS Surgeon Performed Ultrasound for Pneumothorax in A Surgical Suite. J Trauma 2004 March; 56(3):527-30.
8. KEVIN R. ROWAN, ANDREW W. KIRKPATRICK, FRCSC, DAVID LIU ET AL, Traumatic Pneumothorax Detection with Thoracic US: Correlation with Chest Radiography and CT—Initial Experience Radiology 2002;225:210-214.
9. SOFFER d, MC KENNEY MG, COHN S, GARCIA ROCAR A Prospective Evaluation of Ultrasonography for the Diagnosis of Penetrating Trauma. J Trauma 2004 May; 56(5):957-9.
10. BOKHARI F, NAGY K ,ROBERTS R, BRAKENRIDGE S,SMITH R, JOSEPH K Ultrasound Screen For Penetrating Truncal Trauma American Surgeon 2004 April;70(4):316-21.
11. CARILLO E H, GUINN B J, ALI A T BOAZ PW ,Transthoracic Ultrasonography as an Alternative to Subxiphoid Ultrasonography For The Diagnosis Of Hemopericardium In Penetrating Chest Trauma.Amj Surg 2000 Jan; 179(1):34-36.
12. ROZYCKI GS, BALLARD RB, FELICIANO DV, SCHMIDT JA Surgeon Performed Ultrasound For The Assessment Of Truncal Injuries Annals Of Surgery 1998 Oct; 228(4):557-67.
13. HANSEN M, MUHL E Blunt Thoracic Trauma and Relevance of Roentgen Image, Ultrasound and CT Langenbecks.Arch.Chirurgie-1997; 114:458-460.
14. GLASER K,TSCHMELISCH J, KLINGLER P, WETSCHER G,BODNER E Ultrasonography In The Management Of Blunt Abdominal And Chest Trauma. Arch.Surg July 1994; 129(7):743-7.
15. BOULANGER BR ,KEARNEY PA ,TSUEI B, The routine use of sonography in penetrating torso injury is beneficial. J Trauma. 2001 Aug;51(2):320-5.