PREDICTING THE OUTCOME OF CHEST INJURY PATIENTS BY THORAX TRAUMA SEVERITY SCORE AT AIIMS JODHPUR: AN OBSERVATIONAL STUDY

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DECLARATION

I hereby declare that this thesis entitled **"Predicting the outcome of chest injury patients by Thorax Trauma Severity Score at AIIMS Jodhpur: An observational study"** is a bonafide and original research work carried out in partial fulfillment of the requirements for the degree of Masters of Surgery in General Surgery under supervision and guidance, in the Department of General Surgery, All India Institute of Medical Sciences, Jodhpur.

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CERTIFICATE

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CONTENTS

LIST OF ABBREVIATIONS

TTSS	Thorax Trauma Severity Score
ABG	Arterial Blood Gas
P/F	PaO2/FiO2
HLOS	Hospital Length Of Stay
ICU LOS	Intensive Care Unit Length Of Stay
IQR	Interquartile Range
ATLS	Advanced Trauma Life Support
ABCD	Airway, Breathing, Circulation, Disability
CXR	Chest X-Ray
e-FAST	Extended Focussed Assessment In Trauma
PCS	Pulmonary Contusion Score
CVS	Cardiovascular
RTI	Road Traffic Injury
ICD	Intercostal Drain

PEA	Pulseless Electrical Activity
ROSC	Return Of Spontaneous Circulation
ECG	Echocardiography
BPM	Beats Per Minute
MAP	Mean Arterial Pressure
NG tube	Nasogastric tube
ED	Emergency Department
CT	Computed Tomography
VATS	Video-Assisted Thoracoscopic Surgery
GCS	Glasgow Coma Scale
RTS	Revised Trauma Score
ISS	Injury Severity Score
TRISS	Trauma and Injury Severity Score
AIS	Abbreviated Injury Score
SBP	Systolic Blood Pressure

RR	Respiratory Rate
PTS	Paediatrics Trauma Score
ARDS	Acute Respiratory Distress Syndrome
ROC	Receiver Operating Characteristic Curve
CI	Confidence Interval
RFS	Rib Fracture Score
CTS	Chest Trauma Score
RS	Rib Score
BTI	Blunt Thoracic Injury
MV	Mechanical Ventilation
BAL	Bronchoalveolar Lavage
NPRS	Numerical Pain Rating Score
SD	Standard Deviation
AUC	Area Under Curve
DAI	Diffuse Axonal Injury

SUMMARY

Background: Thoracic trauma accounts for the increased burden of mortality and morbidity in the Indian scenario. Approximately, 16000 deaths in India alone are as a result of thoracic trauma(1). It includes almost 25% of mortality worldwide. The majority of chest injuries are caused by blunt mechanisms. Hence accurate evaluation of injury is needed prior to a proper evaluation and intensive management from the beginning. So various trauma scoring systems were developed to determine the severity of the traumatic injury. A dedicated scoring system for chest trauma was needed. Hence TTSS was developed by Pape et al. in 2000. The TTSS scoring system ranges from 0-25. TTSS includes the parameters like ABG (P/F), rib fractures, lung contusion, number of rib fractures, and age. Hence my study aims at using this validated and well-established scoring system in predicting the morbidity and mortality in chest trauma patients in our hospital, situated in Rajasthan. Also, no such quantification has prior been done in our hospital. It would help our hospital to set up proper treatment protocols and to prognosticate the at-risk person for developing complications.

Methods: A prospective observational study is done among the Indian patients of varied age groups excluding the paediatric population, from January 2020 to November 2021. TTSS was applied at admission and is correlated with outcomes, which are measured in terms of HLOS and ICU LOS, return to normal activity within 30 days of discharge, respiratory complications, i.e. pneumonia, need for mechanical ventilation, mortality. SPSS version-23 software was used to analyze the data.

Objectives: Primary objective:

· To determine the duration of Hospital length of stay (HLOS) and ICU length of stay (ICU LOS) in patients with a chest injury.

Secondary objective:

To determine the proportion of patients with chest injury who return to normal activity at 30 days of discharge.

To determine the proportion of patients with chest injury who develop pneumonia.

To determine the proportion of patients with chest injury requiring mechanical ventilation during the hospital stay.

To determine the mortality rate among the patients with a chest injury in our hospital

Result:

100 patients with thoracic trauma, aged (38 +/- 14) years, were included in the study. The majority of the injuries were due to road traffic accidents (68%), followed by falls from height (16%). The average TTSS was 8. The patients were divided into two groups as per earlier studies, group 1 with TTSS less than equal to 7 and group 2 with TTSS more than 7. The median hospital length of stay was 6.00 days with an interquartile range of 4-8 days for patients under group 1. The median hospital length of stay for patients under group 2 was 7.00 with an IQR of 3.5-11 days. In group 1, a total of 8 patients required ICU stay of which the median ICU LOS was 5 days with an IQR of 3-10.75 days. In group 2, a total of 12 patients required ICU stay of which the median ICU LOS was 6.5 days with an IQR of 2.5-13. HLOS and ICU LOS were analyzed separately with TTSS using the Mann-Whitney U test and the P-value was 0.150 and 0.739 respectively which is statistically non-significant. 63 patients had returned to normal activity within 30 days of discharge and when statistically compared using the chi-square test, P-value came to be 0.000. TTSS was able to better predict patients developing pneumonia and the requirement of mechanical ventilation with a P-value of 0.000 and 0.009 respectively using the chi-square test, which is statistically significant. 17 patients required mechanical ventilation, which was analyzed using the chi-square test and the P-value came out to be 0.009 which is statistically significant. 11% had mortality. The area under the ROC curve for predicting the mortality with TTSS was 0.831 which is fairly good. Applying Youden's index, it was found that TTSS of more than equal to 9.50 was able to better predict mortality with a sensitivity of 90.9% and specificity of 78.7%.

Conclusion:

TTSS seems to be an appropriate and feasible tool to predict mortality, development of pneumonia, need for mechanical ventilation and return to normal activity within 30 days of discharge. TTSS is not effective in predicting hospital length of stay and ICU length of stay. It's probably due to injuries, other than the thoracic trauma affecting the hospital and ICU stay.

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INTRODUCTION

INTRODUCTION

Torso trauma is one of the most common mechanisms of injury leading to morbidity and mortality. One part of torso trauma is chest injury. It is any physical injury to the chest including the chest wall, ribs, heart, and lungs. Chest injury accounts for 25 % of all deaths from traumatic injury. Thoracic trauma is the third most leading cause of mortality only next to the head and spinal injury. Approximately, 16000 deaths in India alone are as a result of thoracic trauma(1). The majority of chest injuries are caused by blunt mechanisms. It accounts for a great fraction of mortality and morbidity. Various trauma scoring systems were developed to determine the severity of the traumatic injury. An accurate evaluation of the injury is needed to determine the patient's prognosis. Hence scoring systems have been developed.

Advanced Trauma Life Support protocols are used for the initial stabilization, management, and assessment of any trauma patient. The ATLS protocol includes assessment and stabilization of a patient's airway, breathing, circulation, and disability in a sequential manner (ABCDs). Initial CXR, pelvic X-ray, and e-FAST are included in the initial assessment of the patient as the radiological adjuncts.

Earlier the scoring systems were based on the trauma as a whole (like TRISS, ISS, and RTS). However, they were not dedicated to chest trauma individually. Hence the need for a dedicated scoring system for chest trauma was mooted(1). Despite TRISS being most commonly used to predict the outcome in a trauma patient, it is not specific to chest trauma patients as it underestimates the chest trauma severity. To overcome these shortcomings Pape et al. developed the thorax trauma scoring system (TTSS) which includes both the anatomical and the functional parameters of thorax trauma(1). TTSS includes the parameters like ABG (P/F), rib fractures, lung contusion, number of rib fractures, and age. The TTSS scoring system ranges from 0-25. Other scoring systems being used are Pulmonary Contusion Score (PCS) and CT-dependent Wagner Score. All these parameters give a functional and anatomical basis for quantifying the degree of rib fracture complications. Also, we do not know about the proportion of patients in this western belt of India, mainly Rajasthan, who had mortality, morbidity, and other respiratory complications following chest trauma. Hence this study aims at using this validated and well-established scoring system in predicting the morbidity and mortality in chest trauma patients in our hospital, situated at Rajasthan.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Trauma is ranked as the third most common cause of death worldwide amongst all age groups just after cardiovascular (CVS) and cancer-related causes respectively. The middle age group in the first four decades is the most vulnerable population(1). Thoracic trauma accounts for a majority of this mortality i.e. one out of four deaths is attributed to thoracic-related trauma(1). 80%-90% of severe thoracic trauma patients have injuries involving other systems(2). Thoracic injuries are associated with a mortality of 30%–40%. 60% of poly-trauma patients would have thoracic trauma and it accounts for 20%-25% of mortality(3,4).

Anatomy of thorax

The term thorax ranges from the neck and abdomen enclosed by ribs, sternum, and vertebrae radially to the thoracic inlet superiorly and the diaphragm inferiorly. The thorax generates the negative inspiratory force that initiates ventilation and the positive expiratory force needed for vocalization. The major thoracic structures include the heart and lungs; the organ needed for circulation and ventilation respectively. The chest wall comprises the ribs, sternum, and vertebrae. Other structures present are the diaphragm, trachea, esophagus, and the great vessels. The parietal pleura i.e. the internal lining of the chest wall is separated from the visceral pleura i.e. the outer lining of the lung, by pleural fluid. The visceral pleura covers the lung and separates the lobes from one another by entering into the fissures of the lung. The mediastinum separates the right and left pleural spaces. The thorax is a bony cage that is covered by three groups of muscles:

- The primary muscle of respiration: the intercostal muscles and the diaphragm
- Secondary muscle of respiration
- Muscle attaching the upper extremity to the body

The intercostal muscles include the external, internal, and innermost muscles. The intercoastal bundles travel at the lower edge of each rib between the internal and the innermost intercostal muscles.

The secondary muscles of respiration consist of the sternocleidomastoid, serratus posterior, and levator costarum. They help in forced expiration or inspiration.

The muscles attaching the upper extremity to the body include pectoralis major and minor muscles, trapezius, latissimus dorsi. Deep muscles include the serratus anterior and posterior, the levators, and the rhomboid major and minor.

The bony thorax consists of 12 ribs. The 11th and 12th are the floating ribs and are not attached directly to the sternum. Ribs 1 to 5 are directly attached to the sternum through costal cartilage and the lower 6 to 10 ribs coalesce into the costal arch. The manubrium joins the body of the sternum at the angle of Louis which corresponds to the anterior aspect of the junction of the second rib.

The trachea in adults is 12 cm long with 18-22 cartilaginous rings. It begins at 1.5 cm below the vocal cords. The lungs are divided into 5 lobes and multiple segments in each lobe. The right lung has 3 fissures and the left lung has 2 fissures. There are anatomically separate arterial, venous and bronchial supplies for each bronchopulmonary segment. The lung has a dual blood supply, hence minimal chance of having infarction. The mediastinum includes the thoracic inlet superiorly, the diaphragm inferiorly, the sternum anteriorly, the vertebral column posteriorly, and the parietal pleura medially. The anterosuperior compartment of the mediastinum includes the thymus gland. The middle mediastinum contains the heart, pericardium, great vessels, trachea, and bronchi. It also contains phrenic, vagus, and recurrent laryngeal nerves. The posterior mediastinum lies between the pericardium and trachea anteriorly and the vertebral column and paravertebral spaces posteriorly. It contains the esophagus, descending aorta, azygous, and Hemi-azygous veins, thoracic duct, sympathetic chain, and lymph nodes.

Figure 1: Surface view of the chest wall

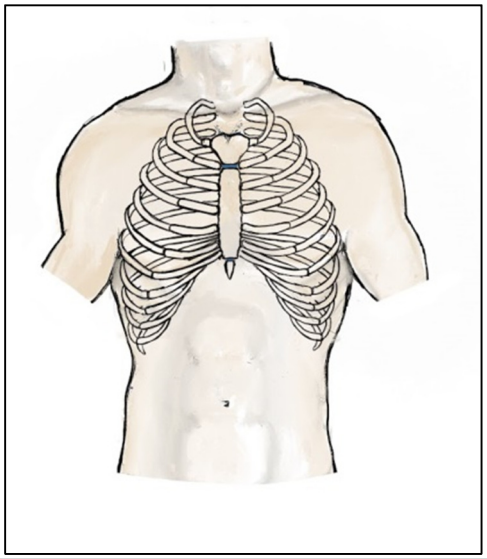


Figure 2: Anatomy of the bony thorax

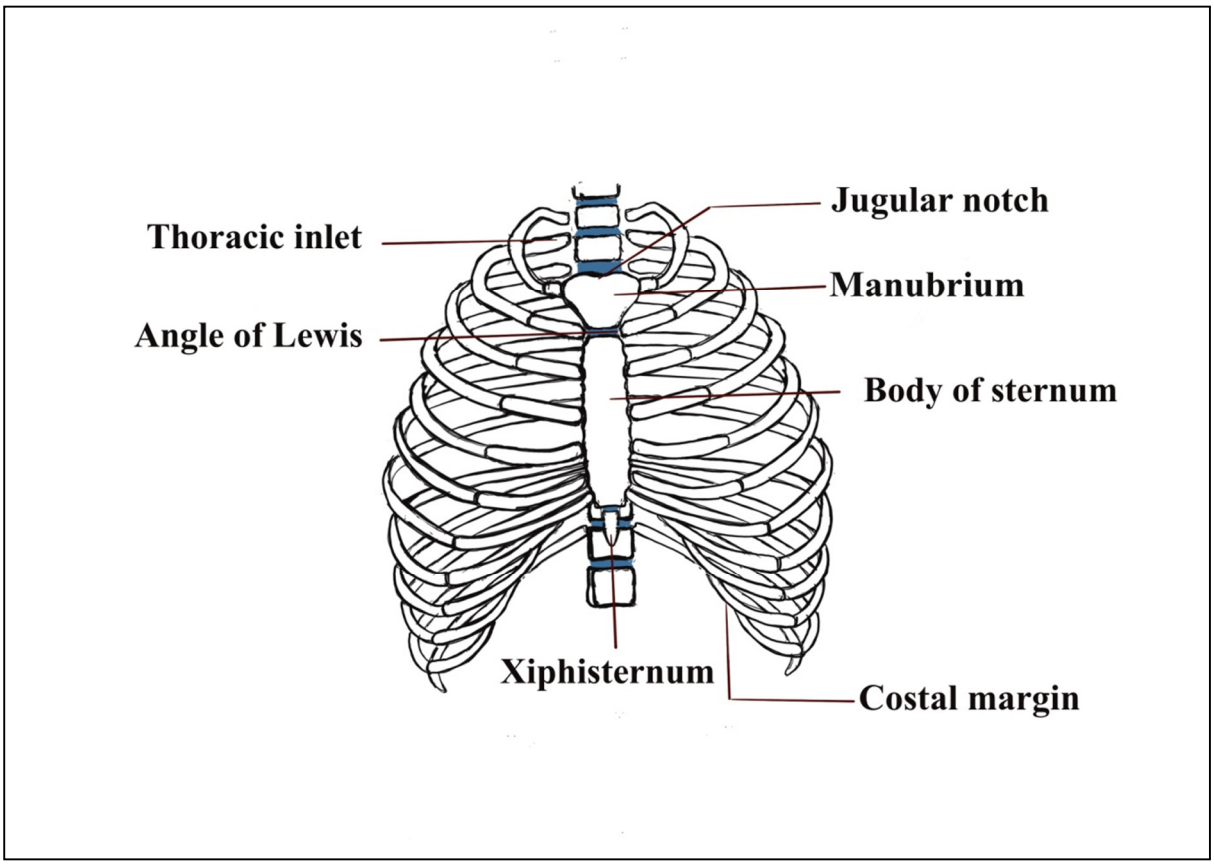
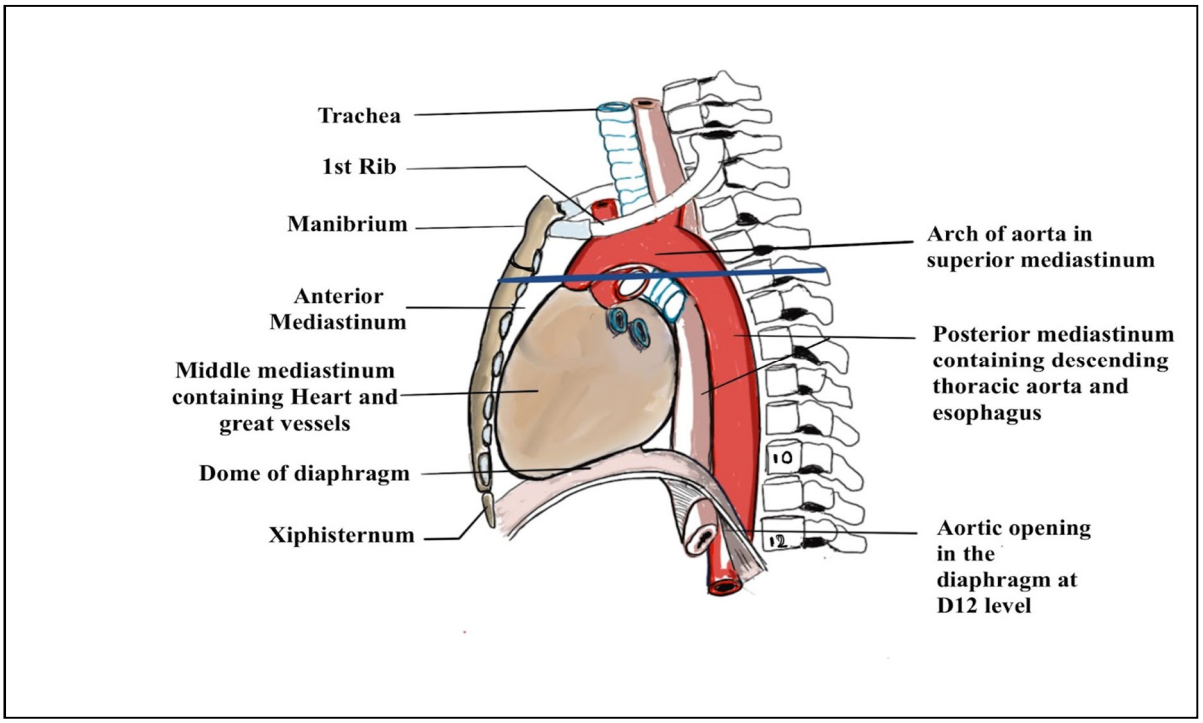


Figure 3: Anatomy of the mediastinum



Trauma is classified into two major types: penetrating and blunt trauma. Stab and firearm injuries are examples of penetrating injury which disrupts tissue integrity. Fall from height, RTI, occupational injuries are all examples of blunt trauma(1). Blunt trauma accounts for 70% of thoracic trauma(5). 15% of all traumas are blunt chest trauma(6,7).

Common mechanisms resulting in blunt trauma are

1. Motor Vehicle Crashes or Road Traffic Injuries(RTI)
    - Head or rear-end collision
    - Motorcycle or bicycle crashes
    - Pedestrian struck by a vehicle
    - Lateral impact
2. Falls
    - Fall from height
    - Falling downstairs
    - Fall while walking or bathing (mostly in old age)
3. Others
    - Falling objects e.g. fall of a heavy object on a person
    - Sports injuries
    - Animal injuries
    - Occupational hazards

The other major mechanism causing injuries is penetrating traumas. These are due to any sharp object entering the cavity and sometimes may exit, resulting in damage to the traversed path. Superadded infection over these open wounds can add to the morbidity and mortality of the patient as well. The severity and the organ affected depend upon the site of injury, the velocity of the sharp object, the direction of the traversed path.

The major mechanisms of penetrating trauma are:

1. Stab injury
2. Gunshot injury
    - High energy gunshot injury
    - Low energy gunshot injury

Stab injuries are low-energy injuries. These cause laceration or tearing of tissues in the path of penetration. In contrast, high-velocity gunshot injury causes damage at the tract traversed

as well as to the surrounding tissue due to dissipation of the kinetic energy, resulting in temporary cavitations and also multiple injuries due to fragmentation of the bullet particle after hitting any hard surface like bone.

Stabs at the lower thoracic region need special attention as there might be simultaneous abdominal visceral injuries along with diaphragmatic injury. The diaphragmatic injuries are usually detected later as they are mostly silent on presentation and need a high degree of suspicion.

Blast injury

These are more dangerous injuries causing multi-system injuries. The injuries occur via a combination of different mechanisms of injury, including penetrating injury as a result of projectile fragments; blunt injuries from the direct blow as patients are thrown out or struck by projectiles. Patients nearer to the blast site usually have additional injuries like rupture of the tympanic membrane, injury to lungs and bowel as a result of shock waves. These injuries are usually missed during the initial assessment. Most of these patients need critical care.

Initial assessment and evaluation

Initial assessment consists of the primary survey with the resuscitation of vital functions, a detailed secondary survey, and definitive care according to ATLS protocol. The goal is to correct and prevent hypoxia (the secondary insult) which itself is the most serious consequence of thoracic trauma. The causes of hypoxia in chest trauma patients are:

- Pulmonary contusion
- Pulmonary hematoma
- Alveolar collapse
- Tension/open pneumothorax

Hypoxia can lead to metabolic acidosis. Hypercarbia is the major cause of respiratory acidosis. Injuries that are most life-threatening are treated first and as quickly as possible.

The primary survey should begin with an airway assessment. It is necessary to look for any evidence of air hunger. The oropharynx needs to be assessed to look for any foreign body causing airway compromise. Any stridor, voice change, crepitus over the anterior neck and chest wall is to be noticed. The high degree of suspicion for any tracheobronchial injury should be there in mind. Here incomplete expansion of lung and continued air leak after ICD

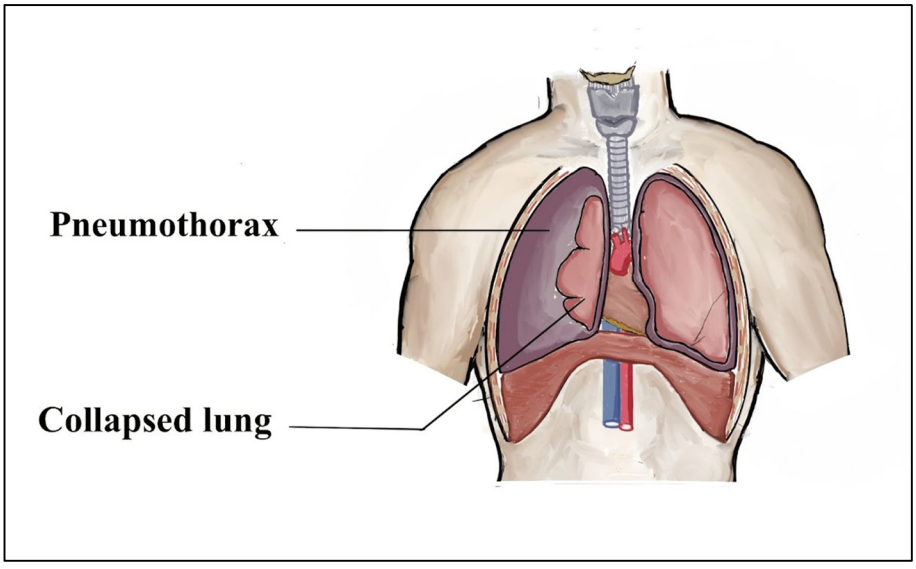
placement suggest trachea-bronchial injury. The air leak in ICD can be graded according to the Cerfolio classification.

After airway stabilization, comes the breathing part management. This may require the temporary release of the front of the cervical collar. Chest wall movement is assessed. Signs of chest injury and/or hypoxia are to be noticed which include increased respiratory rate and alterations in the patient's breathing pattern. Cyanosis is a late finding of hypoxia. Tension pneumothorax, open pneumothorax, and massive hemothorax are the major thoracic injuries affecting breathing and are life-threatening when not dealt with immediately.

Tension pneumothorax is characterized by:

- Chest pain
- Tachypnea
- Air hunger
- Tachycardia, hypotension
- Respiratory distress
- Unilateral absence of breath sounds
- Tracheal deviation away from the side of injury
- Elevated hemithorax without respiratory involvement
- Neck vein distension
- Cyanosis- a late manifestation
-

Figure 4: Tension Pneumothorax

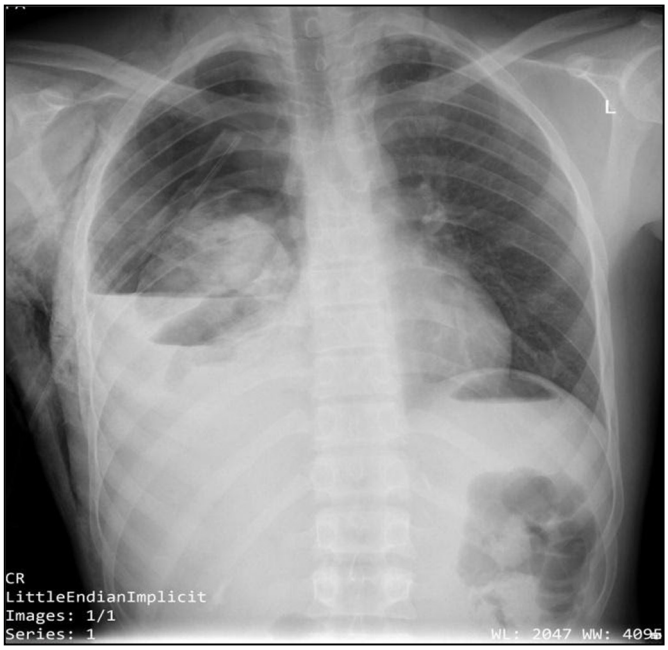


The management of tension pneumothorax is needle decompression with an 8 cm long needle. It has a 90% chance of entering the pleura.

Open pneumothorax is also known as a sucking chest wound. The management of open pneumothorax includes the use of a large sterile dressing to overlap the wound edges. Any occlusive dressing to occlude the wound, preventing the air from entering is used. These dressings are taped on three sides to provide a flutter valve effect.

Massive hemothorax means the accumulation of more than 1500 ml of blood in one side of the chest. It can lead to hypotension and shock(8).

Figure 5: Massive hemothorax



After stabilizing the breathing part, comes the circulation. Major thoracic injuries that affect the circulation are massive hemothorax, cardiac tamponade, and traumatic circulatory arrest. Tension pneumothorax, cardiac tamponade, or profound hypovolemia can lead to Pulseless Electrical Activity (PEA). PEA arrest can be the only manifestation of severe blunt thoracic trauma leading to rupture of the atria or the ventricles.

Causes of PEA include:

- Hypovolemia
- Acidosis
- Hypoxia
- Hypoglycemia

- Hypokalemia/hyperkalemia
- Hypothermia
- Toxins
- Tension pneumothorax
- Cardiac tamponade
- Coronary or pulmonary thrombosis

Cardiac tamponade is the compression of the heart by fluid accumulation in the pericardial sac. This results in decreased cardiac output due to diminished inflow to the heart as the pericardium is a non-expansile fixed fibrous structure. Cardiac tamponade is more common after penetrating trauma as compared to blunt trauma. It can develop slowly or rapidly requiring a less urgent evaluation or a rapid diagnosis and treatment respectively. The clinical triad of cardiac tamponade includes muffled heart sounds, hypotension, and distended veins. Kussmaul's sign is a paradoxical venous pressure abnormality associated with cardiac tamponade. FAST is 90-95% accurate in identifying pericardial fluid. Emergency thoracotomy or sternotomy should be done in cases where pericardial fluid or tamponade is identified.

Traumatic circulatory arrest includes PEA (Pulseless Electrical Activity), ventricular fibrillation, and asystole (true cardiac arrest). Causes of traumatic circulatory arrest are:

- Severe hypoxia
- Profound hypovolemia
- Tension pneumothorax
- Cardiac herniation
- Cardiac tamponade
- Severe myocardial contusion

In case of traumatic circulatory arrest closed, CPR is started simultaneously with airway, breathing, and circulation (ABC) management. A resuscitative thoracotomy may be required if there is no return of spontaneous circulation (ROSC).

Secondary survey

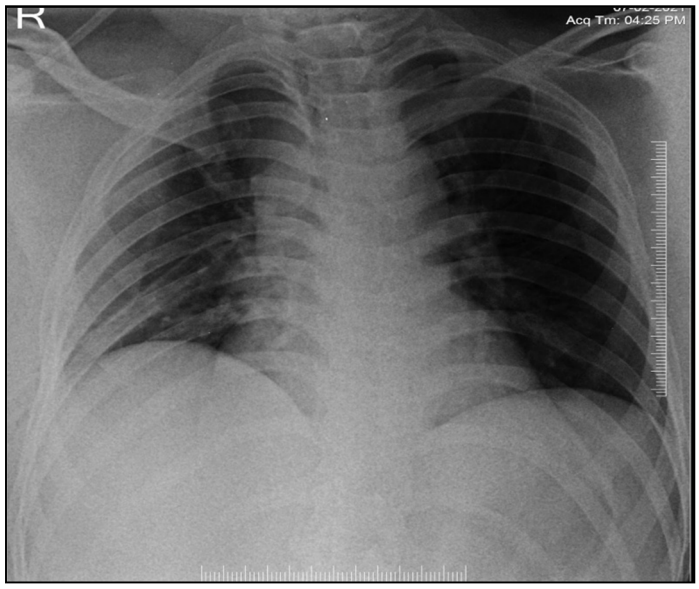
Secondary survey of thoracic trauma patients involves in-depth physical examination, ongoing ECG and pulse oximetry monitoring, arterial blood gas (ABG) measurements, upright chest X-ray, and contrast CT scan. Here potentially life-threatening injuries are

examined unlike in primary surveys where immediately life-threatening injuries are examined and treated. The 8 potentially lethal life-threatening injuries are identified and managed in the secondary survey:

- Simple pneumothorax
- Hemothorax
- Pulmonary contusion
- Flail chest
- Traumatic aortic disruption
- Blunt esophageal rupture
- Blunt cardiac injury

Simple pneumothorax: It means air entering in between parietal and visceral pleura. Causes can be due to both penetrating and blunt trauma. The most common cause resulting in air leaks is lung laceration following blunt trauma. There will be decreased breath sounds on the ipsilateral affected side. Upright chest X-ray aids in the diagnosis. Treatment includes placement of ICD at the 5th intercostal space, just anterior to the mid-axillary line at the triangle of safety. In the case of subclinical pneumothorax or occult pneumothorax, the safest approach is to place an ICD before tension pneumothorax develops.

Figure 6: Simple pneumothorax



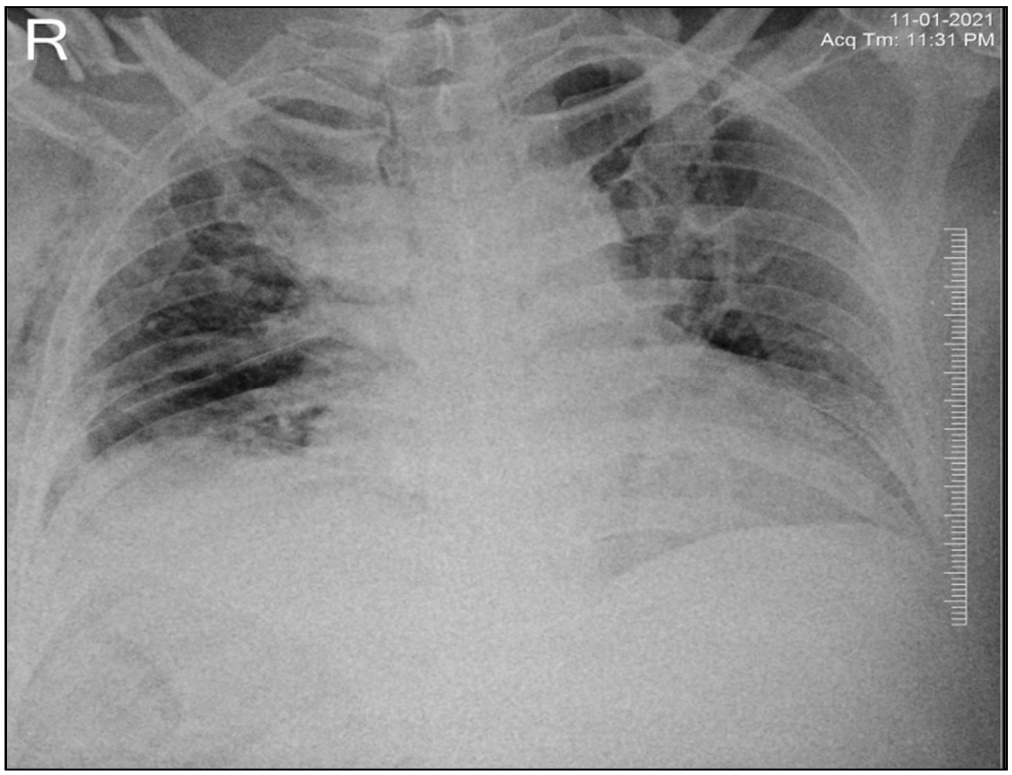
Hemothorax: Less than 1500ml of blood accumulates in the pleural cavity. The causes are:

- Laceration to lung
- Injury to great vessels
- Injury to the intercostal vessel or internal mammary artery either from penetrating or blunt trauma injury

Treatment includes placement of 28-32 Fr chest tube (ICD). Post insertion of chest tube X-ray is to be done to check the position of the chest tube.

Flail chest and pulmonary contusion: Flail chest occurs when two or more than two adjacent ribs fracture in two or more places. It can also occur when there is a costochondral separation of a single rib from the thorax. Pulmonary contusion is a bruise of the lung that can occur in a single lobe or at multiple lobes. Children can have an underlying pulmonary contusion without having any overlying rib fracture. Children have a limited pulmonary reserve which can predispose them to early respiratory failure in older patients. Patients with significant hypoxia (i.e., Pao2<60mmHg or SaO2<90%) on room air may require intubation. Definitive treatment of flail chest and pulmonary contusion involves adequate oxygenation, adequate fluid resuscitation, and analgesia. At times they may need intubation. They might also need rib fixation.

Figure 7: Flail chest



Blunt cardiac injury: It can result in:

- Myocardial muscle contusion
- Coronary artery dissection
- Cardiac chamber rupture
- Cardiac tamponade
- Valvular disruption

Patients can present with hypotension, dysrhythmia, and/or wall abnormalities on echocardiography. 24 hour ECG monitoring should be done on these patients to monitor for any dysrhythmia.

Traumatic aortic disruption: It results from incomplete or complete laceration near the ligamentum arteriosum of the aorta. Blood escapes into the mediastinum and all survivors who are able to reach the hospital usually have contained hematoma. It is usually life-threatening and the patient usually dies before arriving at the emergency. The radiologic signs of blunt aortic injury include:

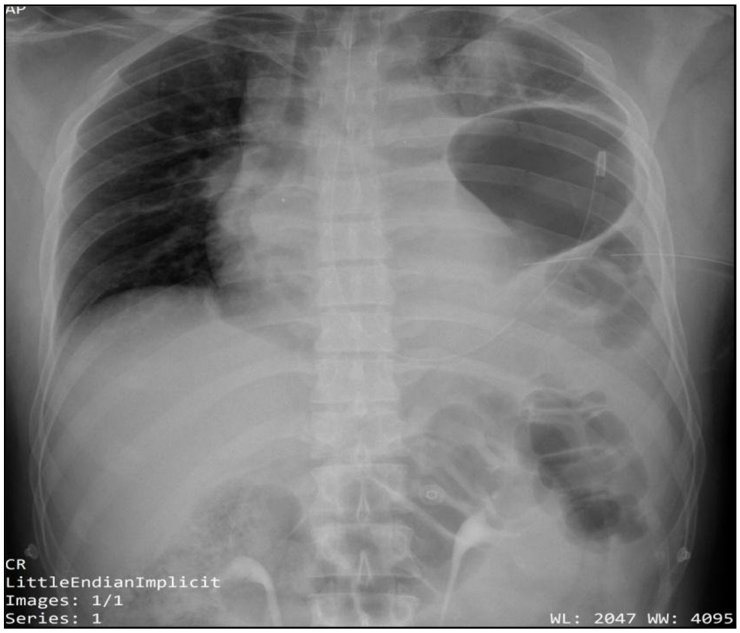
- Widened mediastinum
- Obliteration of aortic knob
- Depression of left mediastinum bronchus
- Rightward deviation of the trachea
- Deviation of esophagus towards the right
- Elevation of right mediastinum bronchus
- Presence of pleural cap
- Widened paratracheal stripe
- Left hemothorax

The different modalities of investigations available are helical contrast-enhanced computed tomography of the chest, transesophageal echocardiography. The main goal of treatment aims to maintain the heart rate less than 80 BPM (beats per minute) and MAP (mean arterial pressure) of less than 60-70mmHg.

Traumatic diaphragmatic injury: These are more common over the left side. The liver protects the right diaphragm from injury. Blunt trauma produces larger radial tears that lead to herniation in contrast to penetrating trauma which produces small perforations that can remain asymptomatic for years. On placing an NG tube, it lies at the left hemithorax. The

appearance of peritoneal fluid lavage in the ICD bag also confirms the diagnosis. Treatment involves direct repair of the tear.

Figure 8: Traumatic diaphragmatic herniation



Blunt esophageal rupture: Esophageal trauma mostly occurs after penetrating injury. Here leakage of esophageal contents into the mediastinum occurs resulting in mediastinitis and empyema. The clinical picture is similar to post-emetic esophageal rupture. Typically patients present with left pneumothorax or hemothorax without having a rib fracture. The patient would have pain or shock out of proportion to the apparent injury. Also on ICD, particulate matter drains out. In contrast studies, air can be found at mediastinum. The above features should raise suspicion of esophageal injury. Treatment involves wide drainage of the pleural space and mediastinum with the direct repair of the injury within a few hours of injury.

Chest injuries can also have other different manifestations. During the secondary survey, the trauma team should also look at these injuries:

- Subcutaneous emphysema
- Crushing injury or traumatic asphyxia
- Rib, sternum and scapula fractures

Subcutaneous emphysema: It can result from injury to the airway. Injury to lung, or blast injury. If these patients are planned for positive pressure ventilation, then ICD should be inserted to prevent the development of tension pneumothorax.

Figure 9: Subcutaneous emphysema

Crushing injury to the chest: This may lead to temporary compression of the superior vena cava. Mostly occurs after Road Traffic Injury (RTI).

Rib, sternum, and scapular fracture: It results in pain on motion resulting in splinting of thorax, impairing the ventilation, oxygenation, and coughing. The fracture of the scapula, first and second rib is suggestive of a high magnitude of trauma. Sternal fractures may accompany underlying pulmonary contusion. Posterior displacement of the sternoclavicular joint may result in mediastinal compression. Here immediate reduction is required.

The middle ribs are most commonly affected in blunt trauma(2–5). Even minor trauma can result in rib fracture in older age as a result of osteopenia. These populations can have delayed development of clinical hemothorax, hence need close observation and follow up. Left lower rib fracture should raise the suspicion of splenic injury. Treatment includes relief of pain to enable adequate ventilation via intercoastal blockage, epidural analgesia, and systemic analgesics.

About 10% of thoracic injury patients die on the spot even before reaching any medical service and another 5% die within an hour of reaching the hospital. The physiologic consequences of thoracic trauma are hypoxia, hypercarbia, and acidosis. The causes of death in blunt thoracic trauma are attributed to either pulmonary or non-pulmonary complications. Six life-threatening conditions are present, which need to be immediately dealt with in the primary survey i.e.airway obstruction, tension pneumothorax, open pneumothorax, massive hemothorax, flail chest, pericardial tamponade. The primary survey includes CXR and e-FAST as adjuncts that can diagnose all of the above conditions. Chest CT is needed in patients with positive chest findings i.e. flail chest, multiple rib fracture, respiratory distress, and unstable vitals in the secondary survey(9).

Blunt thoracic trauma includes many organs, tissues, and systems thus a multidisciplinary approach is needed for management. Only 10% or less of blunt chest trauma patients require surgical treatment, and the remaining patients can be treated conservatively such as with airway assessment, oxygen support, ICD, volume resuscitation, pulmonary toilet, and adequate analgesia(7,9,10). The indications for emergent thoracotomy include massive hemothorax of more than 1500 ml of blood immediately on putting tube thoracostomy, persistent bleeding in ICD with more than 200 ml/hour for more than 3 hours(9).

In the setting of blunt trauma, emergency thoracotomy rarely results in successful resuscitation. The patients most likely to benefit from emergency thoracotomy after blunt trauma are:

- Patients who lost vital signs in the ED and appear to have no obvious non-survival injury (eg. Severe head trauma, severe multi-systemic injuries)
- Patients with cardiac tamponade were rapidly diagnosed by ultrasound, with no other non-survival injuries.

Emergency thoracotomy in blunt trauma patients appears to be futile in the following circumstances:

- The patient required over 15 minutes of prehospital CPR
- The patient is apneic, pulseless, and has no rhythm on a cardiac monitor in the field
- The patient has massive, non-survival injuries

A significant number of thoracic trauma patients present with hemothorax. These patients can be managed with simple Intercostal Drainage (ICD). For ICD there are two schools of thought i.e. role of low-pressure suction attached to the ICD and no role of suction.

Connecting the ICD to the suction drain (continuous low-pressure suction drain) helps in improving the apposition of the pleura to the chest wall; however, this negative suction can result in maintenance of the flow of air through an alveolar-pleural fistula, resulting in its persistence(2). The placement of suction is superior with respect to reducing the incidence of pneumothorax(2). Clotted hemothorax occurs once these chest tubes fail to drain the blood. This retained hemothorax may become infected and lead to empyema formation(3). Diagnosis of this clotted hemothorax is made with a CT scan. Surgery is needed to manage this clotted hemothorax(4). If clot evacuation is delayed beyond time a formal thoracotomy or VATS decortications will be needed as a result of the inflammatory reaction in the pleura, which in turn would increase the hospital stay and cost.

The indications for Video-Assisted Thoracoscopic Surgery (VATS) are retained hemothorax after ICD for 3-7 days and pneumothorax with persistent air leak for 3 days after ICD placement. Age is an important aspect in thoracic trauma patients. Paediatrics patients may not have a rib fracture due to bone elasticity but may have a significant underlying trauma; in contrast, the elderly would have a rib fracture most of the time.

Many risk factors affect the outcomes like patient's age, the presence of other bony fractures and neurosurgical injuries, mechanical ventilation, pre-existing chronic lung diseases, co-existing head injury, hypotension and extrathoracic organ injury(11–14), low Glasgow coma scale (GCS) score. Chest traumas are in an increasing trend and the mortality and morbidity are mostly due to delayed pulmonary complications(15). Classically, it is seen that three or more than three rib fractures including the first rib are associated with increased mortality and morbidity.

It is to be noted that the preventable in-hospital mortality rate in trauma patients is between 4%-60% worldwide(16). So early accurate grading of chest injury severity is critical for the clinical outcome of multiple trauma patients. Hence we need some scoring systems to predict the outcome of patients following trauma, so that prompt and aggressive management can be done early to the one needed(2). It would also help us to correct our treatment approach by predicting intensive care needed, to future possible complications(17).

Scoring systems

Thoracic injury severity grading remains difficult, in spite of having different scoring systems. The different global trauma scoring systems include the Revised Trauma score

(RTS), the Injury Severity Score (ISS), and the Trauma and Injury Severity Score (TRISS). These include thoracic injuries as part of the overall injury system(18,19).

The chest injuries comprise anatomical and physiological injuries. The anatomical injuries consist of bony and parenchymal lung injuries. AIS thorax gives the thoracic-specific scoring within the ISS. It gives the anatomical assessment of chest injuries. The Pulmonary Contusion score (PCS)(20) and the CT-dependent Wagner-score quantify the extent of pulmonary contusions. The Thoracic Trauma Severity score (TTSS)(21) combines both the anatomical and physiological parameters.

The creation of different trauma scales is particularly important to predict the progression of injury and also to predict the outcomes in advance so that rigorous monitoring of the patient's vital parameters and his/her treatment can be done. It's also important to know the epidemiology of trauma(17). A scale should also be reliable, accurate, and specific.

Description of different scoring systems

Injury Severity Score (ISS): It is mainly an anatomical score in a poly-trauma patient. Each injury is assigned AIS. AIS ranges from 0-6. The higher values are associated with decreased survival. The whole body is divided into 6 anatomical regions: head, face, chest, abdomen, extremities (including the pelvis), and external. The highest score is given to each anatomical region. Out of these the 3 highest scores are individually squared and added to give the ISS score i.e. let the three highest points be a, b and c, so the ISS would be a2 +b2 + c2

Abbreviated Injury Score (AIS): The body is divided into six anatomical regions as explained earlier and each region is given a severity value of 1(being minor) to 6(fatal). ISS is calculated as explained. ISS ranges from 1 to 75. Any victim with AIS of 6 in any of these 6 anatomical parameters is assigned automatically an ISS value of 75. The main drawback of ISS is it cannot predict the outcome for multiple severe injuries in a single region.

Revised Trauma Score (RTS): It is a physiological scoring system. It has high inter-rater reliability and better predicts death. It uses 3 physiological parameters: Glasgow Coma Scale (GCS), Systolic Blood Pressure (SBP), Respiratory Rate (RR). It ranges from 0(worst)-7.8408(best)(31). It was derived from two earlier versions of triage scores i.e. the Triage Index and the Trauma Score developed by Champian et al.

RTS = 0.9368(GCS) + 0.7326(SBP) + 0.22908(RR Value)

A higher value suggests a better chance of survival. A score </= 11 indicates that the patient needs to be treated at a trauma hospital.

Trauma and Injury Severity Score (TRISS): Its calculation uses both RTS and ISS. It also considers patients' age along with type of trauma i.e. blunt or penetrating trauma. This index is calculated by summing the results of these 3 components and multiplying them by their respective weights. A logistic regression model to compute the probability (range: 0–1) using the following equation:

Probability of Survival (P) = 1/(1 + eb) in which b = b0 + b1(RTS) + b2(ISS) + b3, and values for b0 to b3 depend on whether the trauma is blunt or penetrating and on patient age.

Pulmonary Contusion Score (PCS): It is based on plain CXR at the time of admission and after 24 hours after trauma(20). The lung is divided into upper, middle, and lower third. Contusion in each part is given a score of 1-3 and thereafter added. . A score value of 1–2 is classified as mild, a value of 3–9 as moderate, and a value of 10–18 as a severe pulmonary contusion.

CT dependent Wagner Score: Wagner and Jamieson developed this scoring system based on CT findings(22). The severity of thoracic trauma is divided into different grades based on the extension of pulmonary lesions on CT. Grade I: pulmonary lesion < 19% of the total air space, grade II: 19%-27%, grade III >/= 28%.

Paediatrics Trauma Score (PTS): This is used in children and is similar to RTS. It has 6 components: weight, airway, systolic blood pressure, central nervous system, open wound, and skeletal injury. Each component is given a score of -1 to +2. A score of <8 means severe trauma and will need a formal transfer to a paediatric trauma centre.

Thorax Trauma Severity Score (TTSS): It takes into account both anatomy and physiology. It is calculated by adding each of the individual scores. It ranges from 0-25(21). Increasing score values accounts for a more severe injury. TTSS greater than equal to 7 is associated with increased morbidity and a score of 20 or more has a fatal prognosis(23).

Table 1: TTSS (Thorax Trauma Severity Index)

Grade	Pao2/Fio2 (S)	Rib fractures	Pulmonary contusion	Pleural involvement	Age(years)	Points
0	S >/= 400	0	None	None	<30	0
I	400 > S >/= 300	1-3	one lobe, unilateral	pneumothorax	30-41	1
II	300 > S >/= 200	>3	Unilobar bilateral or bilobar Unilateral	Hemothorax or hemopneumothorax unilateral	42-54	2
II	200 > S >/= 150	>3 bilateral	<2 lobes bilateral	Hemothorax or hemopneumothorax bilateral	55-70	3
IV	S < 150	Flail chest	>/=2 lobes bilateral	Tension pneumothorax	>70	5

Scales are a basic necessity in the epidemiology of trauma to predict the outcomes in terms of mortality and morbidity(5). These scales combine both anatomical and physiological parameters. The scale should be specific, reliable, and accurate. Validation of these scales requires their use in a population different from the original one. The observed variation in outcomes via using these scales in different centres and countries may actually reflect inaccuracies or actual mistakes in the scale used to synthesize information(5,7). In this study, TTSS has been validated in the population which mostly comprises western India.

Many studies have been done in the chest trauma patient to assess the severity of the injury, while a few studies are present which are particularly aimed at quantifying anatomically or functionally in particular to the thoracic trauma patients. Also, scores such as ISS or TRISS, which are being used widely, are global poly-trauma scales that under-estimate the evaluation of thoracic trauma in particular. Hence there is a need for a precise scoring system for the evaluation of chest injuries in particular(17).

A series of 1,495 blunt thoracic trauma patients, conducted by Pape et al.(9) concluded that radiologically determined lung parenchymal injury has a closer association with adverse outcomes as compared to chest wall injuries but these injuries are rarely diagnosed before 24

hours. They have for the first time introduced the TTSS in order to predict the outcome of thoracic trauma patients.

In 2000, Pape et al for the first time described TTSS to deal with chest injuries in particular. It has both anatomical and functional aspects, and the main aim was to help emergency medical treatment and evaluation in identifying chest injury patients at risk of pulmonary complications. This scale has been validated in the prediction of HLOS, ICU LOS, and mortality(24).

Pape et al. performed a retrospective study with the data retrieved from the polytrauma database at the Department of Trauma Surgery at Hannover Medical School, which was established in 1990. Inclusion criteria being patient with thoracic trauma and multiple associated trauma (ISS>/=18), GCS>/=8, having no local or systemic infections. A Chi-square analysis test was used. The investigation was made with the patients being admitted between January 1, 1975, and April 1, 1999. Serial chest x-ray evaluation of the patients was done. This study concluded that a single X-ray evaluation was of limited value and serial evaluation must be done. A composite score that included several anatomical, radiographic, and physiologic criteria would better demonstrate the thoracic injury severity. The study said that radiography better defines lung parenchyma injury but is often missed in the first 24 hours of injury. A new TTSS helps to predict thoracic-related complications(21).

Another retrospective study was done between 2000 to 2004 at the Universal Medical Centre Utrecht, for patients with AIS thorax score >/=1, aimed at validating TTSS with ICU LOS, HLOS, mortality, ARDS, days of ventilation. This study included 516 patients out of which 27% (140) developed chest-related complications i.e. ARDS. The ROC curve was used for predicting mortality. The patients with higher TTSS died of thorax-related complications than those of non-thoracic-related complications with a P-value of (0.001). The study concluded that the higher the TTSS, the higher is the probability of developing ARDS i.e. chest related complications with (P = 0.005, CI 95%). Hence, the study demonstrated TTSS capable of predicting ARDS(24).

In a retrospective, consecutive review of the medical records of patients with severe thoracic trauma conducted in a tertiary care hospital in South Korea between January 2005 to December 2015, the inclusion criteria being patients with severe thoracic injury (injury severity score>18) or the one who required intensive care treatment and who had no local or systemic infection were included and analyzed by the association between

the trauma severity scores mainly between TTSS and Trauma and Injury Severity Score (TRISS) concluded that the in-hospital mortality rate was 21.9%. There was a statistically significant association between the TRISS and in-hospital mortality (P<.001), but the association between the TTSS and in-hospital mortality was not statistically significant (probability P=0.547) as the study was trauma as a whole and not just chest trauma with a rib fracture. At a cut-off value of 25.9%, the TRISS had a sensitivity of 83.6% and specificity of 73.5% to predict in-hospital mortality. The present study demonstrated that the TRISS, but not the TTSS, can be used to predict in-hospital mortality in patients with severe thoracic trauma; hence, additional prospective studies are required for specific rib fractures cases(25).

In a retrospective cohort study performed in Delray Medical Centre, Delray Beach, Florida where the geriatric patients with Rib Fracture Score (RFS) ≥8 had higher mortality as compared to patients with RFS <8, higher injury severity score(ISS), hospital length of stay(HLOS), ICU length of stay(ICU LOS), and P <0.03. Non-geriatric patients with Chest Trauma Score (CTS) ≥4 had higher mortality as compared to patients having CTS <4. Geriatric patients with CTS ≥6 versus CTS <6 had greater values for all variables (P < 0.01) like hospital length of stay (HLOS), intensive care unit length of stay (ICU LOS). Similarly, the patients with Rib Score (RS) ≥1 versus RS <1, had greater values for all variables (P < 0.05). In the geriatric group, prediction of the rate of pneumonia(PN) was good by CTS (c = 0.8) and fair by rib fracture score(RFS)and rib score(RS) (c = 0.7)(26).

In a study conducted at a teaching hospital in Keelung, Taiwan, the investigators retrospectively reviewed the trauma registry between January 2013 and May 2015. A total of 3151 trauma patients were reviewed. 174 patients were finally enrolled. Most injuries were due to RTI. The severity of chest trauma was assessed using TTSS and Rib score by multivariable logistic regression analysis suggesting that patients with three or more rib fractures or any displaced rib fracture were the most significant predictor for developing pulmonary complication. Moreover, 31.6% of patients with fewer than 3 rib fractures also developed pulmonary complications. They concluded that three or more rib fractures or any displacement were found to be the most sensitive risk factor for chest complications, independent of other risk factors or severity index(9).

In another study conducted at King's College, Denmark Hill, London which had a predefined systematic search strategy in which three major themes were identified from the 15 studies

which were included in this review: (i) physical impact of blunt thoracic injury (BTI), (ii) psychological impact of blunt thoracic injury (BTI) and (iii) socio-economic impact of BTI. The bulk of the available data focused on the physical impact where further sub-themes included:(i) physical functioning, (ii) ongoing unresolved pain, (iii) reduced respiratory function, (iv) thoracic structural integrity(27). The main aim of the study was to identify the impact of BTI on long-term functional outcomes of major trauma patients, to explore which outcome measures have been used in previous research, and to identify the physical, psychological and socio-economic impact on long-term follow-up. They had used 5 databases.

In a prospective observational study done in a trauma care center at a tertiary care teaching public hospital, Topiwala National Medical College and B.Y.L. Nair Ch. Hospital, Mumbai Central, Mumbai, Maharashtra, India. A total of 30 patients was included and they were divided into 2 groups i.e. CTS<5(15) and CTS>/=5 (15). This study concludes that a CTS ≥5 is associated with poor outcomes in terms of increased requirement of mechanical ventilation (P = 0.025) and mortality (P = 0.035) in chest trauma patients(28).

A retrospective trauma registry review was done at Virginia Tech Carillion School of Medicine, Roanoke, VA, USA, particularly aimed to test the hypothesis that a scoring system based on initial clinical findings can identify patients with rib fractures at the greatest risk for morbidity and mortality. Points were assigned as follows: age < 45 years = 1 point, age 45 to 65 years = 2 points, age > 65 years = 3 points; <3 fractures = 1 point, 3 to 5 fractures = 2 points, >5 fractures = 3 points; no pulmonary contusion = 0 points, mild pulmonary contusion = 1 point, severe pulmonary contusion = 2 points, bilateral pulmonary contusion = 3 points; and bilateral rib fracture absent = 0 points, bilateral rib fracture absent present = 2 points. A score ≤ 7 indicated lower mortality compared with patients with scores > 7. Patients with scores ≤ 6 were less likely to be admitted to an ICU compared with those with scores ≥ 7. Patients with total scores < 7 were less likely to require intubation compared with those with scores ≥ 7 .Patients with scores ≤ 4 had shorter lengths of stay compared with those who had scores > 4(29).

In a retrospective cohort study done at the National University Hospital Gyeongsang, which evaluated patients with severe chest trauma defined as ISS>18, with GCS>8, who remained mechanically ventilated for >2 days, who survived for >2 days following injury, and having no local or systemic symptoms at the time of injury between the time period of Jan 2005 to

Dec 2015. The Wilcoxon signed-rank test was used to analyze associations between TTSS and TRISS and the in-hospital mortality for validation. The study showed that the relation between TTSS and in-hospital mortality was not statistically significant with P-value being (0.547). This study concluded that TRISS, but not TTSS, can be used to predict hospital mortality in patients. The TRISS comprises both the physiological and anatomical scoring system, i.e. RTS and ISS(1).

A retrospective cohort study was done by Gabrielle et al in a hospital in Southern Brazil from Jan 2008 to Dec 2018, which included 121 patients with a median age of 47 years with the majority being male(84.3%). Blunt trauma comprised 85.1%. ICU was needed for 14% of patients and MV for 5.8%. The median length of stay was 6.0 (4.0-10.5), and the outcome was death in 1.7% only. The median TTSS was 3.0 and the ISS score was 4.0. For patients with a length of stay ≥ 6 days, there was an association with the female gender, needing ICU, O2, and MV, ISS scores, and TTSS scores in the females tend to be more as compared to males. The study concluded that most victims who were of younger age with TTSS and ISS were better predictors of prolonged HLOS(30).

Bagaria et al. conducted a prospective observational study between May 2015 to May 2017 which included all patients with blunt trauma aged between 18-65 years, and who were intubated. Patients with any other comorbidities were excluded. The blood and BAL samples were taken and the cytokines (IL-1β, IL-6, IL-8, IL-10, and TNF-α) and biomarkers (vWF, CC16) were assayed from the above samples. ELISA was used. Assessment of severity of chest trauma was done by TTSS. The outcome was to assay cytokines (IL-1β, IL-6, IL8, IL-10, and TNF-α) and biomarkers (vWF, CC16) in serum and BAL in patients of traumatic chest injury on MV and comparing with controls. The secondary objectives were to correlate TTSS with cytokines and biomarkers levels and patient outcomes. A total of 865 patients with thoracic trauma were managed out of which 43 patients were mechanically ventilated. The male-female ratio was 35:8. The mean HLOS of patients was 25.4 ± 21.6 days with a median of 22 days. The mean ICU LOS was 13.6 ±10.9 days with a median of 11 days. The range of hospital stay was between 2 and 110 days and that of ICU stay was between 1 and 48 days. ICD was required in 64.7% of the patients, for having either hemothorax and/or pneumothorax. The mean TTSS was 6.5 ± 2.1 with the median score being 6. The range was 3-12. The median values of cytokines and biomarkers were compared between the controls and baseline values of the patients. Serum IL-1β and IL-10 were significantly raised in

thoracic trauma patients (p = 0.00 and p = 0.00 respectively), whereas IL-6, vWF, and CC16 failed to rise significantly as compared to controls. The study concluded that patients with a high TTSS (> 5) have a significantly longer ICU stay. The serum and BAL fluid had higher levels of IL-1β and IL-10, whereas levels of IL-6 and IL-8 were increased only in BAL fluid. A statistically significant correlation between the cytokines and biomarkers and TTSS was not found(31).

Martinez Casas et al. conducted a retrospective analysis over a period of two years with ICD-9 codes related to thorax trauma validating the relationship of TTSS with complications and mortality using the ROC curve. A total of 228 patients were taken with thoracic trauma mostly middle-aged (62.2 ± 15 years). The average ISS was 3 ± 5. Morbidity was 2.5% and mortality was 2.1% as a result of thoracic injury. These patients were found to have significantly higher TTSS values. The area under the curve for TTSS was significant for predicting complications (0.848) and mortality (0.856) values. TTSS>/=8 had a sensitivity of 66% and specificity of 94% to predict complications and 80% sensitivity and 94% specificity for predicting mortality. The study concluded that TTSS was appropriate in predicting the complications or mortality in patients with thoracic trauma.

AIMS & OBJECTIVES

AIM AND OBJECTIVES

AIM

To predict the outcome of chest injury patients by Thorax Trauma Severity Score (TTSS) at AIIMS Jodhpur

OBJECTIVES

Primary objective:

To determine the duration of Hospital length of stay (HLOS) and ICU length of stay (ICU LOS) in patients with a chest injury.

Secondary objective:

To determine the proportion of patients with chest injury who return to normal activity at 30 days of discharge.

To determine the proportion of patients with chest injury who develop pneumonia.

To determine the proportion of patients with chest injury requiring mechanical ventilation during the hospital stay.

To determine the mortality rate among the patients with a chest injury in our hospital

MATERIALS & METHODS

MATERIALS AND METHODS

STUDY SETTING:

- This study was conducted in the Department of General Surgery (T&E) AIIMS JODHPUR

STUDY DESIGN:

- Hospital-based prospective observational study.

STUDY PARTICIPANTS:

INCLUSION CRITERIA

- Patients with a blunt or penetrating chest injury.
- Adult patients presenting to AIIMS Jodhpur with hemothorax with or without rib fracture.
- Adult patients presenting to AIIMS Jodhpur with pneumothorax with or without rib fracture.
- Adult patients presenting to AIIMS Jodhpur with hemopneumothorax or tension pneumothorax with or without rib fracture.
- Adult patients presenting to AIIMS Jodhpur with any thoracic visceral injury with or without rib fracture.
- Patient with rib fracture

EXCLUSION CRITERIA-

- Patients presenting with rib fracture due to iatrogenic causes (CPR/ Post-surgery)
- Patients presenting with iatrogenic chest injury as in thoracotomy
- Patients < 18 years of age (pediatric age group)

SAMPLING AND SAMPLE SIZE

All patients presented to the Trauma and Emergency department from Jan 2020 to Dec 2021 were recruited in the study based on inclusion and exclusion criteria. We enrolled 100 patients during this period in the study.

STUDY DURATION: 2 years from Jan 1, 2020, to Dec 31, 2021

STUDY PROCEDURE:

Patients who met the selection criteria were explained the objectives and methodology of the study. A written informed consent, socio-demographic data, and clinical details were noted. Those patients who were not fit to give consent, relatives were requested to give consent for inclusion in this observational study on their behalf. All patients were managed as per the standard institutional protocol. TTSS was calculated for all patients at admission. Numerical pain rating score (NPRS) was used to assess the severity of pain on admission, day- 1, day-3, day-7, at discharge, and 1 month after discharge. Data regarding pain assessment; oxygen requirement (amount, duration, dose, and medium), route of analgesia were recorded on admission, day-1 day-3 day-7, and at discharge. NPRS is the pain assessment scoring in which 0 indicates no pain and 10 indicates the worst pain imaginable. Any additional complications and any other systemic injury present, during the course of the hospital stay, were noted. ISS was also calculated for each patient along with the TTSS.

STUDY SIZE:

All the patients presented to the emergency department during the time period of Jan 2020 to Dec 2021 were enrolled in the study. The majority of the population in this study are from the western part of India, particularly Rajasthan

STATISTICAL ANALYSIS:

- Data were analyzed by using SPSS statistical software (version 17.0). Mann Whitney U test was used to compare numerical data without normal distribution. The Chi-square test or Fischer exact test, Mann-Whitney U test was used for data analysis. A p-value of <0.05 was considered as significant. ROC was used to choose a suitable cut-off point to predict mortality.

RESULTS

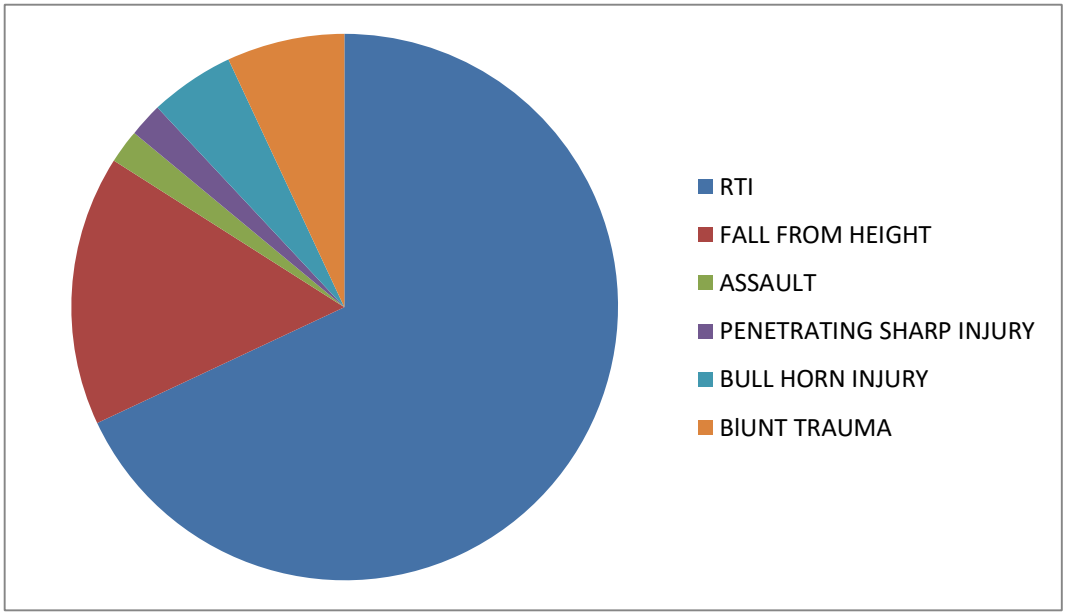
RESULT

A total of 100 patients were recruited during the study period. Out of the 100 patients, 85 patients were male and 15 patients were female. The mean age was 38 +/- 14 years. These all patients have thoracic injuries along with other multi-visceral injuries. 30 patients required surgery either due to thoracic or extra-thoracic causes, mostly due to orthopaedic reasons. Out of the 100 chest trauma patients, 11 patients had died.

Table 2: Baseline data of study patients

Total number of patients	100
Mean age in years (SD)	38(14)
Sex of patient	
Male	85(85%)
Female	15(15%)

Figure 10: Mode of Injury



The main mode of injury was Road Traffic Injuries (RTI) accounting for 68%, followed by fall from height (16%), blunt trauma (7%), bull horn injury (5%), penetrating trauma (2%), and assault (2%).

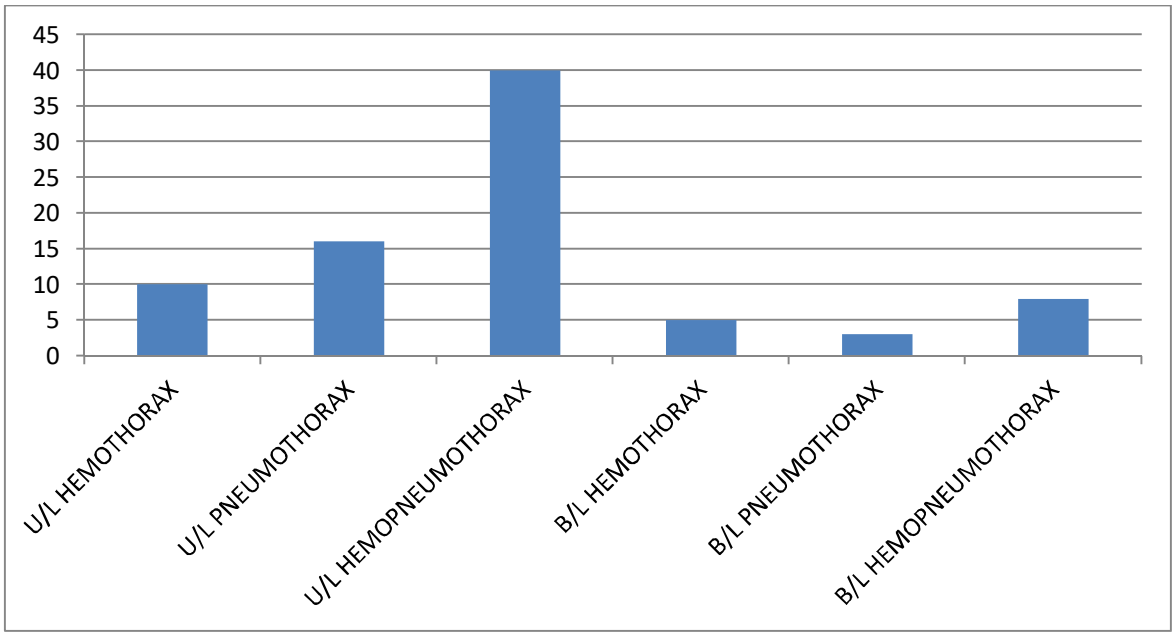
Table 3: Parameters in the 100 patients

Hospital stay in days(median)(IQR) **TTSS</=7** **TTSS>7**	 6(4-8) 7.00(3.5-11)
Patients requiring ICU stay	20
Median stay in ICU with IQR **TTSS</=7** **TTSS>7**	 5.00(3-10.75) 6.50(2.5-13)
Patients who underwent surgery	30
Patients developing pneumonia	27
Need for mechanical ventilation	17
Normal return to activity within 30 days	63
Death	11

Table 4: Description of chest wall injuries

Chest wall injuries	**No. of patients**
Rib fractures	100
Unilateral	78
Bilateral	19
Haemothorax	68
Unilateral	55
Bilateral	13
Pneumothorax	69
Unilateral	57
Bilateral	12
Tension pneumothorax	5
Lung contusion	58
Unilateral	46
Bilateral	12
Flail segment	17

Figure 11: Indication of ICD Insertion

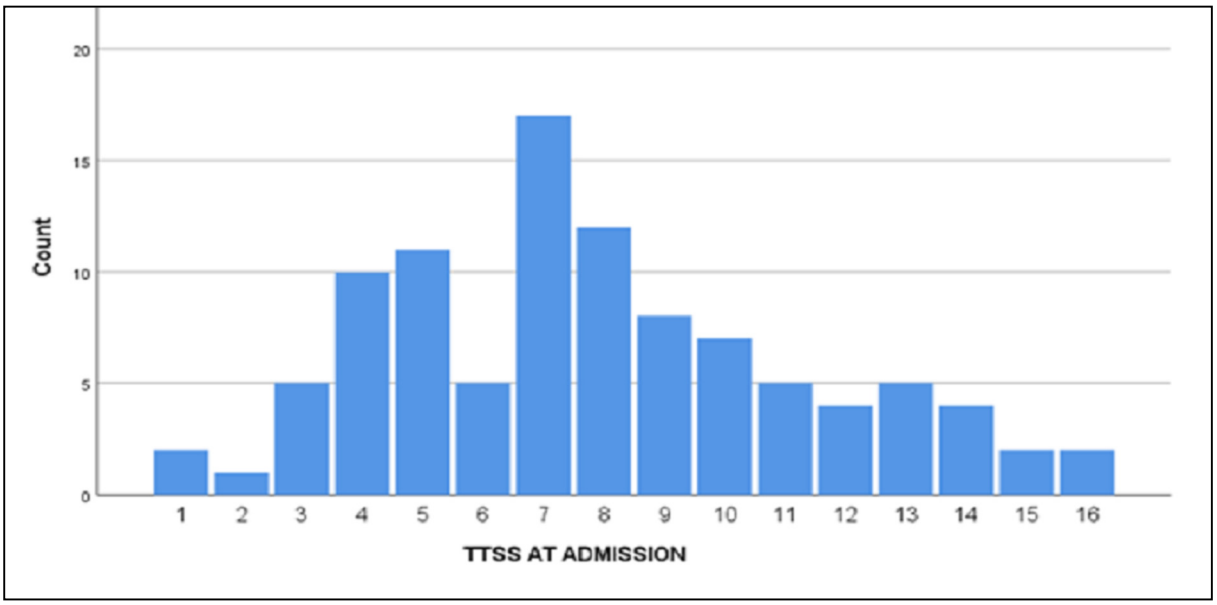


Most of the patients in the study needed ICD placement (non-operative management) for the treatment of chest trauma patients. Also after surgical intervention, ICD was kept for monitoring of these patients. A total of 82 patients needed ICD placement after chest trauma, out of which 66 patients needed unilateral ICD insertion and the rest 16 patients needed bilateral ICD insertion. The most common indication of ICD insertion was unilateral hemopneumothorax followed by unilateral pneumothorax. The other indications of ICD insertion are unilateral hemothorax, bilateral hemopneumothorax, bilateral hemothorax, and bilateral pneumothorax. 18 patients did not require ICD placement. These patients had mostly rib fractures with or without minimal hemothorax or pneumothorax, which was managed with analgesics either in the form of oral, intravenous or in the form of epidural analgesics.

Admission severity and events

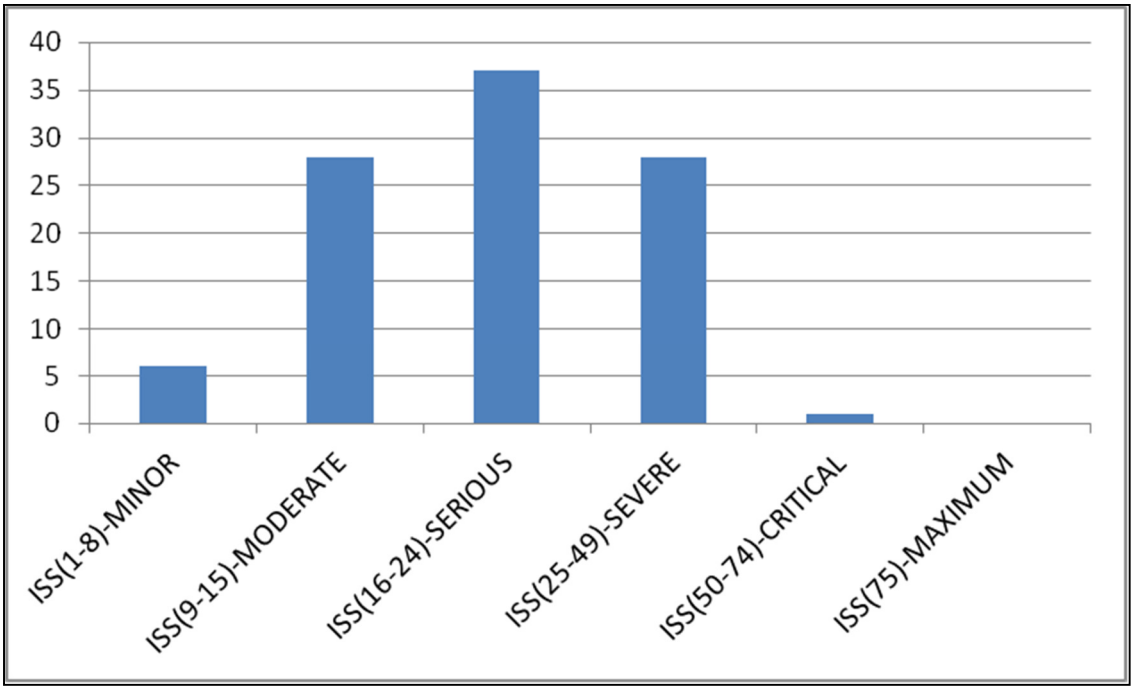
Of the five parameters of TTSS, 78% of the 100 patients had unilateral rib fracture, 19% had bilateral rib fracture. Hemothorax was present in 68 patients, out of which unilateral hemothorax was there in 55 patients and bilateral hemothorax was there in 13 patients. Pneumothorax was present in 69 patients, unilateral pneumothorax in 57 patients, and bilateral pneumothorax was present in 12 patients. Tension pneumothorax was there in 5 patients. A total of 58 patients had a pulmonary contusion, 46 had unilateral lung contusion and 12 had bilateral lung contusion. Flail segment was present in 17 patients.

Figure 12: TTSS at admission



The distribution of TTSS has been shown in figure 12. In the study, the minimum TTSS was 1 and the max score was 16. The majority of the patients were having a TTSS of 7 followed by 8. There are a lesser number of patients with a higher TTSS. In between TTSS values of 0-5, there were 29 patients. A maximum number of patients were having TTSS values of 6-10 i.e. 49 patients. Between TTSS of 11-15, there were 20 patients and between TTSS values of 16-20, there were 2 patients. The maximum TTSS value in this study was 16.

Figure 13: ISS Value of patients



The ISS values of all the patients were calculated. The highest ISS score was 60 and the lowest score was 4. The majority of the patients are in the ISS range of 16-24 i.e. 37 patients. In the ISS range of 1-8, there are a total of 6 patients, in the ISS range of 9-15, there are a total of 28 patients. In the ISS range of 25-49, there are a total of 28 patients. Only 1 patient is there at the critical range i.e. ISS range of 50-74.

Table 5: Comparing outcomes

TTSS	**</= 7**	**> 7**
Median hospital stay in days (IQR)	6.00 (4-8)	7.00 (3.5-11)
Median ICU stay in days (IQR)	5.00 (3-10.75)	6.50 (2.5-13)

The Total Hospital Length of Stay (HLOS) was correlated with TTSS using different statistical tests. It was found that in the first group of patients with TTSS less than equal to 7, the median total HLOS was 6.00 days with an IQR of 4-8 days. In the second group, the median HLOS was 7.00 days with an IQR of 3.5-11 days. Using the Mann-Whitney U test the P-value was found out to be 0.150 which is statistically not significant. Hence it can be said that a higher TTSS cannot predict an increased length of stay in hospital.

In group 1 which comprises patients with TTSS of less than equal to 7, a total of 8 patients required ICU stay. The median ICU stay was 5.00 days with an IQR of 3-10.75 days, among those who were admitted to ICU. In the second group which included patients with TTSS more than 7, a total of 12 patients required ICU beds. The median ICU stay was 6.5 days with an IQR of 2.5-13 days. TTSS was found to be statistically non-significant when compared with ICU LOS with a P-value of 0.739, using the Mann-Whitney U test.

TTSS was correlated with the number of people returning to normal activity within 30 days of discharge. 63 patients had returned to their normal work within 30 days of discharge on follow-up. They could do their daily activities. Applying the chi-square test, the P-value was calculated to be less than 0.001 (CI=95%) which is statistically significant. Hence it can be concluded that TTSS at admission can statistically predict this outcome.

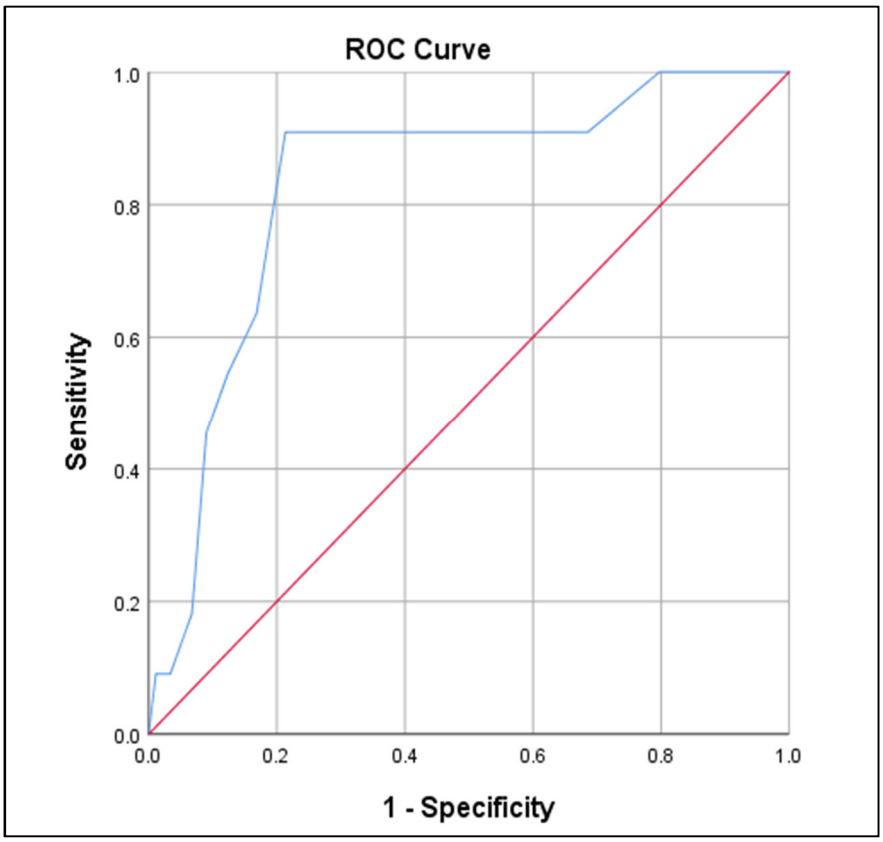
Table 6: Comparing Pneumonia and Mechanical Ventilation with TTSS

	Median TTSS (IQR)
Patients who developed pneumonia	12.00 (10.34-12.77)
Patients who do not developed pneumonia	7.00 (5.93-7.09)
Patients who needed Mechanical Ventilation	10.00 (7.49-12.04)
Patients who did not need Mechanical Ventilation	7.00 (6.80-8.17)

Patients who developed pneumonia during the hospital stay also had higher TTSS values. A total of 27 patients developed pneumonia. The median TTSS value among the patients who developed pneumonia is 12.00 with an IQR of 10.34-12.77. Among the patients who did not develop pneumonia, the median TTSS is 7.00 with an IQR of 5.93-7.09. Applying the chi-square test, the P-value was calculated to be less than 0.001 which is statistically significant i.e. any P-value less than 0.05 is significant statistically. Thus it can be said that a higher TTSS can better predict the development of pneumonia.

Patients requiring mechanical ventilation were also correlated with TTSS. A total of 17 patients needed mechanical ventilation. The median TTSS value for the patients who needed mechanical ventilation is 10.00 with an IQR of 7.49-12.04. The median TTSS among those who did not require mechanical ventilation is 7.00 with an IQR of 6.80-8.17. Using the chi-square test the P-value was calculated to be 0.009(CI=95%) which is statistically significant as it is less than 0.05. Thus it can be rightly said that higher TTSS can better predict the need for mechanical ventilation.

Figure 14: ROC for mortality



The overall mortality among chest trauma patients is 11%. This mortality was correlated to higher TTSS scores. The ROC was used to calculate the sensitivity and specificity of the TTSS to predict hospital mortality. The area under the curve (AUC) shows a value of 0.831 (figure 2). The patients who died of thoracic injuries had higher TTSS scores. With a TTSS cut-off of 9.5, it can predict mortality with a sensitivity of 90.9% and specificity of 78.7%. Youden's index for this TTSS value was 69.6%.

DISCUSSION

DISCUSSION

TTSS is an easy scoring system to assess the degree of thoracic trauma. It is performed on admission and can prognosticate the patient based on the scoring system.

The majority of the patients are young males with the mean age being 38 years. This is comparable to other studies such as the one performed by Zahran et al(23). This study included a total of 284 male patients with a mean age of 41 years. Study concluded that a TTSS value of 7 points and more was 100% sensitive and 97.73% specific in predicting the poor prognosis and associated with acute respiratory distress syndrome and the need for mechanical ventilation. Also, the majority of the studies conducted earlier had more male patients as compared to females.

In this study, blunt thoracic trauma is the major mode of injuries followed by falls from height. Road Traffic Injuries (RTI) is the major mechanism of blunt trauma. This is similar to many earlier studies, where RTI was the main mechanism of injury(1).

Comparing TTSS with the HLOS, it's found that TTSS is not significant in predicting the duration of hospital length of stay. This is due to other systemic injuries in the poly-trauma patients needing prolonged hospital stay, particularly the orthopedic injuries needing bony fixation. Many patients had a neurological injury for which they needed prolonged hospital or ICU stay even if they had minor thoracic injuries.

Similar to the HLOS, the ICU LOS also was not found to be correlated with TTSS. This is due to patients needing prolonged ICU care even if their chest was fine, as a result of neurosurgical injury (particularly the head injury). Also, some had DAI (Diffuse Axonal Injury), needing prolonged ICU care even if their chest was fine. This result is not in accordance with the one published by Bagaria et al. where they have proposed that patients with higher TTSS scores had a significantly prolonged ICU stay(31).

Many patients sustained multiple systemic injuries. Many patients had isolated thoracic injuries only. Patients were followed up for 30 days post-discharge and were observed if they could do their normal routine daily activities. 63 patients had returned to normal activity. Most other patients had orthopedic injuries. The patients who could not do their daily activities had either undergone spine fixation surgery or had fracture reduction for which they

were advised in bed mobilization. Lower TTSS could effectively predict the early return of normal activity.

TTSS has a significant association with the development of pneumonia in chest trauma patients. A total of 27 patients developed pneumonia. For patients who developed pneumonia, the median TTSS is 12.00. This result is similar to the one published by Aukema et al. who proposed that in the patients who developed ARDS the TTSS was significantly higher (P=0.005, CI=95%)(33). Most of the older age are more prone to develop pneumonia after chest injury.

TTSS is also effective in predicting the need for mechanical ventilation during the hospital stay. A total of 17 patients needed mechanical ventilator support after trauma, either due to the chest injury itself or as a need to operate. Applying the Chi-square test, it was found out that TTSS can statistically significantly predict the outcome for the need of mechanical ventilation (P=0.009, CI=95%). This result is similar to the result published by Zahran et al. showing TTSS above 7 was associated with an increased probability of mechanical ventilation and duration of mechanical ventilation(23).

Death occurred in 11 patients. When TTSS was compared with mortality the area under the curve came 0.831. This is in comparison with the study conducted by Aukema et al. where he had found the area under the ROC curve to be 0.844(24). The TTSS cut-off of 9.5 points had a sensitivity of 90.9% and specificity of 78.7%. Thus we can say that a TTSS cut-off of 9.5 can better predict mortality. This result is somewhat higher from earlier results where the TTSS value of 8 or more had 92.3% sensitivity and 100% specific to poor prognosis(23). In another study, they deduced the TTSS cut-off of 8 had a sensitivity of 80% and specificity of 94%(17). In another study, the TTSS cut-off of 7 or above was 100% sensitive and 100% specific to poor outcomes.

The strength of the study is that it is a prospective observational study performed at a level 1 trauma centre. There is also a varied presentation of cases.

Some limitations in this study should be acknowledged. First, all the patients are selected from a single hospital, which may have introduced selection bias. Second, this study had only a minority of patients with severe thoracic injury, thus a larger population is needed to validate the findings. Larger population studies are needed to support the findings. Third, the

COVID pandemic came during the study period, which led to a complete lockdown resulting in a lower number of patients.

This study can guide us in the future for further research. PFT can be done and can be compared with TTSS. Also, further research needs to be done to find out a better scoring system that can predict the degree of thoracic trauma in a patient with severe other systemic injuries.

CONCLUSION

CONCLUSION

Most of the patients are young adults with males more than females. TTSS has a higher correlation with the occurrence of complications in terms of development of pneumonia, need for mechanical ventilation, and mortality. TTSS failed to predict the duration of HLOS and ICU LOS. With a TTSS cut-off of 9.5, it can better predict mortality.

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BIBLIOGRAPHY

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ANNEXURES

ANNEXURE I

Ethical Clearance Certificate

अखिल भारतीय आयुर्विज्ञान संस्थान, जोधपुर
All India Institute of Medical Sciences, Jodhpur
संस्थागत नैतिकता समिति
Institutional Ethics Committee

No. AIIMS/IEC/2020/2076 **Date: 01/01/2020**

ETHICAL CLEARANCE CERTIFICATE

Certificate Reference Number: **AIIMS/IEC/2019-20/1001**

Project title: **"Predicting the outcome of chest injury patients by Thorax Trauma Severity Score at AIIMS Jodhpur: An observational study"**

Nature of Project:	**Research Project**
Submitted as:	**M.S. Dissertation**
Student Name:	**Dr.Netrananda Acharya**
Guide:	**Dr.Mahaveer Singh Rodha**
Co-Guide:	**Dr.Ashok Kumar Puranik, Dr.Naveen Sharma, Dr.Ram Karan Chaudhary, Dr.Mahendra Lodha & Dr.Satya Prakash Meena**

This is to inform that members of Institutional Ethics Committee (Annexure attached) met on **23-12-2019** and after through consideration accorded its approval on above project. Further, should any other methodology be used, would require separate authorization.

The investigator may therefore commence the research from the date of this certificate, using the reference number indicated above.

Please note that the AIIMS IEC must be informed immediately of:

- Any material change in the conditions or undertakings mentioned in the document.
- Any material breaches of ethical undertakings or events that impact upon the ethical conduct of the research.

The Principal Investigator must report to the AIIMS IEC in the prescribed format, where applicable, bi-annually, and at the end of the project, in respect of ethical compliance.

AIIMS IEC retains the right to withdraw or amend this if:

- Any unethical principle or practices are revealed or suspected
- Relevant information has been withheld or misrepresented

AIIMS IEC shall have an access to any information or data at any time during the course or after completion of the project.

On behalf of Ethics Committee, I wish you success in your research.

Dr. Praveen Sharma
Member secretary
Institutional Ethics Committee
AIIMS,Jodhpur

Enclose:
1. Annexure 1

Page 1 of 2

Annexure 1

Institutional Ethics Committee
All India Institution of Medical Sciences, Jodhpur

Meeting of Institutional Ethics committee held on **23-12-2019 at 10:00** AM at Committee Room, Admin Block AIIMS Jodhpur.

Following members were participated in the meeting:-

S/No.	Name of Member	Qualification	Role/Designation in Ethics Committee
1.	Dr. F.S.K Barar	MBBS, MD (Pharmacology)	**Chairman**
2.	Justice N.N Mathur	LLB	Legal Expert
3.	Dr. Varsha Sharma	M.A (Sociology)	Social Scientist
4.	Mr. B.S.Yadav	B.Sc., M.Sc. (Physics), B.Ed.	Lay Person
5.	Dr. K.R.Haldiya	MD (General Medicine)	Clinician
6.	Dr. Arvind Mathur	MBBS, MS (General Medicine)	Clinician
7.	Dr. Surajit Ghatak	MBBS, MS (Anatomy)	Basic Medical Scientist
8.	Dr. Vijaya Lakshmi Nag	MBBS, MD (Microbiology)	Basic Medical Scientist
9.	Dr. Sneha Ambwani	MBBS, MD (Pharmacology)	Basic Medical Scientist
10.	Dr. Kuldeep Singh	MBBS, MD (Paediatric), DM (General Medicine)	Clinician
11.	Dr. Abhinav Dixit	MBBS, MD (Physiology), DNB (Physiology)	Basic Medical Scientist
12.	Dr. Pradeep Kumar Bhatia	MBBS, MD (Anaesthesiology)	Clinician
13.	Dr. Tanuj Kanchan	MBBS, MD (Forensic Medicine)	Basic Medical Scientist
14.	Dr. Pankaj Bhardwaj	MBBS, MD (CM&FM)	Clinician
15.	Dr. Praveen Sharma	M.Sc., Ph.D. (Biochemistry)	Member Secretary

Dr. Praveen Sharma
Member Secretary
Institutional Ethics Committee
AIIMS,Jodhpur

ANNEXURE II

PATIENT RECORD PROFORMA

GENERAL INFORMATION:

1. Signed Consent Form **Yes** **No**

2. Completed Form **Yes** **No**

PATIENT DETAILS:

Name: **UHID No.**

Age / Sex: **Address**

DOA: **DOD:**

Total hospital stays after admission:

Total stay at ICU (if any):

Total hours of oxygen requirement (also via the route like nasal prong or mask):

HISTORY:

1. Chief complaints & Duration:
2. Mode of injury
3. Comorbidities: DM (yes[ ]/no[ ]),
4. HTN (yes[ ]/no[ ])
5. COPD (yes[ ]/no[ ])
6. Hypothyroidism (yes[ ]/no[ ])

7. Previous heart disease like myocardial infarction(MI), coronary artery disease(CAD),congestive heart failure(CCF):(yes[ ]/no[ ])

8. Hyperlipidaemia (yes[ ]/no[ ])

9. CVA/Stroke (yes[ ]/no[ ])

10. Any other pulmonary disease(yes[ ]/no[ ])

3. Addictions: Smoking- yes [ ]/no[ ]

Alcoholism-yes [ ]/no[ ]

Opium-yes [ ]/no[ ]

Examination:

General physical examination: Pallor (yes [ ],no [ ])/ Icterus(yes[ ],no[ ])/ Clubbing(yes[ ],no[ ])/ Cyanosis(yes[ ],no[ ])/ Pedal oedema(yes[ ],no[ ])

Vitals at admission: temperature : ( ), pulse rate( ),respiratory rate( ),blood pressure( ).

Local examination:

Chest: on inspection and description of it

1) Any open wound

2) Bruise

3) Flail segment

4) RR

5) Any other injury if present like splenic injury, liver laceration, visceral injury, others

If yes, any surgery/ non-operative management

Systemic examination:

1) Abdomen:

2) CVS:

3) CNS:

Investigation for routine workup on admission at the ward

CXR findings:

- No. of rib fracture:
- Unilateral or bilateral rib fracture:
- Hemothorax and side:
- Pneumothorax and side:
- Tension pneumothorax and side:

CT chest finding:

- No. of rib fracture:
- Lung contusion and side:
- Any other visceral injury:
- Flail segment:

Hb - DLC: Blood Urea -

ABG(PaO2/FiO2):

Serum Creatinine- Blood Sugar-

TTSS at admission:

DETAILS DURING THE STAY:

POD vitals	Imediately on admission	POD 1	POD 3	POD 7	At time before Discharge	PFT at discharge and at 1month after discharge
NPRS score						
Dose,route and no. of analgesics given						
Any additional complication arising						
Surgical intervention if needed for chest or any other						
Need for oxygen to maintain saturation(l/min)						

ICD:

- Indication of insertion
- Date of insertion:
- Duration of placement:
- Date of removal:

Date & Time of Discharge:

ANNEXURE III

INFORMED CONSENT FORM

Title of Thesis/Dissertation:

Predicting the outcome of chest injury patients by Thorax Trauma Severity Score at AIIMS Jodhpur: An observational study

Name of PG Student : Dr Netrananda Acharya Tel. No. 9777794584

Patient/Volunteer Identification No. :_____

I_____S/o or D/o _____

R/o_____ give my full, free, voluntary consent to be a part of the study: Predicting the outcome of chest injury patients by Thorax Trauma Severity Score at AIIMS Jodhpur: An observational study"

The procedure and nature of which has been explained to me in my own language to my full satisfaction. I confirm that I have had the opportunity to ask questions.

I understand that my participation is voluntary and I am aware of my right to opt out of the study at any time without giving any reason.

I understand that the information collected about me and any of my medical records may be looked at by responsible individual from _____ (Company Name) or from regulatory authorities. I give permission for these individuals to have access to my records.

Date : _____ _____

Place : _____ Signature/Left thumb impression

This to certify that the above consent has been obtained in my presence.

Date : _____ _____

Place : _____ Signature of PG Student

1. Witness 1

Signature_____

Name:

Address :

2. Witness 2

Signature_____

Name:

Address :

ANNEXURE IV

ऑल इंडिया इंस्टीट्यूट ऑफ मेडिकल साइंसेज

जोधपुर, राजस्थान

सूचित सहमति प्रपत्र

थीसिस / निबंध का शीर्षक:

एम्स जोधपुर में थोरैक्स ट्रॉमा गंभीरता स्कोर द्वारा छाती की चोट के रोगियों के परिणाम की भविष्यवाणी: एक अवलोकन अध्ययन

पीजी छात्र का नाम : डॉ. नेत्रानंद आचार्य

टेलि सं 9777794584

रोगी / स्वयंसेवी पहचान संख्या: _____

मैं, _____ एस / ओ या डी / ओ _____

आर / ओ _____ अध्ययन के एक हिस्से होने के लिए मेरी पूर्ण, नि: शुल्क, स्वैच्छिक सहमति दें "

एम्स जोधपुर में थोरैक्स ट्रॉमा गंभीरता स्कोर द्वारा छाती की चोट के रोगियों के परिणाम की भविष्यवाणी: एक अवलोकन अध्ययन

", जिसकी प्रक्रिया और प्रकृति मेरी पूरी संतुष्टि के लिए मेरी अपनी भाषा में मुझे समझाई गई है। मैं पुष्टि करता हूं कि मुझे प्रश्न पूछने का अवसर मिला है।

मैं समझता हूं कि मेरी भागीदारी स्वैच्छिक है और मुझे किसी भी कारण के बिना किसी भी समय अध्ययन से बाहर निकलने का अधिकार है।

मैं समझता हूं कि मेरे और मेरे किसी भी मेडिकल रिकॉर्ड के बारे में एकत्र की गई जानकारी को _____ (कंपनी का नाम) या नियामक प्राधिकरणों से जिम्मेदार व्यक्ति द्वारा देखा जा सकता है। मैं इन व्यक्तियों के लिए अपने रिकॉर्ड तक पहुंचने की अनुमति देता हूं।

दिनांक : _____

स्थान: _____ हस्ताक्षर / बाएं अंगूठे की छाप

यह प्रमाणित करने के लिए कि उपर्युक्त सहमति मेरी उपस्थिति में प्राप्त की गई है।

1. साक्षी 1 2. साक्षी 2

हस्ताक्षर: _____

नाम:_____

पता:_____

पीजी छात्र के हस्ताक्षर: _____

दिनांक:_____

स्थान:_____

ANNEXURE V

ALL INDIA INSTITUTE OF MEDICAL SCIENCES

JODHPUR, RAJASTHAN

DEPARTMENT OF GENERAL SURGERY

PATIENT INFORMATION SHEET

Name: **Age/Gender:**

Phone No: **Address:**

AUTHORIZATION:

I feel free to accept or refuse to participate in this study.

I have had a choice to ask questions and all of my questions were answered to my satisfaction

I have been given the information on the survey concerning its nature, purpose, and duration as well as the procedures involved in the study, including any known or expected inconvenience and I accept the same

By signing this form I give my free and informed consent to take part in this study as outlined in the information sheet and this consent form. I understand that I am free to withdraw from the study at any given time. By signing up this form I have not given up my legal rights.

Hence I, hereby give my wilful consent for my inclusion in this study which is being conducted by the Department of General Surgery, All India Institute of Medical Sciences, Jodhpur by Dr Netrananda Acharya
In any case of queries you may contact:
Dr Netrananda Acharya
Academic Junior Resident, General Surgery
All India Institute of Medical Sciences, Jodhpur
9777794584

ANNEXURE VI

आल इंडिया इंस्टिट्यूट ऑफ़ मेडिकल साइंसेज

जोधपुर, राजस्थान

जनरल सर्जरी विभाग

रोगी की सूचना पत्र

नाम:

आयु / लिंग:

फ़ोन नंबर:

पता:

प्राधिकार:

मैं इस अध्ययन में भाग लेने के लिए सहमति दे सकता हूँ या मना भी कर सकता हूँ ।

मेरे पास सवाल पूछने का स्वतंत्रता है और मेरे सभी सवालों का संतोषजनक जवाब मिला

मुझे सर्वेक्षण में इसकी प्रकृति, उद्देश्य और अवधि के साथ-साथ अध्ययन में शामिल प्रक्रियाओं के बारे में जानकारी दी गई है, जिसमें किसी भी ज्ञात या अपेक्षित असुविधा शामिल है और मैं इसे स्वीकार करता हूं

इस फॉर्म पर हस्ताक्षर करके मैं इस अध्ययन में भाग लेने के लिए अपनी स्वतंत्र और सूचित सहमति देता हूं जैसा कि सूचना पत्र और इस सहमति फॉर्म में उल्लिखित है। मैं समझता हूं कि मैं किसी भी समय अध्ययन से पीछे हटने के लिए स्वतंत्र हूं। इस फॉर्म पर हस्ताक्षर करके मैंने अपने कानूनी अधिकारों को नहीं छोड़ा है।

इसलिए, मैं इस अध्ययन में मेरे समावेश के लिए अपनी इच्छा-सहमति प्रदान करता हूं, जो कि जनरल सर्जरी विभाग, आल इंडिया इंस्टिट्यूट ऑफ़ मेडिकल साइंसेज, जोधपुर द्वारा डॉ. नेत्रानंद आचार्य द्वारा संचालित किया जा रहा है।

प्रश्नों के किसी भी मामले में आप संपर्क कर सकते हैं:

डॉ. नेत्रानंद आचार्य

अकादमिक जूनियर रेजिडेंट, जनरल सर्जरी

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