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Research Article

Role of Intercostal Chest Tube Drainage in Management of Chest Injuries in Hostile Environment

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Abstract

Introduction and Aim: Penetrating chest injuries are one of the leading causes of death and major morbidity in operations involving high energy weapon systems. This study aimed at assess the role of intercostal chest tubes in management of chest injuries suffered during armed combat operations in a hostile environment over a four year period.

Methods: A retrospective and prospective, non-randomized study designed to assess the role of intercostal chest tube drainage in chest injuries in armed combat operations over four years. All patients with chest injuries suffered during armed combat operations were included in the study.

Results: There were 1426 trauma cases out of which 22 casualties were brought dead and were excluded from the study leaving 163 patients who suffered chest injuries. The age range of patients was 20 to 46 years and all were male. Thoracotomy was required in nine patients (5.52) and Intercostal chest drainage (ICD) in 41 patients (25.15%). There was one mortality in the operated patients and there were 13 lung injuries and three diaphragmatic injuries. Average blood loss was 440ml and duration of hospital stay ranged from 4 to 62 days.

Conclusion: Ballistic injuries to the chest are frequently fatal due to injuries to the heart, major vessels and tracheobronchial tree. Prompt and efficient prehospital treatment, expedient evacuation to a surgical facility and swift management by critical care specialists and surgeons can be instrumental in reducing mortality and morbidity. The cornerstone of management is bedside intercostal chest drain insertion as a formal thoracotomy is seldom needed. Penetrating chest injuries can be managed by general surgeons with training in thoracotomy and repair of intra-thoracic structures with the key to success being a prompt and safe intercostals chest tube drainage.

Keywords: *Chest Injuries; Intercostal Chest Tube; Thoracotomy; Chest Tube Drainage*

Introduction

Traumas are the leading cause of death in the first four decades of life and are mostly caused by traffic accidents [1]. Thoracic injury accounts for significant mortality during military conflict [2]. Chest injury occurs in about 15% cases of war injuries in conventional warfare

[3]. In 20% of traumatized patients, chest trauma is observed isolated or accompanied with other injuries and approximately 25% of all deaths caused by trauma occur due to chest injuries and when it is associated with other lesions, produce a fatal outcome in an additional 50% of polytrauma patients, especially if the cardiovascular system is involved [4]. The insertion of an intercostal chest tube to drain Pneumothorax or Hemothorax is a simple surgical measure to treat most of the wartime thoracic injuries.

Materials and Methods

All patients transferred to our Specialist hospital with chest injuries in armed combat operations over a four-year period from May 2015 to Apr 2019 were included in this prospective non-randomized study. Patients who were received dead due to penetrating chest trauma were excluded from the study. Resuscitation was started at the Trauma Centre of our specialist hospital and continued in the operating room (OR), if required. All patients underwent a Chest Radiograph at the Trauma Centre and then shifted for a Computed Tomography (CT) Scan of the chest to the co-located CT Scan center if there was a need for the scan. Unstable patients were rushed to the OR. Management was done as per ATLS guidelines. Tube thoracostomy was done for patients with clinical evidence or imaging findings suggestive of Hemothorax or Pneumothorax. The insertion procedure was conducted in full aseptic conditions after taking informed consent from the patient or attendants as the case may be. Standard chest tubes of size 28 or 32 Fr were used for drainage and it was inserted in the 'Triangle of safety' by the attending Surgeon in all cases. The tube was connected to under water seal drainage system. If the blood aspirate from the Intercostal chest drain (ICD) was more than 1500 ml on inserting or more than 500ml per hour thereafter, Thoracotomy was done. All patients underwent debridement and repair for the entry and/or exit wounds. If the penetrating wounds breached the pleural cavity, thoracotomy was undertaken to examine and repair the pleura and/or underlying structures. Lung lacerations were repaired with Polypropylene or expanded Polytetrafluoroethylene (ePTFE) sutures. ICD was placed in all thoracotomies. Standard surgical and critical care management was administered to all patients after the definitive management and chest physiotherapy was encouraged for all patients including incentive spirometry.

Results

A total of 163 patients were included out of 1426 total casualties received at our hospital amounting to 11.86% of the total casualties. 22 casualties were brought in dead and were excluded from the study. There were 55 gun-shot wounds (Figure 1) and 108 grenade blast/splinter injuries. Out of 163 patients, 108 were transferred by Helicopter while the rest were brought by road. The time lag from time of injury till reaching the Trauma Centre of the Specialist hospital was 0.5 to 36 hours. Of the 163 patients who were treated, Intercostal chest drainage (ICD) in 41patients (25.15%), thoracotomy was required in 9 patients (5.52%), and only wound debridement and primary repair in 113 patients (69.32%) as depicted in Illustration 1. There two deaths in the operated group of patients (mortality rate = 1.23%). The age group of the patients was 22 to 45 years and all were male. There were 13 lung injuries and three diaphragmatic injuries. Chest radiographs were taken at the Trauma Centre for all patients and hemodynamically stable patients underwent a contrast enhanced chest tomography (CECT) chest before surgery while unstable patients were taken directly to the Operating Room (OR). Complications included Blast lung, atelectasis, broncho-pleural fistula, pneumonia and acute kidney injury. Injuries specific to ICD insertion were bronchopleural fistula (BPF) in two cases and peri-drain leak in five cases. All these cases resolved with conservative management. Pain associated with and likely due to ICD was experienced by 14 of 41 patients who were managed with opioid and non-opioid analegesia. Associated injuries were fractures of the ribs, clavicle, sternum, cervico-dorsal spine and bones of the upper limbs. There were associated abdominal injuries including liver, spleen, bladder and kidney injuries along with small and large bowel perforations. No lung resections were needed in our study group.

Discussion

Decompression of the thorax is a life-saving invasive measure of tension pneumothorax, trauma-related cardiopulmonary resuscitation or massive hemato-pneumothorax, which must be controlled by every ambulance and intensive care physician [5]. Thoracic de-

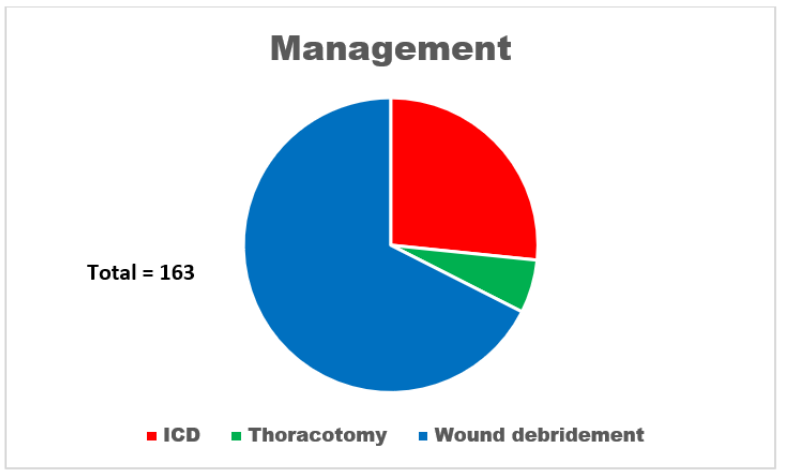

Figure 1: *Management modalities.*

compression can be achieved by invasive methods like tube thoracostomy, ICD insertion or thoracotomy. Needle thoracostomy is usually employed as a temporising measure until formal ICD or thoracotomy can be undertaken. Formal thoracotomy is seldom required in most chest trauma patients and ICD insertion/chest tube drainage remains the mainstay of management in this group of casualties. Kulshrestha., *et al*. showed that diagnosis made in 1,359 chest trauma patients was in 49% 1 - 2 rib fractures, 20% pneumothorax, 12% lung contusion and 6% thoracic vascular injury [6]. Most chest injuries can be treated with simple observation. Only 18.32% of patients required tube thoracostomy and 2.6% needed thoracotomy. In our study, 25.15% of our patients required tube thoracostomy and 5.52% required thoracotomy, which is comparable to available literature. However, the higher percentage of thoracotomies is likely due to the difference in mode of trauma as we experienced a larger number of cases of high velocity ballistic trauma.

There are two main sites of insertion that are commonly used for the positioning of chest drains: the ventral approach, on the second intercostal space on the mid-clavicular line (Monaldi approach); and the lateral approach at 4^{th} - 6^{th} intercostal space on the anterior or mid axillary line (Bulau approach) [7-9]. We prefer the Bulau approach in the setting of traumatic Pneumothorax and/ or Haemothorax, reserving the Monaldi approach for needle thoracostomy for tension pneumothorax. All the chest tube insertions were done using the Bulau approach in this study. There remains intense debate about the optimum size of drainage catheter and no large randomised trials directly comparing small and large bore tubes have been performed [9-12]. In the case of acute haemothorax, however, large bore tubes (28 - 30F minimum) continue to be recommended for their dual role of drainage of the thoracic cavity and assessment of continuing blood loss [13]. We used large bore tubes in all our cases as the indication was haemo and/or pneumothorax in all cases.

A South African study reviewed 1186 patients of penetrating chest trauma over a three-year period [14]. There were 124 (10.46%) gunshot wounds and 1062 stab wounds (89.54%). The authors concluded that penetrating thoracic trauma has a high mortality rate of 30% for subjects with stab wounds and 52% for those with gunshot wounds and gunshot wounds of the thorax remain more lethal than stab wounds. In our study, all 163 patients were ballistic injuries and no stab wounds. Afshar et al described a study from Iran and the underlying cause of the trauma was stabbing in 776 patients (93.7%), bullets in 49 patients (5.94%) and cow butting in 3 patients (0.36%) [15]. Both the above studies evaluating thoracic trauma in the urban setting experienced stab wounds as the cause in approximately 90%

of patients. Our study, however, had no stab wounds and the cause was bullets or other high velocity ballistic weapons in almost all cases. This outlines the hallmark difference in cause of penetrating thoracic injuries in the Civilian setting and during wartime.

Dominguez KM., *et al*. studied forty-one patients with chest trauma, 12 penetrating and 29 blunt, had 47 needled hemithoraces for evaluation; 85% of hemithoraces required tube thoracostomy after needle decompression of the chest [16]. They concluded that patients undergoing needle decompression who do not require placement of thoracostomy for clinical indications may be assessed using chest radiography, but thoracic computed tomography is more accurate. Air or blood on chest radiography or computed tomography of the chest is an indication for tube thoracostomy. In our study, three needle thoracostomies were done for pneumothorax +/- hemothorax presenting with respiratory compromise and radiological evidence of mediastinal shift. All of them required tube thoracostomy to drain blood in the pleural cavity. This is possibly due to the different scenario of trauma with bullet and splinter injuries dominating in our study which probably leads to high velocity trauma and hemo-pneumothorax in most cases where needle thoracostomy does not suffice for the treatment and a tube thoracostomy has to be resorted to. Nonetheless, there is a definite role for needle decompression of the chest as a life saving measure and, in some cases, can provide definitive management.

Hyacinthe., *et al*. studied 237 lung fields in 119 adult patients with thoracic trauma in the Emergency department and concluded that thoracic ultrasonography as a bedside diagnostic modality is a better diagnostic test than clinical examination and chest X-Ray in comparison with CT scanning when evaluating supine chest trauma patients in the emergency setting, particularly for diagnosing pneumothoraces and lung contusions [17]. We used clinical examination and chest X-Ray in all patients and CT Scan in hemodynamically stable patients when the extent of thoracic injuries needed to be delineated prior to surgery or there was a dilemma post tube thoracostomy whether thoracotomy would be beneficial or not. It was felt that Ultrasonography being an operator dependant and time-consuming study stands inferior to CT Scan as the optimum imaging modality, specially for lung lacerations, contusions and hematomas. Strumwasser A., *et al*. investigated the role of Thoracic CT in predicting surgery vs non-operative management in 212 cases of penetrating chest trauma over a 10-year period [18]. They concluded that thoracic CT had a negative predictive value of 99% in triaging hemodynamically normal patients with penetrating chest trauma. Screening thoracic CT successfully excludes surgery in patients with non-significant radiologic findings. CT chest was done for 114 of our 163 patients and Thoracotomy/ICD insertion was undertaken for all cases suggestive of significant hemo-pneumothorax and/or lung lacerations/ongoing bleeding in the chest cavity. CT predicted no definitive intervention in 71 of the 114 patients undergoing CT and all but one cases required intervention. Therefore, the negative predictive value of CT in our study was 98.59% which is comparable to available literature and goes on to suggest that CT chest is a very sensitive modality to assess thoracic trauma and prevent negative thoracotomies which carry significant morbidity.

John M., *et al*. addressed the question whether the trocar technique is comparable to blunt dissection in terms of rate of tube malposition or complications from 258 studies in the published literature [19]. They concluded that the trocar technique for chest tube placement should be avoided in adult patients as it is associated with a higher incidence of malposition and complications. The blunt dissection technique with digital exploration of the pleural cavity prior to chest tube placement is the safest technique and should be considered standard practice. In our study, we did not use trocar chest tubes owing to the past experience of complications and all tubes were inserted by the blunt technique.

This aim of our study is to delineate the diversity of thoracic trauma sustained in active combat operations and war like scenarios in India. It also reinstates the fact that most thoracic trauma can be managed with tube thoracostomies and formal thoracotomy is seldom needed for saving lives in the Trauma setting. Almost all chest injuries can be managed at a non-Cardiothoracic Surgery Centre provided that good Trauma/General Surgeons are available as most thoracic injury patients require minor surgical interventions and Chest tube insertions with only about 2 to 6% patient requiring thoracotomy which can be performed by General and trauma surgeons. This is in the light that most thoracic trauma leading to injury to cardiac structures or major vessels do not survive to reach the trauma centre specially in the war like scenarios where extracting the patient becomes difficult and time consuming due to continuing action at the scene of the injury.

Conclusion

Chest injuries suffered in a hostile environment pose a challenge to the Trauma team due to the high velocity and ballistic injuries which frequently lead to hemothorax, pneumothorax, lung lacerations, contusions and injury to major vessels and heart. It renders high mortality but the patients who reach the trauma centre can be successfully managed with prompt resuscitation, early imaging and tube thoracostomies in most cases. Safe and early intercostal chest tube drainage is crucial for a positive outcome and all trauma team members should be well trained to perform an emergency bed-side tube thoracostomy. Expedient trauma surgical protocols and robust damage control principles are imperative to a favourable outcome in patients suffering chest injuries in active combat operations.

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