



2022 CWISummit Scientific Session – Friday 2B

Moderator: Joseph D. Forrester, MD, MSc, FAWM

Recorder: Marko Bukur, MD, FACS

Title:

Chest Wall Injury and Reconstructive Centers: A Single-Center Experience

Presenting author:

Jennifer Brewer, MD

Name one item still on your bucket list. Being an owner of a ford bronco

Discussant:

Carrie A. Valdez, MD, FACS

The Ohio State University, Associate Trauma Medical Director

If you were a baseball player, what would be your walk-up introduction song? Boogie shoes

Authors:

- Jennifer Brewer, MD
- Rachel Huselid, BA
- Manuel Moutinho, MD, FACS
- Vijay Jayaraman, MD, FACS
- Stephanie C. Montgomery, MD, FACS
- David S. Shapiro, MD, FACS
- Andrew R. Doben, MD, FACS

Background: New Chest Wall Injury and Reconstructive Centers (CWIRC) are emerging; this study aims to investigate the potential benefits of implementing a CWIRC at a single institution. We hypothesized that patients treated at CWIRC will have improved outcomes. Additionally, recent studies show that patients with three or more fractured ribs may benefit from surgical stabilization of rib fractures (SSRF). We hypothesize that making these procedures available as part of the center's practice guidelines will lead to improved outcomes that parallel the recent literature.

Methods: We instituted a CWIRC in 2019 at our American College of Surgeons (ACS) Level One trauma center. We retrospectively compared trauma patients with rib fractures who presented to our center 18 months before (PRE-C) and 18 months after CWIRC implementation (POST-C). Outcomes measured included mortality, length of stay (LOS), intensive care unit (ICU-LOS), readmission rates, and unplanned ICU admission. We then analyzed the subset of patients who underwent surgery in the POST-C cohort.

Results: There were 192 PRE-C patients, compared to 388 POST-C. The injury severity scores (ISS) were similar when comparing the PRE-C group to the POST-C group (17.01 vs 16.52, $p=0.6$). The mortality in PRE-C was not significantly different compared to the POST-C group (11.46% vs 8.8%, $p=0.308$). There were also no differences in LOS, ICU-LOS, readmission, and unplanned ICU admission. ICU utilization was dramatically different: PRE-C 17.8% were admitted to ICU compared to 35.6% POST-C ($p<0.0001$).

Only a handful of surgeries were performed PRE-C, and we were unable to analyze these operative patients in a systematic way. In the cohort of patients who underwent SSRF in the POST-C period, there was significantly improved mortality in the surgical (SURG) versus the non-operative (NON-



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Title:

DeepBackRib: Explainable Deep Neural Network To Predict Readmissions after Rib Fractures

Presenting author:

Jeff Choi, MD, MSc

Stanford University, DeepBackRib: Explainable Deep Neural Network To Predict Readmissions after Rib Fractures

Name one item still on your bucket list. Patagonia

Discussant:

Sarah D. Majercik, MD, MBA, FACS

Intermountain Medical Center, Surgeon

What is a current trend that you just don't understand? Gray hair on young people

Authors:

- Lakshika Tennakoon, MD MPhil
- Joseph D. Forrester, MD MSc

Background: There is growing interest in predictive machine learning algorithms. Deep neural networks yield high predictive performance, yet obscure interpretability limits clinical applicability. Building explainable algorithms for bedside application is a frontier of machine learning research. We aimed to build an explainable deep neural network that predicts readmissions after rib fractures among non-elderly adults, termed DeepBackRib. We hypothesized this deep neural network would unveil key readmission risk factors for targeted intervention and highlight considerations for building clinically applicable machine learning algorithms.

Methods: We queried the 2017 National Readmissions Database for index hospitalization encounters of adults aged 18-64 years hospitalized with multiple rib fractures (Jan-Sep). Patients with major injury in non-chest body regions (abbreviated injury score ≥ 3) were excluded to mitigate confounding. The primary outcome was 3-month readmission(s). Study cohort was split 60-20-20 into training-validation-test sets. Candidate model input features included demographic/hospital/index hospitalization characteristics, and index hospitalization International Classification of Diseases, tenth revision (ICD-10) diagnoses (Table details pre-processing strategy). Features with zero or near-zero variance were excluded.

The seven-layer DeepBackRib deep neural network comprised L2 regularization, dropout and batch normalization layers to mitigate overfitting. The model was compiled using Adam optimization and trained using early stopping for peak learning. Primary performance metrics were recall (the model would be used as a screening tool for high-risk patients) and area under the precision-recall-curve (AUPRC). We did not assess accuracy or area under the receiver operator curve as these metrics are uninformative for imbalanced datasets. Shapley Additive Explanation (SHAP) values identified



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Title:

Health Disparities and Outcomes of Surgical Stabilization of Rib Fractures among Trauma Patients: Evaluation of the ACS TQIP PUF

Presenting author:

Haley Etskovitz, DO, MBS

General Surgery Resident, PGY1

If you were a baseball player, what would be your walk-up introduction song? September by Earth Wind and Fire

Discussant:

Susan Kartiko, MD, PhD, FACS

George Washington University School of Medicine and Health Sciences, Assistant Professor

Name one item still on your bucket list. Make croissant from scratch

Authors:

- Haley Etskovitz, DO
- Daniel Ricaurte, MD
- Jonathan Gates, MD
- Oscar Serrano, MD
- Jane Keating, MD

Background: Indications for surgical stabilization of rib fractures (SSRF) are debated, but generally include flail chest, severely displaced ribs, respiratory failure, and chest wall instability. Prior studies have suggested that SSRF may decrease mortality and length of hospitalization in particular populations. This study aims to identify health disparities and outcomes pertaining to operative management in patients with traumatic rib fractures.

Methods: A retrospective study of the American College of Surgeons (ACS) Trauma Quality Improvement Program (TQIP) Participant Use File (PUF) from 2016-2019 identified patients ≥ 18 years of age with ≥ 3 rib fractures and/or patients with flail chest. We evaluated the influence of patient demographics, injury severity, and concomitant injuries on the rate of SSRF. Hospital outcomes included mortality, rates of PE/DVT, pneumonia, and unplanned admission to the ICU. Analyses included Chi-square tests of proportion and logistic regression.

Results: 190,200 patients were identified. The majority were male (68.7%), Caucasian (70.9%) and 35 to 64 years old (50.1%); 41.1% of patients also had a head injury, and 68.9% had additional thoracic injuries. Overall 2.9% percent of patients underwent SSRF. SSRF was more common among patients who were male, Caucasian, between the ages of 35-64, insured, hospitalized at a for profit hospital, and those who had a flail chest (all $p < 0.001$). Each of these factors were found to be independent predictors of SSRF when evaluated using logistic regression; the highest odds ratios were presence of flail and other thoracic injuries (OR = 9.7 and 6.3 respectively; $p < .001$). Additional logistic regression analysis demonstrated hospital mortality rate was significantly lower among SSRF patients (2.3% vs 7.6% $p < .001$) but patients without SSRF were more likely to be discharged home,



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Title:

National Demographic Disparities in Outcomes for Rib Fracture Patients

Presenting author:

Kaitlyn Petitpas, BS

Saint Francis Hospital and Medical Center/University of Connecticut School of Medicine, Medical Student

Name one item still on your bucket list. Travelling to all the continents

Discussant:

Jose Ribas M. Campos, MD, PhD

Hospital das Clinicas and Hospital Albert Einstein, Sao Paulo, Brazil

If you were a baseball player, what would be your walk-up introduction song? We Are The Champions, by Queen

Authors:

- Elan Jeremitsky, MD, FACS
- Manuel Moutinho, MD, FACS
- Thomas Russell Hill, PA-C
- Andrew R Doben, MD, FACS

Background: Disparities in healthcare outcomes of trauma patients in the United States are well established. Race and sex have significant impacts on morbidity and mortality of patients who suffer traumatic injury. We investigated the correlation between demographic factors, including race and sex, and numerous healthcare outcomes for patients with a diagnosis of a rib fracture. We hypothesize there are significant disparities in outcomes, with White and female patients having improved outcomes as compared to Non-white or male patients.

Methods: We retrospectively reviewed the National Trauma Data Bank (NTDB) for patients aged 18-99 with a diagnosis of a rib fracture (AIS Predot Codes 450200-451099) from 2018 and 2019. Demographic data including race, age, and sex was collected, and the main outcome measures were Injury Severity Score (ISS), mortality, discharge disposition, and surgical status. ICD10 procedure codes OPS104Z (1-2 ribs) and OPS204Z (>3 ribs) for surgical stabilization of rib fractures (SSRF) were identified in the cohort. Simple statistics along with multivariable cox proportional hazard ratio were performed (STATA version 17).

Results: White patients with rib fractures had a mean ISS of 15.0, significantly lower than that of Black (17.6) or Other Race (17.0) patients ($p < 0.001$). The multivariable logistic regression analysis for mortality rates demonstrated similar rates for White and Black patients (4.5% vs. 4.7%, $p = 0.34$), but a significantly increased mortality rate in Other Race patients as compared to White patients ($p = 0.022$). Additionally, female sex was associated with lower ISS and improved mortality rates versus male patients ($p < 0.001$). Upon discharge, White patients were admitted to a skilled nursing facility (SNF) 15.5% of the time, significantly more than Black (8.2%) or Other Race (9.5%) patients ($p = 0.001$).



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For our cohort of 387,716 patients, only 6,725 of these patients underwent SSRF, representing a population of less than 2% of each racial group. When evaluated by multivariable logistic regression for mortality, our SSRF population had an associated odds ratio of 0.15 (CI 0.11-0.20), significantly improved versus control ($p < 0.001$). A Cox proportional hazard ratio was performed for the event of SSRF, which showed that when compared to White persons, being Black or Other Race was associated with decreased likelihood of undergoing SSRF. The hazard ratio was 0.69 (CI 0.59-0.81) for Black Patients and 0.83 (CI 0.73-0.95) for Other Race patients, both significantly decreased rates versus White patients ($p < 0.001$).

Conclusion: Our analysis revealed significant disparities in outcomes for rib fracture patients based on race and sex demographics. White and female patients had significantly improved outcomes compared to Non-White and male patients, indicating significant gaps in healthcare and treatment for rib fractures. The improved mortality associated with SSRF continues to be promising, however, the significant disparity in rates of undergoing SSRF by race warrants further investigation into potential causes. Whether the procedure is being offered or accepted at different rates remains unclear. Further analysis is recommended to identify the source of these disparities and adjust treatment recommendations accordingly to attain more equitable health outcomes.

Notes:



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Title:

Nitinol Ribfixation, a minimal invasive alternative for conventional screw-plate fixation in all types of ribfractures, our experience in the first 100 cases

Presenting author:

Pieter Jan van Huijstee, MD

Haga Teaching Hospital, Nitinol ribfixation, a minimally invasive alternative for conventional screw-plate fixation in flailchest, multiple ribfractures and pseudoarthrosis, our experience in the first 100 patients

Name one item still on your bucket list. Driving the Mille Miglia in a Series 1 Jaguar E-type

Discussant:

Mathieu Rousseau, MD, FRCSC

University of Montreal, Thoracic Surgeon

Authors:

- Daan Ruig, MD
- Alexander Greeven, MD, PhD
- Saskia Willemsen, MD

Background: Operative fixation of multiple ribfractures and flailchest and is being performed increasingly, although consensus on indication has not yet been reached. Once indication for operation has been set, screw-plate fixation is often performed as preferred method. The aim of this study is not indication nor consensus. We present a large case-series of the first 100 patients treated by a novel screwless osteosynthesis technique using shape memory alloy, NiTiNol plates. Aim of the study was to investigate whether due to this new technique, comparable results of bony healing can be achieved. By using smaller incisions and less invasive dissection of muscle, made possible by the Nitinol plates, potentially improving outcome compared to current standards of treatment through a smaller surgical insult after the chestwall trauma.

Methods: The first 100 patients that underwent ribfixation by NiTiNol osteosynthesis for all indications including: Flail-chest, multiple ribfractures, pathological or iatrogenic fractures in oncological treatment and pseudoarthrosis in the period of January 2019 until December 2021 were included and data was collected retrospectively. Demographics, data of operation and admission as well as 90 days follow-up were analyzed using SPSS and complications were noted and compared to literature and previous results.

Results: All data of 100 patients was included, and all had at least 90 days of follow up. 49 patients (49%) with flailchest, 8 of which were anterior flails post-CPR. 28 patients (28%) with multiple ribfractures and 23 patients (23%) with one or more pseudoarthrosis, pathological or iatrogenic fractures in oncological treatment using a total of 477 NiTiNol Fixationplates. Median age was 61 years (IQR 50-72), 72 patients (72%) were male. 10 Patients (10%) developed pneumonia during admission. Wound infection was seen in 3 patients (3%). First 90 days after operation, no plate



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Title:

Surgical Rib Fixation versus Non-operative management in Trauma Patients with TBI, A National TQIP Retrospective Review

Presenting author:

James Williams, MD
Madigan Army Medical Center, Resident
What is a current trend that you just don't understand? Flat earth theory

Discussant:

Jeffrey Skubic, DO, MSc, FACS
DHR Health / UTRGV, Trauma Director
Name one item still on your bucket list. Train Jiu Jitsu in Rio de Janeiro

Authors:

- Andrew Francis, MD
- Beau Prey, MD
- Mike Weykamp, MD
- Jeff Conner, MD
- Daniel Lammers, MD
- John Kuckelman, DO
- Mike Lallelmand, MD
- Jason Bingham, MD
- Daniel Cuadrado, MD

Background: Up to one quarter of patients who present with rib fractures will also have a concomitant traumatic brain injury (TBI). Polytrauma with these concurrent injuries is associated with poorer outcomes. Despite avoidance of secondary hypoxic injury being paramount in these patients, there remains a paucity of data regarding surgical rib fixation in TBI patients. Patients that present with multiple displaced rib fractures are at increased risk for pneumonia, leading to hypoxia, prolonged mechanical ventilation, and death. However, concerns regarding perioperative hypoxia and increased intracranial pressures, related to surgical approach and patient positioning, have tempered surgical enthusiasm to perform rib fixation in TBI patients. We hypothesized that surgical fixation of rib fractures would lead to better outcomes in adult trauma patients with severe rib injuries and moderate to severe TBI when compared to patients managed non-operatively.

Methods: Using the 2017-2019 National Trauma Quality Improvement Database a retrospective review was performed on all adult trauma patients with abbreviated injury scale 3-5 rib injuries and concomitant TBI. Patients who underwent rib fixation were compared to those who were managed non-operatively with primary outcome assessed being mortality. Secondary outcomes assessed were ICU length of stay (LOS), ventilator days, and hospital LOS. Patients were further stratified into moderate (GCS 9-13) and severe (3-8) TBI. Patients who underwent surgical rib fixation were also stratified into early versus delayed fixation (>72 hours). Time to discharge following surgical fixation was also compared between early and delayed fixation patients.



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Title:

Surgical treatment of non-union rib fractures with titanium clips.

Presenting author:

Pablo Moreno de la Santa, MD, FRCS

Ribera-POVISA Hospital, Head Thoracic Surgery

If you were a baseball player, what would be your walk-up introduction song? Toreador song of Opera Carmen, Bizet

Discussant:

Anthony Bacon, MD

Intermountain Medical Center, Trauma Surgeon

Imagine you can instantly learn any language. Which would you choose? Chinese

Authors:

- Maria Dolores Polo, MD
- Carlos Delgado, MD
- Adrian Martín, MPT
- Pilar Magdalena, PhD
- Sonsoles Leal, MD
- Maria Dolores Corbacho, MD
- Maria del Carmen de la Puente, MD
- Carmen Trinidad, PhD

Background: Rib fracture nonunion represents failure of normal fracture healing. In contrast to the emerging evidence on the operative treatment of flail chest, there is a paucity of literature on the surgical treatment of rib fracture nonunion. The purpose of our study is to detail the surgical and functional outcome after rib nonunion reconstruction.

Methods: A single center retrospective cohort study was performed at a level 1 trauma center. Symptomatic rib nonunion was defined as a severe persistent localized pain associated with the nonunion of one or more rib fractures on a chest CT scan at least 3 months after the initial trauma.

Results: Between August 2008 and November 2021, 50 patients (45 men, 5 women), who presented with 108 ribs nonunion (average 1- 4) and disabling pain were treated by a single surgeon with STRACOS / STRATOS® MedXpert system with titanium clips reconstruction, no patient required bone graft. Thirty-eight patients (76%) were referred from other hospitals and 22 patients received treatment from a pain medicine specialist. Median age was 52 years (range:30-85 years). Mean BMI was 28.8 and the average length from injury to surgical rib reconstruction was 6 months (range, 3-22 months). 48% of this cohort used tobacco on a chronic basis in the year prior to repair. There was no operative mortality. Median length of stay was 4 days (range, 1-9 days). One patient developed a pleural effusion that required drainage. The mean follow-up was 54 months (range 3-154). In 6 patients it was necessary to remove the material due to a feeling of tightness, but all the fractures were healed at the time of surgery. During follow-up, there was a symptomatic breakage of the osteosynthesis clips (STRACOS®) in three patients, probably due to an open reduction of the non-union with too much tension. The osteosynthesis material was replaced, by the STRATOS® system,



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with clinical improvement in all patients. The mean postoperative sick leave was 50 days (12-137 days). Nine patients (18%) were able to return to work and / or previous activities without limitations before 1 month, 40 before two months (80%) and 46 before 3 months (92%). Residual pain with activity limitations remained in 4 patients.

Conclusion: Surgical fixation of rib nonunion should be considered as one of the indications for treatment. In our series, the use of titanium clips shows good results, with a full recovery of 92% after three months and a low complication rate. When fracture reduction requires too much tension, bar and clip fixation appears more effective.

Notes:
