Protocol Summary

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Development of a Prediction Model for Patients With Chest Trauma: A Multi-institutional study of the AAST

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ABSTRACT:
Early diagnosis and appropriate management of chest trauma is key to ensure best patient outcome. Up to 25% blunt trauma deaths are due to chest trauma and the ensuing complications.[1] Chest trauma can be classified as blunt or penetrating, the former can then be classified as blast, direct trauma or acceleration-deceleration injuries. These mechanisms all can lead to lung contusion (the most frequent injury identified in 30-70% of all blunt injuries), laceration of the skin or subcutaneous tissue, or fracture of the ribs and sternum. Of chest injuries, treatment of rib fractures continues to be a highly debated subject as fixation has become only slightly more acknowledged. The recommendations for contusion have been more elucidated though “unnecessary fluid should be avoided” remains somewhat non-specific.[1]

Poor patient outcomes are not uncommon in the chest trauma patient. In all trauma patients admitted to an ICU up to 26% are ultimately diagnosed with pneumonia.[2] In trauma patients with nosocomial pneumonia there is a higher mortality rate.[3] Chest trauma can increase the risk of pneumonia thus leading to worse outcomes. In all patients with flail chest 20.6% are diagnosed with pneumonia according to recent review of the National Trauma Data Bank.[4] At admission it is unclear which patients will develop complications after chest wall trauma. Patients with rib fractures may have improved outcome with surgical repair. Though both Tanaka et al and Balci, have suggested superior outcomes with surgical repair, there have not been large randomized trials to prove better outcomes with surgical treatment.[5,6] With surgical repair, there is suggested improvement in outcomes, however many trauma surgeons (84%) are unaware of the current data regarding surgical repair.[7] These recent trials may indicate that there is improved outcome with fixation, however it is unclear exactly which patients would truly benefit from repair.

In order to identify patient that would potentially improve with repair or alternative management strategy, we first need to identify the population of patients that are likely to have worse outcomes from chest trauma. We will create a rib fracture registry from several level one-trauma centers across the US to provide enough volume to identify outcome variance. We will complete multivariable logistic regression analysis to identify factors that influence outcome. Using these factors will then create a prediction model to identify patients that would have worse outcomes based on the injuries and admission criteria. The purpose is to determine if patients chest trauma including at least one rib fracture have certain admission criteria that would predict worse outcome.

SIGNIFIANCE AND BACKGROUND:

Significance

Chest trauma has significant burden on the trauma population. In drivers over the age of 64 who died in a frontal crash, 47% sustained fatal chest injury.[8] Rib fractures are seen in 39% of patients with blunt chest trauma.[4] Of the roughly 100,000 trauma deaths 25% are the result of chest trauma.[9] Pulmonary contusion can be seen in 30-70% of blunt thoracic trauma, however worse outcomes are seen in patients that have both contusion and rib fracture.[1] It appears that the increase in number of ribs fractured causes worse outcomes with pneumonia occurring in 3-5.2% of patients with 1-5 ribs fractured and 6.8-8.4% with 6 or more ribs fractured.[10] According to Dehghan et al, severe chest trauma (flail or any patient with AIS 3 or greater) leads to decreased lung volumes, atelectasis, chest tightness, dyspnea and chronic pain.[4] These factors are amplified in the elderly, but it is unclear to what degree, or if another population may be affected more than the general population. There has been suggestion that mortality can reach 12% in patients with rib fractures with 33% having severe pulmonary complications.[11] In the population 65 and greater there is an increased risk of pneumonia 31% vs 17% in those less than 65. Thoracic trauma also has impact on the population level. It has been reported that only

43% of patients with severe chest wall injury return to previous full time employment.[4] The average patient has a 70±41 lost days of work.[12] At post trauma day 30, 70% of patients with rib fracture are still using narcotics.[12] There is a significant indication that patients with blunt chest trauma have complications, however which patients have the highest possibility of these complications has not been fully elucidated.

Background
Surgical repair for fracture dates back to early Common Era. The practice has evolved and more recent a resurgence in the 1950's describes rib fixation with wire suture repair.[13] Technique of repair has further advanced to include anterior plating, intramedullary fixation, and u-plating among others. Rib fractures are notorious for severe pain which causes patient splinting, leading to worse outcomes.[1] These outcomes encompass pneumonia, long-term pain, prolonged ventilator times and prolonged ICU and hospital stays. Treatment has been proposed and studied for surgical fixation of rib fractures. However there is currently only level 3 evidence suggesting fixation may improve outcome. To date their have only been two small-randomized control studies to demonstrate improved outcome with patients receiving surgical fixation. One study excluded all patients that did not require mechanical ventilation and those patients that did not have surgical repair quoted a 90% occurrence of pneumonia at 21 days.[5] This questions the validity of the study.

Pulmonary contusion also plays a part in patient outcome in regards to chest trauma. EAST guidelines continue to recommend judicious use of IV fluid.[1] Mandatory mechanical ventilation also is not recommended for chest wall deformity. Again there is no level 1 evidence for treatment of pulmonary contusion or flail chest.

Prediction models have been created to evaluate which patients with chest trauma have improved prognosis. These models for the most part are for patients with multiple injuries beyond chest trauma and do no specifically address the morbidity and mortality associated with chest trauma specifically. More specific models have been created to address rib fracture and outcome prediction.[14,15] However neither model incorporates chest computerize tomography (CT) into prediction or analysis of patient outcome. A recent study in 2008 did assess the ability of chest CT to predict outcome and found that it was not an independent predictor of morbidity or mortality beyond plain chest x-ray, however this study was likely underpowered (see sample size calculation), nor did it include any physiologic assessment of pulmonary gas exchange. Chest CT can identify injuries missed by x-ray up to 65% of the time, including contusions which add significant morbidity to the chest trauma patient.[16] In one retrospective review of patients with pulmonary contusion 70% were thought to be caused by direct lung injury or pulmonary failure.[1]

Currently it is unclear at hospital admission which patients will develop complications (pneumonia, prolonged ICU or hospital stay, increased missed work days, or severe pain) throughout hospitalization. A prediction model will determine which patients are likely to develop these outcomes. This will help guide clinical decision making for patients that may benefit from rib fracture fixation or different management of mechanical ventilation to minimize the poor outcome associated with chest trauma and rib fracture.

OBJECTIVES:

Aim 1: To determine if patients who sustain chest trauma including at least two rib fractures have certain admission criteria that would predict worse outcome

Hypothesis 1: Patients with at least 2 rib fractures seen on CT scan will have worse outcome and are more likely to develop adverse outcomes.

Aim 2: To create a prediction model to accurately identify chest trauma patients at the time of admission that may need increased level of care.

Hypothesis 2: Patients that have worse chest CT scan findings (more rib fractures, worse pulmonary contusion) will have worse outcome suggesting a need for higher level of care.

Aim 3: To assess therapeutic outcomes for patients undergoing rib fracture fixation in comparison to those managed medically.

Hypothesis 3: Patients undergoing rib fracture fixation will have improved outcomes compared to those managed medically.

<u>PARTICIPANT SELECTION CRITERIA</u>:

Patient Selection

Inclusion Criteria

Inclusion criteria will be all patients greater than or equal to 18 years old at admission who sustained blunt chest trauma causing at least two rib fractures based on chest CT scan. Patients will have survived at least 48 hours. Patients must have chest CT completed within 24 hours of admission.

Exclusion Criteria

Exclusion criteria include any patients less than 18 years old at time of admission. Patients incurring penetrating injury to the chest and patients without chest CT scan within 24 hours will also be excluded. Patients with “devastating head injury deemed non-survivable at admission” as well as patients with ICP monitoring greater than 3 days or receiving emergency craniotomy within 24 hours will be excluded.

The trauma registry at University of Utah will be reviewed and patients with blunt chest injury from the past 10 years who fall within the criteria above will be included. The following ICD.9 codes will be used for selection process:

807.0 Closed fracture of rib(s) [non-specific rib fracture code]
807.00 Closed fracture of rib(s), unspecified
807.01 Closed fracture of one rib
807.02 Closed fracture of two ribs
807.03 Closed fracture of three ribs
807.04 Closed fracture of four ribs
807.05 Closed fracture of five ribs
807.06 Closed fracture of six ribs
807.07 Closed fracture of seven ribs
807.08 Closed fracture of eight or more ribs
807.09 Closed fracture of multiple ribs, unspecified
807.1 Open fracture of rib(s) [non-specific open rib fracture code]
807.10 Open fracture of rib(s), unspecified
807.11 Open fracture of one rib

807.12 Open fracture of two ribs
807.13 Open fracture of three ribs
807.14 Open fracture of four ribs
807.15 Open fracture of five ribs
807.16 Open fracture of six ribs
807.17 Open fracture of seven ribs
807.18 Open fracture of eight or more ribs
807.19 Open fracture of multiple ribs, unspecified
807.4 Flail chest

DATA COLLECTION:
The patients that match the appropriate inclusion and exclusion criteria with the appropriate diagnostic codes should be included in this study. Representative at University of Utah will then input data into an online secure data accrual tool made available through the AAST. The data will be secure and accessible only via password protection. Any downloaded datasets or patient information will be stored on encrypted and password-protected computers used for data analysis by the primary investigators. The data available to the primary investigators will be de-identified data with specifics consisting of age and gender only. Once all patient data has received from each of the participating medical centers then the primary investigators will conduct a statistical review of the data. Upon completion of the study any links at each of the individual sites to the de-identified patient identifier used in the secure database will be destroyed.

Data Safety and Monitoring: All data will be maintained on a password-protected computer and will not be shared with people outside of the study.

STATISTICAL METHODS, DATA ANALYSIS AND INTERPRETATION:
Methods: Retrospective chart review will occur based on those patients that fit the above inclusion/exclusion criteria. Patients that fit within the above criteria will be analyzed for eight primary outcome variables.

Primary outcome variables:
Pneumonia: defined by CDC guidelines of pneumonia[17]
(http://www.cdc.gov/Features/Pneumonia/)
Radiologic findings:
Two or more serial chest radiographs with at least one of the following:
• New or progressive and persistent infiltrate
• Consolidation
• Cavitation

Signs/Symptoms/Lab:
At least one of the following:
• Fever (>38°C or >100.4°F)
• Leukopenia (<4000 WBC/mm3) or leukocytosis (≥12,000 WBC/mm3)
• For adults ≥70 years old, altered mental status with no other recognized cause
And at least two of the following:
• New onset of purulent sputum, or change in character of sputum, or increased respiratory secretions, or increased suctioning requirements
• New onset or worsening cough, or dyspnea, or tachypnea

• Rales or bronchial breath sounds
• Worsening gas exchange (e.g., O2 desaturations (e.g., $PaO_2/FiO_2 \leq 240$), increased oxygen requirements, or increased ventilator demand)
Secondary Outcomes:
Mortality: during hospitalization or within 30 days of initial discharge
Pleural effusion: fluid identified surrounding lung tissue, seen on chest x-ray or chest CT scan without septations or evidence of pus at time of drainage
Empyema: pus around lung tissue, dictated by provider diagnosis in chart, including positive fluid culture
Tracheostomy: in hospital tracheostomy or within 30 days of initial discharge
Hospital Length of Stay: collected in hours
Ventilator Time: collected in hours

Patient admission data (including first 24 hours of hospital stay) will be collected for inclusion in possible model. Candidate variables are identified in appendix I. Data collected is described fully for admission variables in Appendix I. The objective of this model is to identify data at time of admission that would indicate poor outcomes and possibly indicate patients with higher risk of complications.

Sample Size: In order for the model to have adequate sensitivity and specificity with narrow 95% confidence intervals, it will require 300 patients for analysis. It has been shown that of the outcomes (pneumonia, mortality, pleural effusion, empyema and tracheostomy) empyema and tracheostomy are routinely the least common with a 2.9-10% occurrence.[18] Using STATA to calculate confidence interval a sample size of 300 would give CI, 0.0021- 0.0290 for these outcomes which is adequately narrow. However we intend to include roughly 20 predictor terms in the regression model, where the number of indicator terms needed for the categorical variables is included in the sum of 20. To avoid “overfitting” then, where unreliable correlation is introduced by violating the n=10 events for every predictor term, we will collect a sample size of n= 2000.[19] Level 1 trauma centers that routinely admit patients with the above criteria will be included in the creation of the model. One extra trauma center will be withheld from the initial model in order to validate the final model.

Mortality, pneumonia, pleural effusion, empyema and tracheostomy will be analyzed as binary outcomes. Regarding ICU length of stay, hospital length of stay and ventilator days will be with linear regression modeling.

Candidate variables have been identified. These variables were chosen as predictor variables as they may have impact on hospital course and can be collected for each patient at the time of admission or within 24 hours. Previous models have suggested candidate variables, which will be considered, however clear methodology was not explained in previous methods.[14,15]

For each outcome a logistic regression model will be created. Candidate predictors will all be included in initial prediction model.[20,21] This will then be reduced in stepwise fashion by manually removing variables one at a time. Variables that improve the ROC area by at least 1 point will be retained in the final model, as the goal is discrimination rather than statistical significance.

One of the selected centers will be held from initial evaluation. The model will then be externally validated using this hospital. Internal validation using bootstrapping will also be used.

Deriving a prognostic score will be done by weighing the regression coefficients.

ADMINISTRATIVE RESPONSIBILITIES:

Study Resource: All data will be maintained on password-protected computers and only participants established above will have access to this data.

REFERENCES AND APPENDICES:

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APPENDIX I

Candidate Variables:
Age
Sex
BMI
Race

Dialysis
Previous MI
COPD
Amount of home oxygen use

Previous CV disease
Diabetes
- insulin (y/n)
Previous Stroke

Alcohol
Smoking

VS in ED
-HR
-BP (SBP & DBP)
-RR
-O2 Sat

Admission Labs
-HCT/HGB
-platelets
-WBC
-lactate
-INR
-base excess
-ABG (pO2)

Payment type
Time to ED
Intubate in the field
Intubate in ED

Anticoagulation use

Mechanism

Pulmonary contusion
Location rib
Number rib fractures

APPENDIX II

Evaluation of chest CT:
Contusion: collect the follow to evaluate volume of lung contusion on CT scan
Bilateral (y/n)
Right upper (y/n)
Right middle (y/n)
Right lower (y/n)
Left upper (y/n)
Left lower (y/n)

Fracture: Collect the follow to evaluate rib fracture pattern on CT scan
Total number fractures
Flail (y/n)- defined radiographically with 2 or more consecutive ribs with 2 or more fractures
Bilateral Flail (y/n)
Bilateral fractures (y/n)
Right ribs 1-3 (y/n)
Right ribs 4-8 (y/n)
Right ribs 9-12 (y/n)

Left ribs 1-3 (y/n)
Left ribs 4-8 (y/n)
Left ribs 9-12 (y/n)
Right 1-2 with greater than 50% displacement (y/n)
Left 1-2 with greater than 50% displacement (y/n)
Bilateral 1-2 with greater than 50% displacement (y/n)
Right 3 or more with greater than 50% displacement (y/n)
Left 3 or more with greater than 50% displacement (y/n)
Bilateral 3 or more with greater than 50% displacement (y/n)
Right anterior (y/n) – sternum to mid-axilla
Left anterior (y/n) – sternum to mid-axilla
Bilateral anterior (y/n) – sternum to mid-axilla
Right lateral (y/n) – mid axilla to post axilla
Left lateral (y/n) – mid axilla to post axilla
Bilateral lateral (y/n) – mid axilla to post axilla
Right posterior (y/n) – post axilla to spine
Left posterior (y/n) – post axilla to spine
Bilateral posterior (y/n) – post axilla to spine

APPENDIX III

Other variables to be collected:

24 hour fluid:
- RBC
- platelets
- FFP
- Cryoprecipitate
- colloid
- crystalloid

Procedures performed/date time
- chest tube placement
- laparotomy
- thoracotomy
- extremity fixation
- rib fixation (with number)

Medications given
- muscle relaxers
- PCA
- Epidural

Other diagnosis during hospitalization
- DVT
- ARDS
- CRBSI
- UTI

ICU LOS

Ventilator hours
Hospital LOS
Discharge status/location
Payment type

Pulmonary Parameters

- O2 saturation at admission
- O2 requirement at admission
- Highest O2 requirement in 24 hours
- Lowest O2 saturation in first 24 hours