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ORIGINAL RESEARCH

OUTCOME OF INTERCOSTAL DRAIN MALPOSITION AND ROLE OF CT SCAN IN CHEST TRAUMA: A SINGLE CENTER STUDY

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Abstract

Background: Traumas are the leading cause of death in the first four decade of life. Thoracic trauma might lead to severe life threatening complications. Tube thoracostomy is lifesaving procedure for these complications.

Objectives: The study was performed to evaluate outcome related to chest tube malposition, to assess the requirement of replacement of chest tube and to study the role of HRCT in post intercostal drain (ICD) patients.

Methods: It was a retrospective observational study. The study was conducted on post ICD patients with persistent collapsed lungs for >3 days. Injury severity and patient outcomes were analyzed with respect to insertion environment, and the positions of chest tubes and necessity for replacement is assed after HRCT thorax.

Results: Fifty patients who underwent chest tube replacement met the inclusion criteria. Majority of the patients were male (68%), age in between 40-49 years (40%) with blunt trauma (86%). Chest tubes were in the pleural space in 84% of cases. Most of the chest tubes (72%) were inserted in the resuscitation room. In the overall analysis, we found a significant trend (p=0.017) for longer hospital stay in patients without targeted chest tubes positions. Out-of-hospital chest tube insertion required higher replacement rates than resuscitation room insertions (57.1 vs 2.8%, p= <0.001).

Conclusion: Patients with malposition of emergency chest tube according to CT were not associated with worse outcomes as most of the complications resolved spontaneously. Out-of-hospital chest tube insertions were associated with higher replacement rates compared to resuscitation room chest tube insertion. HRCT helps to identify any other lung injury/ involvement along with ICD malposition.

Keywords: Trauma, Chest Tube, Malposition, Computed Tomography

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INTRODUCTION

Trauma is the major reason of death in the first forty years of life and are mostly caused by road traffic accidents [1]. Nevertheless, they might be related with other types of causalities also, like falling from heights or firearm injuries. Among all thoracic trauma is a frequently encountered in the emergency department with approximately two-thirds of all trauma patients having suffered chest injuries [2]. Most of these injuries are due to blunt trauma, and only few require surgery. Furthermore, thoracic injuries are second in mortality only to head injury and reports for approximately one-fourth of all trauma-related deaths [3]. Hemothorax, simple pneumothorax, and tension pneumothorax are various complications associated with thoracic injuries [4].

The management of hemothorax, pneumothorax or both in the majority of patients with chest injury, particularly in the acute phase has been essentially, the insertion of chest tube or thoracostomy [5-7]. Tube thoracostomy (TT) is the procedure of insertion of a sterile tube or catheter into the pleural space. The use of chest tube is not new, it was described long back at the time of Hippocrates (460 BCE), when metal tubes were used to treat empyema [8, 9]. The techniques of chest tube placement developed gradually in the course of flu epidemic that happened in the year 1918 and in due course in the management of chest trauma occurred due to injuries during World War II [9].

Insertion of chest tube is an important approach in the Advanced Trauma Life Support [10, 11]. When we see on data published recently by a national trauma database, it highlighted the rate of chest tube placements outside hospitals settings and in the hospital resuscitation phase of about 8% and 27% respectively for patients having injury severity score >15[12].

The chest tube is commonly inserted across the chest wall at the level of 5^{th} ICS anterior to mid-axillary line [6]. The reason for choosing this position has been considered to be due reasons like safety and utmost functional level of the tube. Similarly, the intrathoracic placement of the tube has been determined to be important for the tube to be efficient and deliver the desired outcome.

There are many complications associated with tube thoracostomy, few of them are nonfunctioning or malposition of chest tube, recurrent pneumothorax, and infection at insertion site. Malposition of chest tube is find to be most frequent among all others complications.

The incidence of inappropriately placed TT has been noticed to be rising and is currently being said to be 30% [13-14]. Malposition chest tube may often lead to retention of pneumothorax or hemothorax. It has also been observed that patients having complicated chest tube insertion also bear increased hospitalization costs due to demand for surgical or radiological repair [15]. There are various modalities for the management of improperly placed TT. These are to observe, repositioning the tube, tube replacement, additional TT placement or early surgical intervention (thoracotomy).

In spite of the fact, the possibility of chest tube malposition and the requirement for early tube position control are well known things in trauma care, there is dearth of studies using Computed Tomography (CT) for specific analysis for chest tube position. In this study we have analyze positions of chest tube on chest CT in trauma patients. We hypothesized that malposition of chest tube would be associated with higher rates of poor outcomes as compared to correctly placed chest tubes.

The aim of the present study was to evaluate outcome related to chest tube malposition, to assess the requirement of replacement of chest tube and to study the role of HRCT in post ICD patients.

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METHODS

Study Design: retrospective observational study
Study Area: Trauma Center, Tertiary Care Hospital, Bhopal.
Study duration: One year (2019-2020)
Study Population: 50 participants
Methodology: It was a record-based retrospective observational study. Permission was taken from the Institutional Ethics Committee and concerned department. The study was conducted over the duration of one-year reporting at Trauma Center, Tertiary Care Hospital, Bhopal (M.P). The study included post ICD patients with no spontaneous resolution of abnormality for >3 days who then underwent HRCT chest.
Inclusion criteria:

1. Patients who underwent CT following chest tube placement.
2. Patients who underwent chest tube insertion outside hospital and referred to our center.

Exclusion Criteria:

1. Patients in which there is resolution of pathology post ICD.
2. Patients who died before CT evaluation.

Data collection was done from medical records and radiological information system. Data collection was done and information was recorded on a semi-structured proforma.The proforma included socio-demographic parameters including age, gender etc. it also included information on type of trauma, mortality, the Injury severity Score (ISS), abbreviated injury score (AIS) for the chest. Information on ICU days, Hospital stay, insertion side, intercostal space, place of ICD insertion, target position was also collected. HRCT findings were also noted.
Statistical Analysis: The data of a total 50 patients who fulfilled the inclusion criteria were entered into a spreadsheet and analyzed using Epi info version 7.2.2.2. Frequency and percentages were calculated. Categorical data was expressed as percentage. Continuous variables were presented as mean and standard deviation. Chi square test and independent t test were applied where ever needed. Level of statistical significance was set at $p<0.05$.

RESULTS

During the study period, 50 post ICD patients with no spontaneous resolution of abnormality for >3 days who then underwent HRCT chest were included. All 50 patients with 50 chest tube placements had available chest CT data and were further analyzed.
Table 1 depicts distribution of bassline characteristics of study participants. Majority of the participants were in the age group of 40-49 years (40%) followed by 30-39 years (30%), 20-29 years (20%) and >50 years (10%). Male (68%) predominance was observed in the study, with females constituting 32% of study participants. Blunt trauma (86%) was the commonest mode of injury and 7 (14%) of the injuries were caused by penetrating trauma mechanism. Out of seven penetrating injuries five reported pneumothorax and rest two reported hemothorax. Procedure of Chest tube placement was done mostly in the resuscitation room in 36 patients (72%) and outside of hospital setting in 14 patients (28%) before the HRCT imaging diagnostic evaluation. Most of the chest tubes (80%) were placed using lateral approach in between 4^{th} and 6^{th} intercostal. While 16% cases had chest tubes in the 1^{st} and 3^{rd} Intercostal space, and 4% in the 7^{th} and 9^{th} ICS. Most common insertion side for the ICT insertion was right side of chest (54%), followed by 30% left side of chest and in 16% of cases bilateral chest tube were present. Target positions were directly reached in 28 cases (56%), while in 22 cases (44%) ICT failed to reach the target positions. Achievement of target structure position was defined as direct contact between the chest tube and the

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pneumothorax and/or collection of blood/fluid as confirmed by CT. Chest tube position in most of the cases were intrapleural (84%). Malposition of the chest tube was seen in 16% of cases, where various positions were, in 2 cases inter-lobar (Figure 2) and in 6 cases either partially outside/blocked tube. The majority of mal-positioned tube was found in those cases where ICD insertion was done outside of hospital. Among the 14 patients where ICD insertion was done outside the hospital, 8 resulted in malpositioning of tube and remaining 6 had intrapleural position of ICD. Replacement of tubes were needed in 9 out of 50 ICD tubes (18%). Among these, eight tubes were inserted out-of-hospital and one tube in resuscitation room**.** On seeing the duration of hospital stay among the study participants, most of the patient 22 (44%) had 0-5 days of hospital stay. A comparable number of patients 20 (40%) stayed for 6-10 days and the hospital stay duration for 8 (16%) of patients were 11-15 days.

On examining the results regarding use of HRCT in these patients, finding revealed residual pneumothorax in 28 (56%) of cases, hemothorax in 12 (24%) and hemo-pneumothorax in 10 (20%) of patients. Although complications were seen, but most of them resolved spontaneously. Outcome was good as no mortality seen in 48 (96%) of patients. 2 (4%) patients died within 1 week. These mortalities were observed among the patients where Bilateral ICD insertion was done. Further, no patients in the study were having various other complications associated with TT like pneumonia, wound infection and empyema. Treatment modality depicted in majority of the cases (96%) there was no action or intervention required. All the cases of residual pneumothorax (28) and hemo-pneumothorax (10) and 10 out of 12 cases of hemothorax got resolved by itself in 4-5 days. While in 2 cases of where hemothorax developed, it was loculated collection. As these loculated collections did not resolved spontaneously, USG guided aspiration was done to manage it.

Distribution of study participants on the basis of treatment provided to them following HRCT findings have been displayed in Figure 1. Two cases out of 50 needed USG guided aspiration, rest all underwent spontaneous resolution.

A mean Injury Severity Score (ISS) of 24.5±4.8 and mean Abbreviated Injury Score (AIS) chest of 3.45±0.5 was observed. While mean ICU days of stay for these patients were 1.80 ± 0.93 shown in table no. 2. We compared injury severity and outcomes in patients with and without intrapleural chest tube position and with and without target position, respectively (Tables 3). Independent t-test was used for the continuous variable. In the overall analysis, a significant trend (p=0.017) was found for longer hospital stay in patients without targeted chest tubes (Table 3). Injury Severity Score also related significantly with the targeted chest tube positions.

For categorical variables, Chi-square test was used. The results are depicted in the table 4. It can be observed that, chest tube placement outside of hospital was significantly associated with replacement (p value- <0.001). Other parameters like insertion side, intercostal space, target position and hospital stay duration were not significantly associated with any kind of chest tube replacement.

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Table 1: Baseline characteristics of study participants

Sl. No.	Variable	Categories	Frequency (n)	Percentage (%)
1	Age (in years)	20-29 years	10	20.0
		30-39 years	15	30.0
		40-49 years	20	40.0
		> 50 years	5	10.0
2	Gender	Male	34	68.0
		Female	16	32.0
3	Type of trauma to the chest	Blunt	43	86.0
		Penetrating	7	14.0
4	Patient mortality	24-h mortality	0	0.0
		1 week mortality	2	4.0
		No mortality	48	96.0
5	Insertion Side	Right Side	27	54.0
		Left side	15	30.0
		Bilateral	8	16.0
6	Intercostal Space	1-3 ICS	8	16.0
		4-6 ICS	40	80.0
		7-9 ICS	2	4.0
7	Target Position	Yes	28	56.0
		No	22	44.0
8	Insertion Environment	Outside of Hospital	14	28.0
		Resuscitation in hospital	36	72.0
9	Chest tube position	Intrapleural	42	84.0
		Intraprenchymal	2	4.0
		Partially outside/ blocked tube	6	12.0
10	Hospital Stay duration	0-5 days	22	44.0
		6-10 days	20	40.0
		11-15 days	8	16.0
11	HRCT findings	Residual pneumothorax	28	56.0
		Hemothorax	12	24.0
		Hemopneumothorax	10	20.0

Table 2: Mean values of various variables.

Sl. No.	Variable	Mean ± SD
1	ISS	24.5 ± 4.8
2	AIS	3.45 ± 0.5
3	ICU days	1.80 ± 0.93

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Figure 1: Distribution of study participants on the basis of treatment provided to them.

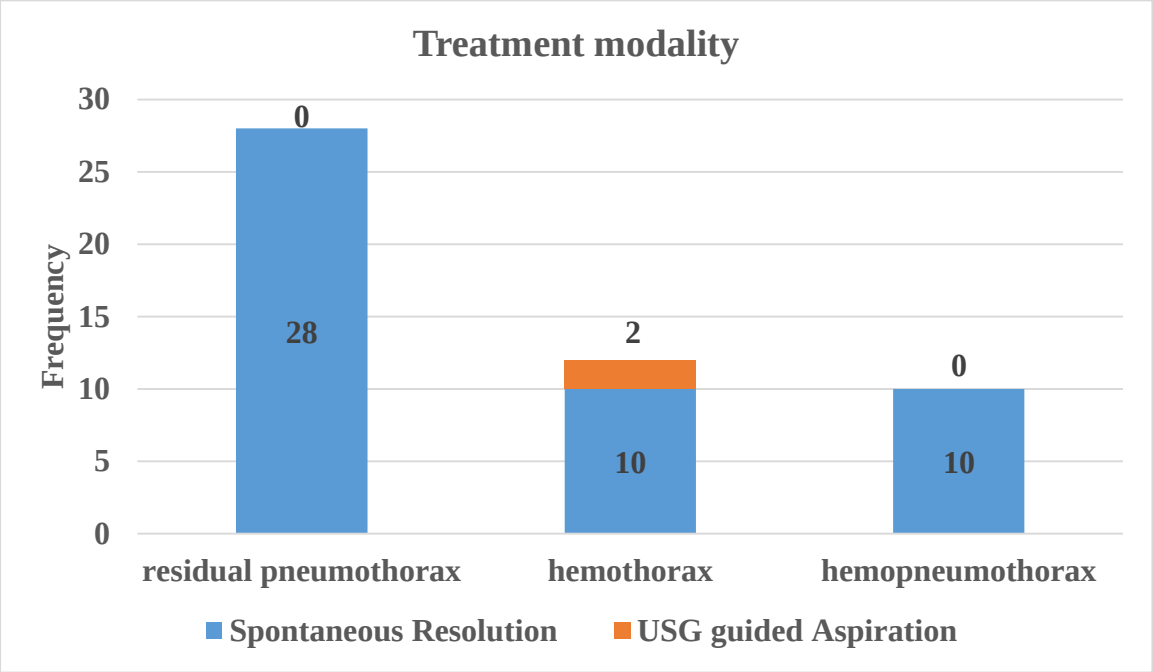

Table 3: Distribution of study participants on the basis of injury severity related to Chest tube position

Independent t test

Sl. No.	Variables	Categories	Mean	Std. Deviation	Std. Error Mean	p value
A	Chest tube position					
1	ISS	Intrapleural	24.81	4.66	0.719	0.337
		Not Intrapleural	23	5.782	2.044	
2	AIS	Intrapleural	3.445	0.5176	0.0799	0.883
		Not Intrapleural	3.475	0.5497	0.1943	
3	ICU Days	Intrapleural	1.76	0.906	0.14	0.511
		Not Intrapleural	2	1.069	0.378	
4	Hospital Stay	Intrapleural	6.36	3.695	0.57	0.059
		Not Intrapleural	7.38	4.926	1.742	
B	Target Position					
1	ISS	Yes	25.82	4.243	.802	0.03
		No	22.86	5.130	1.094	
2	AIS	Yes	3.546	.4639	.0877	0.138
		No	3.327	.5650	.1205	
3	ICU Days	Yes	1.79	.995	.188	0.904
		No	1.82	.853	.182	
4	Hospital Stay	Yes	11.82	6.891	1.302	0.017
		No	16.95	7.755	1.653	

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Table 4: Distribution of study participants on the basis of need for chest tube replacement within 24 hours of CT and associated risk factors

Sl. No.	Parameter	No replacement		Replacement		p value
		Number	Percentage	Number	Percentage	
1	Insertion Side					0.784
	Right Side	22	81.5	5	18.5	
	Left side	13	86.7	2	13.3	
	Bilateral	6	75.0	2	25.0	
2	Intercostal Space					0.46
	1-3 ICS, n (%)	6	75.0	2	25.0	
	4-6 ICS, n (%)	34	85.0	6	15.0	
	7-9 ICS, n (%)	1	50.0	1	50.0	
3	Target Position					0.13
	Yes, n (%)	25	89.3	3	75	
	No, n (%)	16	72.7	6	84	
6	Insertion Environment					<0.001
	Outside of Hospital	6	42.9	8	57.1	
	Resuscitation room	35	97.2	1	2.8	
7	Hospital Stay duration					0.739
	0-5 days, n (%)	19	86.4	3	13.6	
	6-10 days, n (%)	6	75.0	2	25.0	
	11-15 days, n (%)	16	80.0	4	20.0	

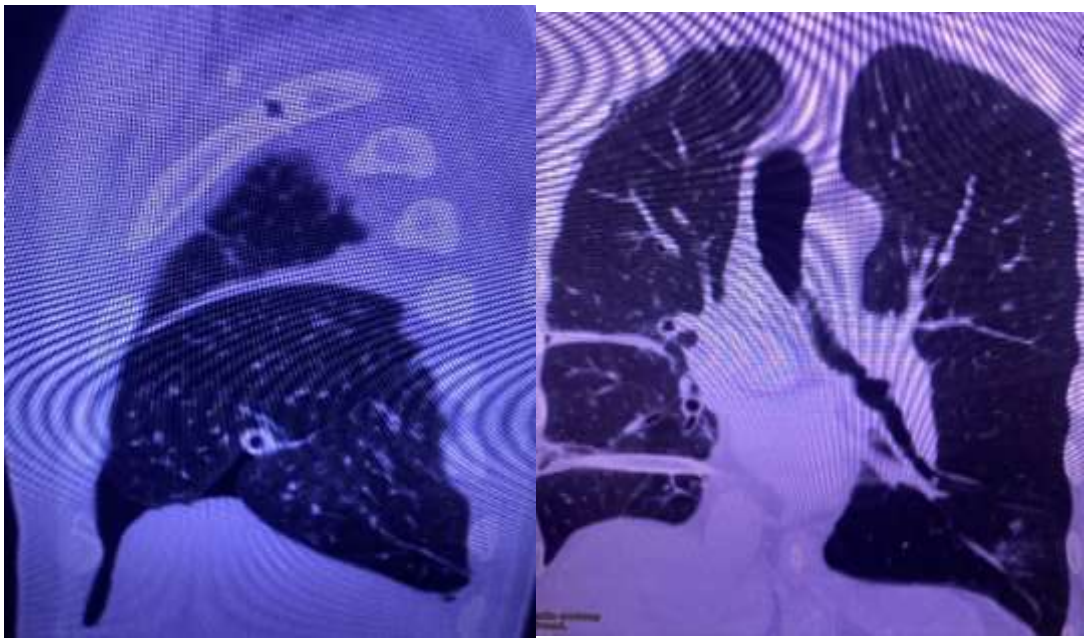

FIGURE 2: Inter-lobar ICD

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DISCUSSION

In trauma care setting, chest tube insertion is a frequent procedure. It is an essential and lifesaving skill as instructed in the Advanced Trauma Life Support Program. It is also acknowledged that there are risks or complications associated with chest tube insertion. The reported number and proportions of such events vary and are not easy to compare, as the definitions and denominators differ.

The current study was done among 50 patients with ICD. After analyzing the results, we found that 42 out of 50 (84%) of chest tubes were located in the pleural space and 56% had direct contact with target structures according to CT analysis. Chest tubes requiring replacement after CT were not associated with a failed target position. This finding was further supported by previous studies that a targeted location was not mandatory for functionality as long as the tube was positioned appropriately in the pleural space [16, 17, 18]. Another study by Makama et al [19] found that those patients whose chest tube insertion was considered non-ideally placed as reported by the radiologists had similar outcome with the ones that were considered ideally placed. These non-ideal TT had few secondary interventions that only varied from observation (nothing was done) to tube reposition and to tube replacement. Above finding was well supported further in Huber-Wagner et al. [7] study where it was found that mal-positioning (non-ideal TT), mostly interlobar, occurred in every fifth TT, but all these non-ideal tubes did well without any malfunction that was significantly different from those that were well placed (ideal TT) TT. Same study also pointed out that replacement should be done only for chest tube with a clinical malposition. In our study, out-of-hospital insertion was significantly associated with replacement compared to resuscitation room placement. This finding highlights the complexity associated with emergency setting and/or the higher risk for possible tube displacement while during the transport. However, other studies did not find relevant variance in complication rates for out-of-hospital chest tube placement compared to resuscitation room placement [7, 20]. In the present study, chest tube replacement was not associated with various noted risk factors for chest tube complications like right side insertions, intercostal level insertion. Many studies include a considerable proportion of penetrating injury patients which is in unison to 14% in our study [16, 21]. A recently done study, identified the significant risk factors such as higher chest AIS scores, penetrating injury mechanism, and initial drainage volume of hemothorax, resulting in requirement of secondary intervention after chest tube replacement [16]. Chest AIS score which had earlier been confirmed in other studies as a prognostic parameter for the development of chest tube complications [22]. The authors underlined that CT diagnostic evaluation of tube position should consider radiologist consultation because neither clinical nor radiologic signs are sensitive enough to appropriately detect chest tube malposition [26]. Literature has documented the advantage of CT over chest radiography in chest trauma patients. CT plays important role in detecting disease in those patients where initial radiographs show normal picture. While in 20% of cases it will reveal more extensive injuries when compared with the abnormal initial radiographs. This helps in demanding a change of management [27]. In detection of pulmonary contusion, thoracic aortic injury and osseous trauma, especially at the cervico-thoracic spine injury, CT plays more effective role than chest radiography. CT is more sensitive in pneumothorax detection, as 78% of them are supposed to be hidden on chest radiograph (occult pneumothorax) [28, 29]. CT is very sensitive in not only detecting even a small hemothorax but can further characterize these hemothorax, by measuring the Hounsfield (HU) units attenuation values of the pleural fluid accurately. [30, 31]. It is also important to remember that there are chance of co-existing multiple types of injury in a single patient. Thus, radiologists should not be disorientated by depicting one type of trauma and neglect other coexisting or associated types of injury.

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Therefore, it is justified to go through investigating all sites of possible injury for systematic exclusion. CT images which are volumetric reformatted and very much improve the detection of injuries and build up the understanding of mechanisms of trauma related abnormalities.
We acknowledge the general limitations of retrospective studies. Findings can only be interpreted as associations in place of causative relations. We only included patients who underwent CT following chest tube placement. Patients who died before CT evaluation may have suffered severe chest tube-related complications that could potentially contribute to fatality, as shown in autopsy or post-mortem CT studies [24, 25]. The indication for chest tube replacement may be subjective and may not be always based on functionality and/or radiologic position. This makes it difficult to analyze, that reposition occurrence as really necessary or not. However, repositioning after CT findings may be associated with higher probability of real necessity for repositioning (e.g., due to persistent tension pneumothorax or large fluid collections).
Despite these limitations, this analysis adds to our understanding of the complications associated with the placement of chest tube, which is among the most commonly performed procedures in trauma care. There are chances of improvement in the care of patients who require chest tubes both in resuscitation room and out-of-hospital. Improving the supervision of patients requiring intercostal drainage needs a systems-based approach, focusing on training and quality improvement.

CONCLUSION

Patients reporting malposition of emergency chest tube as per CT, were not correlated with worse outcomes as most of the complications resolved spontaneously. There were no complications reported like sepsis, pneumonia and empyema. Out-of-hospital chest tube insertions were associated with higher replacement rates compared to resuscitation room chest tube insertion. In the evaluation of severely injured patients with having complications, HRCT chest allows specific detection of possible malposition of chest tubes that may need prompt intervention. If spontaneous resolution does not occur, then HRCT helps to identify any other simultaneous lung injury/ involvement along with ICD malposition.

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