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ROLE OF TRIPLE EXAMINATION CONSISTING OF CLINICAL EXAMINATION, RADIOLOGICAL EXAMINATION AND EXTENDED FOCUSSED ASSESSMENT WITH SONOGRAPHY IN TRAUMA (eFAST) IN EARLY DIAGNOSIS OF VISCERAL INJURIES IN TORSO TRAUMA

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ABSTRACT

BACKGROUND AND AIM: Trauma is a major cause of global suffering and death. Timely management is thought to be a critical predictor of outcomes for patients with acute traumatic injuries. The present study evaluates the role of triple examination in early diagnosis of visceral injuries in trauma.

METHODS: This study included 50 patients with torso trauma admitted to emergency surgical wards at Guru Nanak Dev Hospital, Amritsar after written informed consent. The patients underwent clinical assessment, resuscitation and stabilization followed by eFAST scan and X-ray chest and abdomen. Once patients were hemodynamically stabilized, they underwent CT scan torso to confirm the findings of triple examination. The data collected was later suitably tabulated and statistically analysed to achieve the following results.

RESULTS: Triple examination proved to be comparable to the gold standard CT torso in detecting haemoperitoneum with a sensitivity and specificity of 100%. Triple examination was able to diagnose rib fractures, pneumothorax, haemothorax, pneumoperitoneum and visceral injuries with a sensitivity of 92%, 95%, 100%, 83.33%, 97.30% and a specificity of 96%, 90%, 89.7%, 93.18%, 53.85% respectively.

CONCLUSION: Triple examination is a cost effective, non-invasive and time saving protocol for early diagnosis of visceral injuries in torso trauma patients. It can be easily undertaken alongside hemodynamic resuscitation without withholding necessary care to the patient.

KEY WORDS: eFAST, torso trauma, triple examination, visceral injuries

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INTRODUCTION

Trauma is a major cause of global suffering and death. In low- and middle-income countries, trauma accounts to 11% of all disability-adjusted life years.[1] Traumatic injuries are the most common cause of death in people under 45 years of age.[2] Road traffic accidents due to over speeding, driving under influence of alcohol followed by accidental falls and assaults are the most frequent causes of blunt torso trauma in India.[3]

Timely management is thought to be a critical predictor of outcomes for patients with acute traumatic injuries in developing regions. However, the initial management of a person who is critically injured with polytrauma is a challenging task for the treating physician, and every minute can make a difference between life and death.[4]

Focussed Assessment with Sonography in Trauma (FAST) was coined by Rozycki et al in 1996, which consisted of a basic four view examination (perihepatic, peri splenic, pelvic and pericardiac views) which can be completed in a total of two to five minutes, helping triage trauma patients into those requiring emergency surgical care and those stable enough to undergo further evaluation.[5] The main objective of the eFAST examination is to identify free fluid/air in the pleural/abdominal cavity. eFAST is a rapid, reproducible and non-invasive bedside test, which does not involve radiation and can be used as an initial investigation in all trauma patients as a part of the resuscitation process.[6]

The present study was undertaken to evaluate the role of triple examination consisting of clinical examination, radiological examination and extended focussed assessment with sonography in early diagnosis of visceral injuries in torso trauma.

METHODOLOGY

This prospective study was undertaken at Department of Surgery in collaboration with Department of Radiodiagnosis at Guru Nanak Dev Hospital, Amritsar, on 50 patients with torso trauma admitted to emergency surgical wards after taking written informed consent. The patients were selected on the basis of following inclusion and exclusion criteria:

INCLUSION CRITERIA

All cases of blunt and/or penetrating Torso trauma reporting to surgery emergency.

EXCLUSION CRITERIA

1. Pediatric patients of age less than 14 years
2. Pregnant females

The patients underwent clinical assessment, resuscitation and stabilization followed by eFAST scan and X-ray chest and abdomen, findings of the three were recorded as per the proforma. A provisional diagnosis was made based on the findings of each individual modality.

Triple examination was said to be positive for any particular diagnosis if any of the three individual components tested positive for said diagnosis.

Once the patients were hemodynamically stabilized, they underwent CT scan torso to confirm the findings of triple examination. CT findings were noted along with triple examination findings.

The data collected was later suitably tabulated and statistically analysed to achieve the following results.

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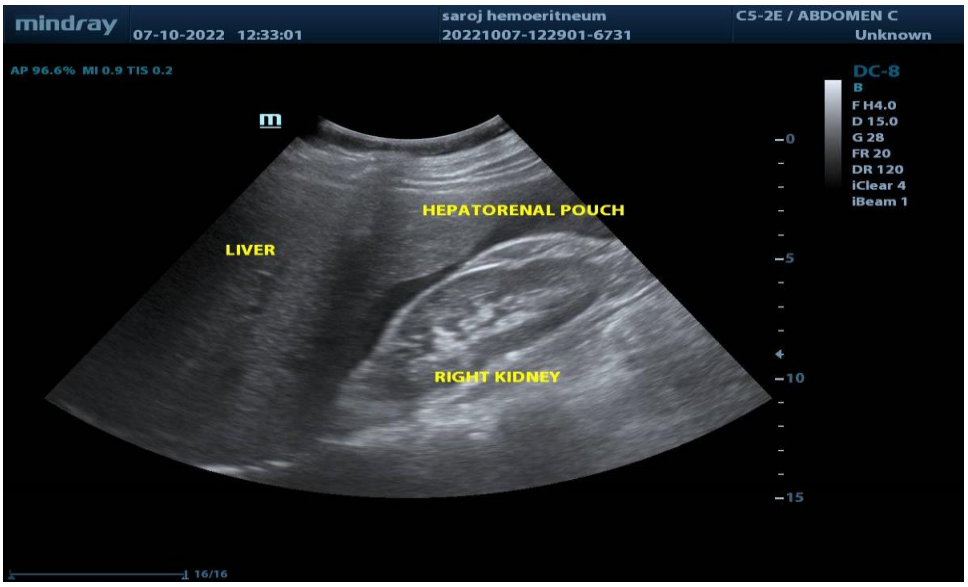

Image 1: Right upper quadrant view showing fluid in hepatorenal space

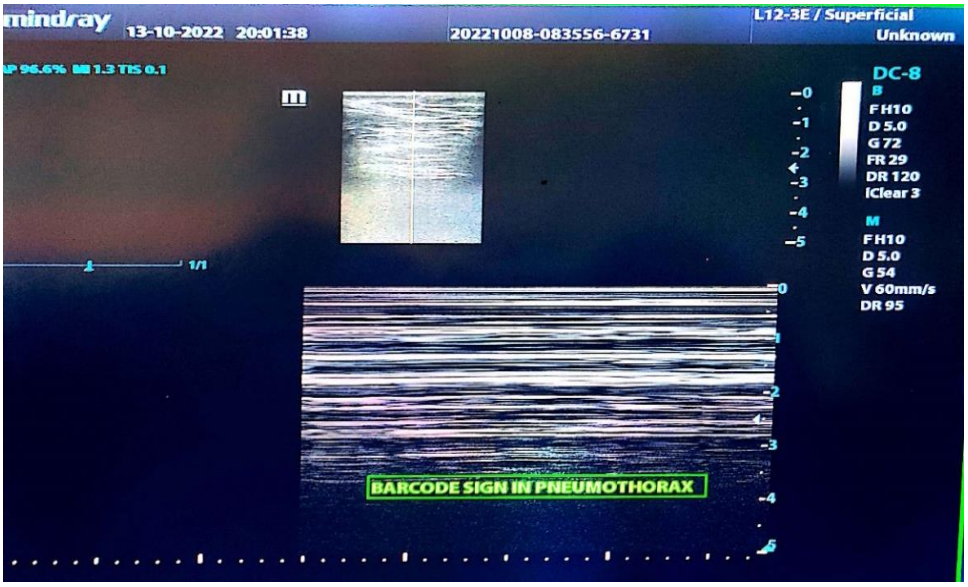

Image 2: Thoracic view showing barcode sign in pneumothorax

RESULTS

The majority of the patients were below the age of 50 years (72%), only 28% of the patients were above the age of 50 years. The mean age of the patients was 41.24± 16.15 years. 90% of the patients included in this study were males (45 patients) with a male to female ratio of 9:1.

Road traffic accidents were responsible for bringing the maximum number of patients to the hospital in this study group (66%) followed by falls (16%), assault (10%), stab injuries (6%) and self-harm (2%). Blunt trauma was seen predominantly in this study (86%) followed by sharp and penetrating injuries in 8% and 6% of the patients respectively.

The distribution of patients based on diagnosis through various methods have been tabulated below:

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Table 1: Distribution of patients according to clinical diagnosis

Clinical diagnosis	Frequency	Percent
Rib fracture	20	40
Clinical abdominal organ/visceral injury	18	36
Haemoperitoneum	13	26
Pneumothorax	13	26
Haemothorax	9	18
Pneumoperitoneum	8	16
Clinical lung contusion	7	14

On the basis of clinical assessment, a clinical diagnosis of rib fracture/s was made in 20 patients (40%), pneumothorax in 13 patients (26%), haemothorax in 9 patients (18%), lung contusions in 7 patients (14%), haemoperitoneum in 13 patients (26%) and pneumoperitoneum in 8 patients (16%). Clinical examination diagnosed abdominal organ/visceral injury in 18 patients (36%).

Table 2: Distribution of patients based on eFAST diagnosis

eFAST	Frequency	Percent
Organ/ visceral injury	42	84
Haemothorax	24	48
Pneumothorax	22	44
Haemoperitoneum	21	42
Pneumoperitoneum	6	12

eFAST detected pneumothorax in 22 patients (44%), haemothorax in 24 patients (48%), haemoperitoneum in 21 patients (42%), pneumoperitoneum in 6 patients (12%) and organ/visceral injury in 42 patients (84%).

Table 3: Distribution of patients based on diagnosis made on X-ray examination

Xray chest/ abdomen findings	Frequency	Percent
Rib fractures	23	46
Subcutaneous emphysema	20	40
Haemothorax	19	38
Pneumothorax	16	32
Pneumoperitoneum	8	16

On X-ray, 23 patients (46%) had rib fracture/s, 20 patients had subcutaneous emphysema (40%), 19 (38%) and 16 (32%) patients had haemothorax and pneumothorax respectively. 8 patients (12%), showed pneumoperitoneum on X-ray abdomen.

Table 4: Distribution of patients according to diagnosis based on triple examination findings

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Triple examination findings	Frequency	Percent
Organ/ visceral injury	42	84
Rib fracture	24	48
Haemothorax	23	46
Pneumothorax	22	44
Haemoperitoneum	21	42
Lung contusion	21	42
Pneumoperitoneum	8	16

The triple examination protocol detected rib fracture/s in 24 patients (48%), haemothorax in 23 patients (46%), pneumothorax in 22 patients (44%), lung contusions in 21 patients (42%), haemoperitoneum in 21 patients (42%) and pneumoperitoneum in 5 patients (10%). Triple examination identified organ/visceral injury in 84% of the patients included in this study.

Table 5: Distribution of patients according to CT findings

CT Torso findings	Frequency	Percent
Organ/visceral injury	36	72
Rib fracture/s	25	50
Haemothorax	21	42
Haemoperitoneum	21	42
Pneumothorax	20	40
Lung contusion	18	36
Splenic injury	9	18
Pneumoperitoneum	6	12
Liver injury	5	10
Hollow viscus perforation	5	10
Renal injury	3	6
Abdominal wall hernia	2	4
Diaphragmatic hernia	1	2
Urinary bladder injury	1	2

Out of the 50 patients included in this study, 25 had rib fracture/s (50%), 20 had pneumothorax (40%), 21 had haemothorax (42%), 21 had haemoperitoneum (42%) and 6 had pneumoperitoneum (12%) as diagnosed by the CT scan torso. 36 patients (72%) had organ/visceral injuries, most commonly noted of which were lung contusions seen in 18 patients (36%), followed by splenic injury in 9 patients (18%). Liver injury was present in 5 patients (10%). Hollow viscus perforation was diagnosed in 5 patients (10%). 3 patients had renal injury (6%) and one patient had urinary bladder injury (2%). Two patients suffered from abdominal wall hernia as a result of torso trauma (4%). One patient was diagnosed with diaphragmatic hernia on CT torso (2%).

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Table 6: Diagnostic Accuracy of Triple Examination in Diagnosing Rib fracture

Rib fracture	Sensitivity (%)	Specificity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)	Accuracy (%)
Clinical Examination	76	96	95	80	86
X-Ray Examination	88	96	95.65	88.89	92
eFAST scan	92	96	95.83	92.31	94
Triple examination	92	96	95.83	92.31	94

Xray examination was found to be superior to clinical examination alone in diagnosing rib fractures with sensitivity (88% vs 76%), specificity (96% for both), PPV (95.65% vs 95%) and NPV (88.89%vs80%). Triple examination showed a sensitivity of 92%, specificity of 96%, PPV of 95.83% and a NPV of 92.31% with an overall accuracy of 94%.

Table 7: Diagnostic Accuracy of Triple Examination in Diagnosing Pneumothorax

Pneumothorax	Sensitivity (%)	Specificity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)	Accuracy (%)
Clinical Examination	45	86.67	69.23	70.27	70
X-Ray Examination	70	93.30	87.5	82.3	84
eFAST scan	95	90	86.3	96.4	92
Triple Examination	95	90	86.3	96.4	92

For pneumothorax, X-ray chest had a higher positive predictive value (87.5%) compared to eFAST (86.3%) and clinical examination (69.23%) in diagnosing pneumothorax, however displayed a lower sensitivity in detecting such patients compared to eFAST (70% vs 95%) hence eFAST proved to be more accurate in detection of pneumothorax than X-ray chest (92% vs 70%). The overall accuracy for eFAST and Triple examination was found to be 92%.

Table 8: Diagnostic Accuracy of Triple Examination in Diagnosing Haemothorax

Haemothorax	Sensitivity (%)	Specificity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)	Accuracy (%)
Clinical Examination	44.44	58.54	19.05	82.76	56
X-Ray Examination	76.2	89.7	84.21	83.80	84

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eFAST scan	100	89.7	87.3	100%	94
Triple examination	100	89.7	87.3	100%	94

Clinical examination alone was found to be least reliable for diagnosing haemothorax. eFAST performed considerably better at diagnosing haemothorax compared to X-ray chest and clinical examination as shown by its sensitivity (100% vs 76.2% vs 44.44%), specificity (89.7 vs 89.7%vs 58.54), PPV (87.3% vs 84.21% vs 19.05%) and NPV (100% vs 83.8%% vs 82.76%). Triple examination displayed a sensitivity of 100%, specificity of 89.7%, PPV of 89.7% and NPV of 100%. The overall accuracy for eFAST and Triple examination was 94%.

Table 9: Diagnostic Accuracy of Triple Examination in Diagnosing Haemoperitoneum

Haemoperitoneum	Sensitivity (%)	Specificity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)	Accuracy (%)
Clinical Examination	53.33	62.86	38.10	75.86	60
eFAST scan	100.00	100.00	100.00	100.00	100.00
Triple examination	100.00	100.00	100.00	100.00	100.00

Triple examination proved to be comparable to the gold standard CT torso in detecting haemoperitoneum with a sensitivity and specificity of 100%.

Table 10: Diagnostic Accuracy of Triple Examination in Diagnosing Pneumoperitoneum

Pneumoperitoneum	Sensitivity (%)	Specificity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)	Accuracy (%)
Clinical Examination	33.3	86.3	25	90.4	80
eFAST Examination	66.67	95.45	66.67	95.4	92
X-ray scan	83.33	93.18	62.5	97.6	92
Triple Examination	83.33	93.18	62.5	97.6	92

Clinical examination was unreliable in predicting pneumoperitoneum as shown by its poor sensitivity (33.3%) and low positive predictive value (25%). X-ray performed the best out of the three with a sensitivity of 83.33%, however eFAST showed a superior positive predictive value of 66.67%. Both X-ray and eFAST was similarly accurate in diagnosing pneumoperitoneum (92%). Triple examination in patients with pneumoperitoneum was 83.33% sensitive, 93.18% specific, with PPV and NPV of 62.5 and 97.6% respectively.

Table 11: Diagnostic Accuracy of Triple Examination in Diagnosing Visceral Injury

Visceral injury	**Sensitivity (%)**	**Specificity (%)**	**Positive Predictive Value (%)**	**Negative Predictive Value (%)**	**Accuracy (%)**
Clinical Examination	45.95	92.31	94.44	37.50	58.00
eFAST scan	97.30	53.85	85.71	87.50	86.00
Triple examination	97.30	53.85	85.71	87.50	86.00

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The sensitivity of clinical examination alone for visceral injury was 45.95% compared to triple examination (97.30%), the specificity was 92.3% vs 53.85%. However, clinical examination had a higher index of suspicion in diagnosis of solid organ and visceral injury compared to Triple examination taking into account the clinician's judgment in evaluation of these injuries. The overall accuracy was 58% for clinical examination and 86% for triple examination.

The average time required for a CT scan (76.40±59.53 min) was significantly more than required by Xray (5±0.67min) for eFAST (4.06±0.79min) for clinical assessment (5.54±1.16 min) and for triple examination (14.62±1.85 min). Only 18% of the patients were managed operatively while rest were managed conservatively.

DISCUSSION

A comparative study on epidemiology, spectrum and outcome analysis of physical trauma cases presenting to emergency department of Dhulikhel Hospital, Kathmandu University Hospital and its outreach centers in rural area published 2012 showed similar results with the most common age group presenting with traumatic injuries being 15-49 years.[7]

In a study by Shrivastava SK et al[8] out of 48 patients, 42 (87.5%) patients were males and only 6 (12.6%) patients were females. In a study by Jayan et al[9] on 180, 83.9% were male. The large proportion of male involvement is attributed to occupational hazards and other socio-economical activities men engage in, which predispose them to injuries. Males also represent the active group in any society that takes part in high-risk activities.

The results of the present study were in accordance with the study conducted by Basnet et al[10] who observed road traffic accidents (44.4%) and fall injuries (43.3%) to be the most common mechanisms of injury. Type of injury was found to be blunt in majority of the patients (86%) whereas sharp and penetrating injuries were present in 8% and 6% of the patients respectively. Similar results were reported in the study published by Hemmati et al[11] showing most of the damage resulted from blunt trauma.

The sensitivity of CXR for rib fracture in chest trauma patients in a study conducted by Kumari P[12] was found to be 40%, similar to the present study. Singleton et al[13] in their study found compared with CT, CXR had a sensitivity of 40% and specificity of 99% for rib fracture detection. In these studies, sensitivity and specificity of plain radiograph for detection of rib fractures was reported to be 42%–60% and 57%–78% respectively.

The study conducted by Kithinji et al[14] which showed that eFAST was more sensitive at detecting haemothorax than chest X-ray with sensitivity of 96.1% versus 45.1% respectively. The accuracy was also higher for eFAST (96.4% versus 49.1%) but the specificity was the same at 100.0%. The study findings by Attia and Gwely[15] in Egypt are also comparable to our findings, where eFAST was reported superior to chest X-ray with sensitivity of 86.2% versus 58.6%, accuracy of 96.3% versus 89% and specificity of 100% for both investigations.

Nagarsheth et al[16] in their study showed the sensitivity of thoracic ultrasound for pneumothorax was found to be 81.8 per cent and the specificity was found to be 100 per cent. The sensitivity of chest X-ray was found to be 31.8 per cent and again the specificity was found to be 100 per cent. The negative predictive value of thoracic ultrasound for pneumothorax was 93.4% and the negative predictive value for chest X-ray for pneumothorax was found to be 79.2% We also found that the NPV of ultrasound in our study was 96.4 per cent, which is quite similar to those values reported by Soldati et al[17], who reported PPV and NPV values of 99.2 per cent and 98.57 per cent, respectively.

For haemoperitoneum, eFAST and clinical diagnosis varied remarkably. The predictive value was greater for eFAST than clinical examination alone. The sensitivity (100% vs 53.33%), specificity (100% vs 62.86%), PPV (100% vs 38.10) and NPV (100% vs 75.86%) were greater for eFAST. Triple examination was able to accurately diagnose haemoperitoneum in 100% of the patients. In a study by Richards et al[18], 3,264 patients with traumatic injuries underwent FAST scan, and the findings were compared with CECT/surgery/clinical outcome. In this study, the sensitivity, specificity, and accuracy were 60, 98, and 80 %, respectively, for free intra-peritoneal fluid. In a large

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review, Adams et al[19] concluded that FAST examination has 82% sensitivity and 99% specificity for detecting intra-abdominal injuries in adults with blunt abdominal trauma.

Clinical examination was unreliable in predicting pneumoperitoneum as shown by its poor sensitivity (33.3%) and low positive predictive value (25%). X-ray performed the best out of the three with a sensitivity of 83.33%, however eFAST showed a superior positive predictive value of 66.67%. Both X-ray and eFAST was similarly accurate in diagnosing pneumoperitoneum (92%). Based on the results of the meta-analysis by Jiang et al[20], ultrasonography has proven itself comparable to plain radiograph in diagnosing pneumoperitoneum.

The overall accuracy for visceral injury was 58% for clinical examination and 86% for eFAST and triple examination. In a study conducted by Bode et al[21] the sensitivity, specificity and positive predictive value of eFAST were found to be 92%, 100%, and 100%, respectively. This provides evidence that eFAST can be regarded as one of the most reliable screening modalities.

CONCLUSION

Triple examination consisting of clinical examination, radiological examination and eFAST is an effective and time saving protocol for early diagnosis of visceral injuries in torso trauma patients. It can be easily undertaken alongside hemodynamic resuscitation without withholding necessary care to the patient.

The major advantages being its cost effectiveness and non-invasive investigation algorithm which can be easily implemented at all equipped trauma centers with use of minimal resources.

LIMITATIONS OF THE STUDY

- This study included a smaller sample size and therefore does not accurately define the overall regional population in terms of demography and injury patterns. Further larger scale studies are required to fully evaluate the scope of this trauma algorithm.
- Unavailability of point-of-care Ultrasound (pocUs) i.e., portable ultrasound machine in the emergency surgical ward led patients to be transported to the ultrasonography room at a distance which led to subsequent delays in diagnosis and management.

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