



Brief Reviews

Rib Fracture Management in Older Adults: A Scoping Review

Ibraheem Qureshi¹, Ramu Kharel, MD², Nadia Mujahid, MD³, Iva Neupane, MD³

¹ New York Institute of Technology College of Osteopathic Medicine, ² Department of Emergency Medicine, Warren Alpert School of Medicine, Brown University, ³ Department of Geriatrics, Warren Alpert School of Medicine, Brown University

Keywords: rib fracture, management, older adult, multidisciplinary, trauma, geriatrics, incentive spirometry, pain management

<https://doi.org/10.56305/001c.82211>

Journal of Brown Hospital Medicine

Vol. 2, Issue 3, 2023

Background: Unique challenges posed by caring for patients of geriatric age, require concurrent management of chronic comorbidities and strategies to avoid or minimize complications related to the injury and/or hospitalization. The presentation in this population of two or more rib fractures is associated higher morbidity and mortality compared to a younger age group. A lack of guidelines regarding the management of multiple rib fractures in the elderly for primary care providers in the community and the complexity of rib fracture management led to reviewing available evidence regarding various approaches to rib fracture management. **Methods:** Online databases (PubMed and MEDLINE) were used to identify 57 publications between 2000 and 2022 regarding the management of multiple rib fractures. **Results:** The majority of publications were retrospective studies and observational cohort studies (56%). 32% of studies were review articles, meta-analyses, and guidelines. Three articles (5.3%) were randomized control studies. Four articles (7%) cited statistics from a national resource. **Conclusions:** The management of rib fractures is predominantly non-surgical, managed with pain control and respiratory rehabilitation. Triaging protocols, available to healthcare providers in outpatient clinics, urgent care centers, and emergency departments, to identify the most vulnerable patients with rib fractures in a timely fashion likely help expedite the level of care they need. A comprehensive treatment team includes not only the primary trauma team (consisting of emergency physicians/trauma surgeons, trauma nurses, and mid-level practitioners) but also incorporates a multidisciplinary team with the early involvement of a geriatrician, physical therapist, anesthesiologist, social worker, and respiratory therapist when required to improve ventilation, breathing and patient comfort.

INTRODUCTION

Rib fractures result in 248,000 emergency department visits and 48,000 hospital admissions annually in the United States.¹ A National Inpatient Sample study revealed 373,053 rib fracture hospitalizations between 2007 and 2016, with 85% of patients presenting with multiple rib fractures.² This study also indicated a significant increase in the financial burden of rib fracture hospitalization, rising from an estimated \$209 million per annum in 2007 to \$469 million per annum in 2016. One cohort study estimated a rib fracture incidence of 3.5 per 1,000 persons per year, with 24% of all non-spinal fractures being rib fractures.³ Up to 94% of rib fracture patients also have additional injuries with more than 50% requiring immediate surgery or admission to the Intensive Care Unit (ICU) level of care.⁴

The majority of rib fractures occur in older adults: patients who are 65 years of age or older.⁵ According to the United States (US) Census, there are 56 million adults over the age of 65 years, 16.8% of the total population.⁶ Hospitals in the US are now experiencing a higher volume of geriatrics patients and are faced with managing the health-

related challenges this demographic brings. Older adults tend to be at heightened risk for respiratory complications following rib fractures such as pneumonia, acute respiratory distress syndrome, pulmonary embolism, pneumothorax, emphysema, and aspiration pneumonia.⁷ The mortality rate for rib fractures is substantial, approximately 10% for all ages.⁸ Although likely confounded by other concurrent traumatic injuries, such as head trauma, a retrospective study showed an increased mortality risk in patients older than 65.⁹ Each additional rib fracture in older adults compared to younger patients increases mortality by 19% and the risk of pneumonia by 27%.¹⁰ Data support a direct correlation between increasing numbers of rib fractures and increased pulmonary morbidity and mortality, with patients presenting with six or more rib fractures being at a higher risk for death from causes unrelated to the rib fracture.⁷ In the case of flail chest, which occurs when multiple ribs are broken in succession causing a paradoxical movement of the broken ribs, treatment in the intensive care unit (ICU) along with implementation of mechanical ventilation, chest tubes, epidural catheters, and/or surgical fixation is needed. A retrospective study on the Na-

Table 1. Trauma and Multidisciplinary Team Members and Roles

Team Members	Role
Trauma Team	Their roles encompass initial assessment, stabilization, surgical intervention, diagnostic imaging, laboratory testing, respiratory support, emotional support, and rehabilitation to optimize patient outcomes.
Emergency Physicians	Initial stabilization and assessment of trauma patients in the emergency department.
Trauma Surgeon	Surgical treatment for life threatening injuries such as flail rib.
Trauma Nurse	Assist in direct patient care and trauma procedures alongside physicians.
Mid-Level Practitioner	Nurse or physician assistant helping diagnose and treat patients.
Multidisciplinary Team	This team comprises healthcare professionals from different specialties who collaborate to provide comprehensive care for trauma patients.
Geriatrician	A geriatrician specializes in the medical care of older adults and can contribute their expertise in managing injuries and conditions specific to elderly trauma patients.
Physical Therapist	A physical therapist helps trauma patients with rehabilitation and recovery by designing and implementing exercises, therapies, and treatments to restore mobility and functionality.
Anesthesiologist	An anesthesiologist administers anesthesia to trauma patients during surgical procedures or provides pain management services, ensuring the patient's comfort and safety.
Social Worker	A social worker assists trauma patients and their families in coping with the emotional, social, and practical aspects of trauma, including providing counseling, connecting them to resources, and coordinating post-discharge care.
Respiratory Therapist	A respiratory therapist specializes in evaluating and treating patients with respiratory conditions, including trauma patients who may require respiratory support or monitoring.

tional Trauma Data Bank found 82% of flail chest injuries required ICU admission.¹¹ After adjusting for injury severity, comorbidities, and multiple rib fractures, patients 65 years and older have five times the odds of dying compared to younger age group.¹² Patients sustaining blunt chest trauma and minor rib fractures should be admitted for close observation when presenting with subcutaneous emphysema because of possible delayed presentation of pneumothorax.¹³

Most rib fracture patients receive non-surgical management, and heal without significant complications. In the vulnerable geriatric population, this period of healing is crucial and requires additional multidisciplinary care. Lack of guidelines regarding the management of multiple rib fractures in older adults and concern for overuse of opiate pain medications by providers in this population led us to a scoping review of the evidence. We describe the most common causes of rib fractures, their management, the roles of various trauma and multidisciplinary team members involved in treating rib fractures ([Table 1](#)) and the utility of a multidisciplinary approach.

METHODS

Our review was drafted via the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) protocols. Articles included in this review focused on the causes, management, and existing protocols on rib fracture management. Peer-reviewed journal papers were included if they were published between the period of years 2000 – 2022, involved human participants and described management of rib fractures. Quantitative, qualitative, and mixed-method studies from PubMed and MEDLINE were included to consider different aspects of measuring treatment. Pa-

pers were excluded if they did not fit into the conceptual framework of the study.

RESULTS

A total of 57 articles were included in the scoping review. Information regarding rib fractures in older adults was organized in multiple categories. The first category was the causes and prevalence of rib fractures, followed by management of rib fractures. The third category was common causes for hospitalization and life-threatening complications, particularly in the presence of multiple rib fractures. Special attention was paid to pain management modalities and respiratory expansion techniques. Lastly, the utility of multidisciplinary approaches tailored to the needs and risks of geriatric patients and existing current protocols were reviewed.

A. CAUSES OF RIBS FRACTURE IN OLDER ADULTS

Blunt or penetrating trauma causes rib fractures. Two leading causes of these traumas in the older population are falls and motor vehicle accidents (MVA). Other mechanisms include gunshot injuries, pathological fractures, and stress fractures. A study that analyzed nearly 24,000 patients aged 65 years and older, between 2015-2016, reported the leading cause for rib fracture to be fall (67.6%) followed by transportation-related injuries (24.1%) and other or unspecified causes (8.3%).¹⁴

FALLS

While most rib fractures in young adults result from high-energy trauma, the geriatric group tends to be more susceptible to rib fractures from minor traumas, such as a fall from a standing height.¹⁵ Low bone mass, slow gait speed, falling, impaired vision, and decreased muscle strength puts them at higher risk of falls.¹⁶ Osteoporosis, common in the geriatric age group, increases the risk of fracture. Up to 49 million people in 9 industrialized countries in North America, Europe, Japan, and Australia have met the World Health Organization's criteria for osteoporosis.¹⁷

A cohort study found that low bone mineral density (BMD) at the femoral neck and lumbar spine was a strongly associated with rib fracture.¹⁸ Those with a rib fracture had a significantly lower femoral neck BMD. Men with a fracture had a BMD of 0.86 compared to a BMD of 0.94 for those without. The same trend was seen in women (Fracture: 0.84, Non-Fracture: 0.75).¹⁸ Low BMD and osteoporosis are common in women due to estrogen deficiencies after menopause.¹⁵

Prolonged use of glucocorticoids and cigarette smoking are some of the risk factors associated with bone loss and osteoporosis.^{16,19,20}

MOTOR VEHICLE ACCIDENTS

According to the Federal Highway Administration, licensed drivers aged 65 or older have increased dramatically since the year 2000.²¹ One study showed that older drivers, 70 years and above, have a higher fatality rate per 1,000 crashes compared to middle-aged drivers.²² A study conducted on the Crash Injury Research and Engineering Network (CIREN) database found that most rib fractures in the geriatric population are caused by impact with safety belts or airbags. Specifically, 92% of 211 patients aged 65 to 79 and 90.4% of 76 patients aged 80 and above had rib fractures.²³ This may be due to age-related changes in vision, physical functioning, reasoning, and memory, as well as the impact of underlying diseases and medications altering older adults' driving abilities.²⁴ Adults older than 65 are at a higher risk of suffering traumatic injuries from MVAs.

B. MANAGEMENT OF ISOLATED RIBS FRACTURE

A crucial step in the management of isolated multiple rib fractures is deciding the necessity of hospitalization of the patient. The initial encounter and diagnosis of rib fractures often occur at primary care offices, urgent care centers, and emergency departments. Hospitalization is warranted in cases of rib fracture complications such as pneumothorax, hemothorax, lung contusion, flail chest, collapsed lung, and respiratory failure. Pain management coupled with pulmonary toilet using assistive devices has shown to reduce pulmonary complications.^{25,26} Surgical treatment can be indicated by more severe symptoms such as flail chest, chest wall deformity, and symptoms associated with nonunion.²⁷

According to multiple studies, hospitalization is necessary for individuals sustaining multiple rib fractures.^{7,27,28} One study reported higher mortality associated with 3 or more posterior rib fractures.²⁸ Fligel et. al. found that six or more rib fractures is a significant risk factor for death from causes unrelated to ribs fracture.⁷ The average age for surviving rib fracture patients was 47 years old, while the average age of non-surviving patients was 52. Mortality and other adverse effects increased when multiple ribs were broken. Mortality was 5.82% in patients with two rib fractures rising to 15.03% in patients with seven rib fractures. Fifty five percent of patients with five rib fractures had thoracic injuries which increased with each successive rib fracture. The incidence grew to 100% with eight or more rib fractures. A similar pattern was also seen in head injuries with a frequency of 40% of patients with five rib fractures having head injuries and up to 70% of patients with seven rib fractures. Complications such as pneumothorax, empyema, and aspiration pneumonia also showed a significantly increased incidence when the number of fractured ribs increased.

When observing geriatric patients, higher rates of pneumonia were seen with each additional rib fracture compared to younger patients.²⁷ In 1-2 rib fractures, 18 % of older patients developed pneumonia compared to 2% of younger patients. The disparity increased further when looking at six fractures or more, where older adults had pneumonia incidence of 55% compared to 20% in younger patients. Since the force required to fracture multiple ribs is often enough to injure the upper torso, it may cause multiple associated complications, especially in the case of geriatric patients, necessitating transfer to a trauma center. Once hospitalized, the focus is on providing pain control and respiratory volume expansion strategies. Improved oxygenation and peak expiratory flow reflect the patient's ability to take deep breaths and clear respiratory secretions.²⁹

RIB FRACTURE MANAGEMENT

1. PAIN MANAGEMENT

Ineffective management of pain leads to decreased chest mobility and intercostal muscle spasm around the site of the fracture, which subsequently leads to decreased tidal volume and reduced cough. This exacerbates the risk of atelectasis in older adults in sitting positions for prolonged times, who are already predisposed to a reduced lung volume due to aging and any underlying chronic respiratory conditions such as asthma or chronic obstructive pulmonary disease.

A multimodal pain management approach is likely to address pain while minimizing side effects in the geriatric population ([Table 2](#)).^{30,31}

1. Scheduled acetaminophen (oral or intravenous): acetaminophen has relatively fewer side effects and is better tolerated, however, the effect is modest.³²
2. Opiates (oral or intravenous): should be minimized and started at the lowest effective dose. Balancing se-

Table 2. List of Multimodal Pain Management Treatments

Multimodal Pain Management Treatments	
Acetaminophen	This over-the-counter medication is commonly used for mild to moderate pain relief and is often combined with other pain management techniques.
Opiates	For severe pain, opiates may be prescribed for short-term use. However, their use should be carefully monitored due to the risk of severe side effects.
Topical Medication	These include creams, gels, or patches containing lidocaine or capsaicin that provide localized pain relief.
Regional Nerve Block	By injecting anesthetics or anti-inflammatory medications around specific nerves, nerve blocks can temporarily disrupt pain signals.
Epidural Analgesia	These involve injecting medication into the space around the spinal cord to provide pain relief.
Non-steroidal anti-inflammatory drugs (NSAIDs)	Medications such as ibuprofen or naproxen sodium are often used to reduce inflammation and provide pain relief.

dation is important as patient respiratory volume and status should not be compromised.

3. Topical medication: lidocaine patch can be a safe, effective adjunct for rib fracture pain.³³
4. Insufficient pain management that does not relieve discomfort and/or concern for adverse effects including sedation or respiratory depression, the early involvement of the anesthesia team for regional nerve block, thoracic epidural, or paravertebral block may be beneficial. Trained emergency physicians can also conduct regional blocks including the serratus anterior block. Epidural analgesia has been shown to reduce pain in traumatic rib fractures when compared to intravenous analgesia, paravertebral block, and intercostal block.³⁴ In the geriatric population, the risk of infection, prior spinal surgeries, and the use of anticoagulation/antiplatelet agents add an additional challenge to this mode of pain control. A multicenter cohort of injured older adults with multiple rib fractures reported up to 35% lower risk of delirium with regional anesthesia.³⁵ Use of anesthetics without opiates is also beneficial in adults older than 65 by reducing/avoiding opiate-related adverse effects.³⁶⁻³⁸
5. Non-steroidal anti-inflammatory drugs (NSAIDs) should be reserved for case-by-case due to many potential side effects, including renal, cardiac and gastrointestinal (GI) toxicity. Geriatric patients are likely to have underlying comorbid conditions including GI or renal disease that limits the use of NSAIDs.³⁹

2. RESPIRATORY FUNCTION/VOLUME EXPANSION STRATEGIES

In managing pulmonary complications of rib fractures, a comprehensive approach that encourages deep breathing, active coughing, and treatment of underlying pulmonary conditions is important. The utilization of assistive devices such as incentive spirometry (IS) and oscillatory airway clearance devices (OACD) can also play a crucial role in promoting lung function. These two devices help optimize breathing dynamics for patients.

A randomized controlled trial (RCT) in 2019 demonstrated IS reduced pulmonary complications and improved pulmonary function in patients with rib fractures.²⁵ The

American Association of Respiratory Care recommends this inspiratory maneuver, which involves maximal inspiration performed over five seconds followed by breath holding and normal exhalation.⁴⁰ This can be challenging in geriatric patients due to conditions such as delirium and dementia, for whom OACD are an adjunct option that provides positive vibratory expiratory pressure treatment. An RCT compared IS with OACD after lung resection surgery and reported similar pulmonary function after surgery. OACD may be more comfortable for the patient to use.⁴¹

C. MULTIDISCIPLINARY APPROACH

Trauma nurses have been shown to have a critical role in documenting and tracking IS volume in patients with rib fractures, promoting early detection of respiratory decline.⁴² Early involvement of respiratory therapists, physical therapists, and occupational therapists has been associated with decreased ICU and hospital LOS.⁴³ A systematic review showed acupuncture, transcutaneous electrical nerve stimulation (TENS), noninvasive ventilation (NIV) modalities, physiotherapy techniques, and multidisciplinary pathways used alongside pharmacological interventions are effective for use in the treatment of acute rib fractures.⁴⁴ Grammatopoulou et al. investigated the effect of the active cycle of breathing technique (ACBT), added to standard physiotherapy management (body positioning, IS, supported coughing, and early mobilization), and analgesia administration on pain levels in adult patients with three or more rib fractures. This reduced pain on days 3-7 of hospitalization.⁴⁵

In geriatric patients, the overall medical and cognitive status affects recovery and hospital LOS. Many of these patients are taking antiplatelet and anticoagulation agents, putting them at higher risk of developing hemothorax and subsequent need for chest tube drainage. Apart from pulmonary complications, these patients are also at a higher risk for delirium. The medical or geriatric team can help facilitate healing and recovery by adjusting medication, and preventing and managing delirium, medication-induced constipation, and GI bleeding (NSAIDs). Medical management of comorbidities such as hypertension, anemia, fluid overload, and diabetes needs concurrent management. Sec-

ondary fracture prevention strategies can be initiated during hospitalization. The involvement of a geriatrician in a trauma service to co-manage patients with multiple rib fractures has shown mortality benefits in patients greater than 80 years old.⁴⁶ Superiorly located rib fractures represent more intense trauma to the chest and are associated with cardiac and great vessel injury whereas inferior ribs risk splenic and liver laceration which might require assistance from subspecialties including interventional radiology.⁴⁷

Rib fractures take approximately 12 weeks to heal and patients typically regain up to 84% of their expected forced vital capacity, but it may be longer for older adults with underlying osteoporosis.⁴⁸ Post hospitalization, a geriatric patient may require time in an acute rehabilitation or skilled nursing facility. At home they may require ongoing physical therapy and visiting nurse services. The involvement of a social worker and/or case manager may smoothen the transition of care.

Follow-up with the primary provider and/or a trauma surgeon is necessary to ensure healing and manage medications, especially in the case of chronic rib pain, persistence of pain after 3 months, which may disrupt daily function. Hearing, vision impairment also need to be addressed for recurrent fall prevention. In patients younger than 65 years, one study reported 9% of rib fracture patients were prescribed opioids on discharge but this number may be greater in older adults due to limitations of other pain management options.⁴⁹ Household measures include avoiding area rugs, and providing lighting, grab bars, handicap access, and assistive devices for safe ambulation. Home safety assessments can identify and address these issues.

On a community level, educating and enforcing road safety precautions such as seat belts, avoiding highways and unfamiliar roads, avoiding nighttime driving, driving sober, and undergoing a driving evaluation will likely help older patients stay safe and avoid traumatic injuries. Clear road signs, adults older than 65 cautionary crossing signs in suitable areas and illuminating lights in traffic signals/crossings are likely to help safe driving for older drivers who might have compromised visual acuity and neck movement-related disease. Education on smartphone taxi service apps may give older drivers an alternative method of transport.⁵⁰

D. RIB FRACTURE PROTOCOL FOR OLDER ADULTS

Trauma centers, nationally, have shown better outcomes when rib fracture protocols were geared towards geriatric age groups. These protocols not only help to triage high-risk patients but also incorporate timely involvement of a multidisciplinary team. It is important to note that protocols can vary by center and can lead to different paths of management for similar cases. A study from North Carolina noted lower ICU admissions, fewer pulmonary complications, and shorter hospital lengths of stay (LOS) in a center with a rib fracture protocol.⁵¹ A level 1 trauma center in Rhode Island established a geriatric rib fracture pro-

tol that resulted in decreased ICU LOS, mortality, and reduced need for mechanical ventilation.⁵² Multidisciplinary rib fracture protocol in a level 1 trauma center in Washington State incorporated early initiation of multimodal pain therapy, and frequent function-based scoring driven by nursing staff and the patient.⁵³ The Western Trauma Association developed recommendations based on institutional practice and experience for rib fractures. They recommend admitting patients with more than 2 rib fractures and aged 65 or older to the ICU as well as patients with severe rib fractures, respiratory compromise, or patients who could not manage their pain.⁵⁴

While hospital-based admission protocols help triage patients during initial encounters, providers face challenges regarding prognostication in geriatric age groups. Rib Fracture Frailty Index (RFF), which Choi et. al. reported to be a practical frailty risk stratification tool for geriatric patients with multiple rib fractures, may be helpful.⁵⁵ When compared to three of the most popular scoring, a review noted that the Chest Trauma Score (CTS) was best suited to assess the risk in the geriatric population with a rib fracture, predicting poor outcomes within 24 hours of admission and thus likely requiring ICU admission.⁵⁶ PIC (Pain, IS, and Cough ability) scores have shown to be a moderate discriminator of critical care need, and when PIC score delineation for ICU need appears to be at 7 or less; this threshold can be used during admission triage to guide care.⁵⁷

DISCUSSION

In this scoping review, we identified 57 papers published since the year 2000 regarding the complexity of management of multiple rib fractures. Older adults are at higher risk of rib fracture even with minor trauma and also at increased risk for complications. Although the number of isolated rib fractures gives a good guideline to the level of care, the location of the injury also deserves attention. Once triaged, a multidisciplinary team approach for rib fracture management can help to provide optimal care for patients. (Figure 1).

Our study has its limitations. We found that the mechanism of injury, the multimodal analgesia and protocol driven management were equally important. We noted that it remains a challenge to predict which patient might need more intense measures for pain management and who will require a chest tube. We also do not know to what extent frailty plays a role in the outcome of these older adults. The role of palliative care in severe trauma cases and very old patients is likely important but unclear.

In conclusion, we recommend an interdisciplinary team approach (Figure 1) in the management of multiple rib fractures. Randomized controlled trial is needed to explore the efficacy of collaborative protocol-driven management to develop guidelines for rib fracture in the geriatric population. Collaboration of outpatient providers, urgent care, and emergency department doctors who often see the patient for the first time, along with the trauma surgery team/ICU team, geriatric medicine, anesthesia, PT, and caregiver

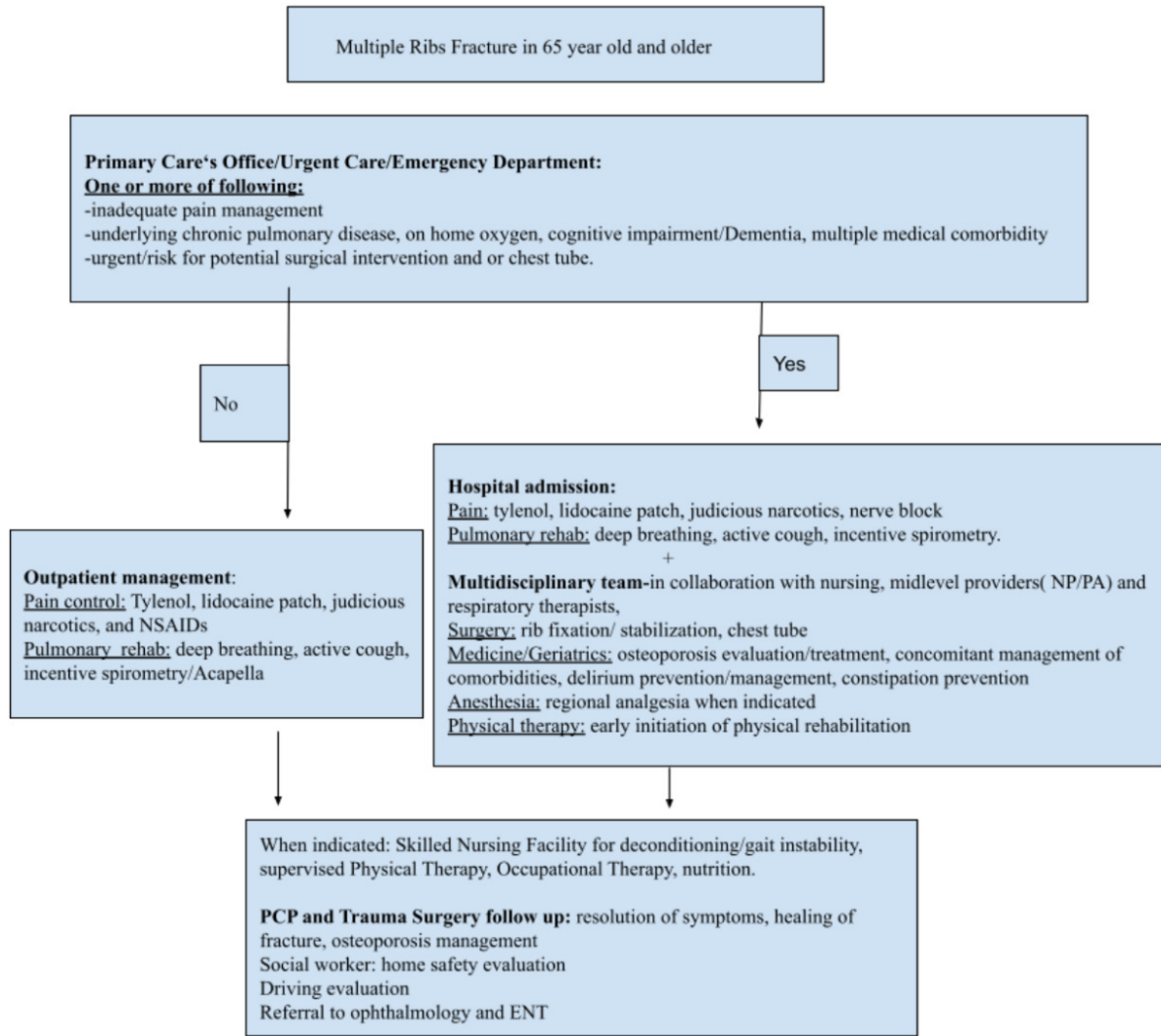


Figure 1. Management of Isolated Multiple Rib Fractures in Older Adults

is of utmost importance to improve outcomes in older adults with rib fracture injuries.

Key Points

1. Multiple rib fractures in older adults are associated with higher morbidity and mortality.
2. Rib fracture protocols in trauma centers have helped triage vulnerable older adults and decide whether they need a higher level of care.
3. A multidisciplinary team consisting of an emergency specialist and/or trauma surgeon, geriatrician, physical therapist, anesthesiologist, and respiratory therapist can potentially help improve outcomes in hospitalized geriatric patients with rib fractures alongside pain management and respiratory rehabilitation which remain the cornerstone for rib fracture management.

AUTHOR CONTRIBUTIONS

All authors have reviewed the final manuscript prior to submission. All the authors have contributed significantly to the manuscript, per the International Committee of Medical Journal Editors criteria of authorship.

- Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND
- Drafting the work or revising it critically for important intellectual content; AND
- Final approval of the version to be published; AND
- Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

DISCLOSURES/CONFLICTS OF INTEREST

The authors declare they have no conflicts of interest.

ACKNOWLEDGMENTS

None.

CORRESPONDING AUTHOR

Iva Neupane, MD
Assistant Professor of Medicine
593 Eddy St
Providence, RI, USA
Email: iva_neupane@brown.edu

Submitted: April 17, 2023 EDT, Accepted: June 28, 2023 EDT



This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CCBY-NC-4.0). View this license's legal deed at <https://creativecommons.org/licenses/by-nc/4.0> and legal code at <https://creativecommons.org/licenses/by-nc/4.0/legalcode> for more information.

REFERENCES

1. Martin TJ, Eltorai AS, Dunn R, et al. Clinical management of rib fractures and methods for prevention of pulmonary complications: A review. *Injury*. 2019;50(6):1159-1165. doi:10.1016/j.injury.2019.04.020
2. Sarode AL, Ho VP, Pieracci FM, Moorman ML, Towe CW. The financial burden of rib fractures: National estimates 2007 to 2016. *Injury*. 2021;52(8):2180-2187. doi:10.1016/j.injury.2021.05.027
3. Barrett-Connor E, Nielson CM, Orwoll E, Bauer DC, Cauley JA, for the Osteoporotic Fractures in Men (MrOS) Study Group. Epidemiology of rib fractures in older men: Osteoporotic Fractures in Men (MrOS) prospective cohort study. *BMJ*. 2010;340:c1069-c1069. doi:10.1136/bmj.c1069
4. Talbot BS, Gange CP Jr, Chaturvedi A, Klionsky N, Hobbs SK, Chaturvedi A. Traumatic Rib Injury: Patterns, Imaging Pitfalls, Complications, and Treatment. *Radiographics*. 2017;37(2):628-651. doi:10.1148/rg.2017160100
5. National Trauma Data Bank (NTDB). American College of Surgeons. <http://www.facs.org/trauma/ntdb.html>
6. U.S. Census Bureau. Explore Census Data. <https://data.census.gov/profile?g=0100000US>
7. Fligel BT, Luchette FA, Reed RL, et al. Half-a-dozen ribs: the breakpoint for mortality. *Surgery*. 2005;138(4):717-725. doi:10.1016/j.surg.2005.07.022
8. Coary R, Skerritt C, Carey A, Rudd S, Shipway D. New horizons in rib fracture management in the older adult. *Age Ageing*. 2020;49(2):161-167. doi:10.1093/ageing/afz157
9. Marini CP, Petrone P, Soto-Sánchez A, García-Santos E, Stoller C, Verde J. Predictors of mortality in patients with rib fractures. *Eur J Trauma Emerg Surg*. 2021;47(5):1527-1534. doi:10.1007/s00068-019-01183-5
10. Bulger EM, Arneson MA, Mock CN, Jurkovich GJ. Rib fractures in the elderly. *J Trauma*. 2000;48(6):1040-1047. doi:10.1097/00005373-200006000-00007
11. Dehghan N, de Mestral C, McKee MD, Schemitsch EH, Nathens A. Flail chest injuries: a review of outcomes and treatment practices from the National Trauma Data Bank. *J Trauma Acute Care Surg*. 2014;76(2):462-468. doi:10.1097/ta.0000000000000086
12. Bergeron E, Lavoie A, Clas D, et al. Elderly trauma patients with rib fractures are at greater risk of death and pneumonia. *J Trauma*. 2003;54(3):478-485. doi:10.1097/01.ta.0000037095.83469.4c
13. Lu MS, Huang YK, Liu YH, Liu HP, Kao CL. Delayed pneumothorax complicating minor rib fracture after chest trauma. *Am J Emerg Med*. 2008;26(5):551-554. doi:10.1016/j.ajem.2007.08.022
14. Bowman JA, Nuño M, Jurkovich GJ, Utter GH. Association of Hospital-Level Intensive Care Unit Use and Outcomes in Older Patients With Isolated Rib Fractures. *JAMA Netw Open*. 2020;3(11):e2026500. doi:10.1001/jamanetworkopen.2020.26500
15. Lane NE. Epidemiology, etiology, and diagnosis of osteoporosis. *Am J Obstet Gynecol*. 2006;194(2 Suppl):S3-S11. doi:10.1016/j.ajog.2005.08.047
16. NIH Consensus Development Panel on Osteoporosis Prevention, Diagnosis, and Therapy. Osteoporosis prevention, diagnosis, and therapy. *JAMA*. 2001;285(6):785-795. doi:10.1001/jama.285.6.785
17. Wade SW, Strader C, Fitzpatrick LA, Anthony MS, O'Malley CD. Estimating prevalence of osteoporosis: examples from industrialized countries. *Arch Osteoporos*. 2014;9(1):182. doi:10.1007/s11657-014-0182-3
18. Prins JTH, Van Lieshout EMM, Reijnders MRL, Verhofstad MHJ, Wijffels MME. Rib fractures after blunt thoracic trauma in patients with normal versus diminished bone mineral density: a retrospective cohort study. *Osteoporos Int*. 2020;31(2):225-231. doi:10.1007/s00198-019-05219-9
19. Cherian KE, Kapoor N, Paul TV. Glucocorticoid-induced Osteoporosis. *Indian J Endocr Metab*. 2017;21(5):652-654. doi:10.4103/ijem.ijem_187_17
20. Al-Bashaireh AM, Haddad LG, Weaver M, Chengguo X, Kelly DL, Yoon S. The Effect of Tobacco Smoking on Bone Mass: An Overview of Pathophysiologic Mechanisms. *J Osteoporos*. 2018;2018:1206235. doi:10.1155/2018/1206235
21. Federal Highway Administration, Department of Transportation (US). *Highway Statistics 2020*. FHWA; 2021. <https://www.fhwa.dot.gov/policyinformation/statistics/2020/>

22. Cox AE, Cicchino JB. Continued trends in older driver crash involvement rates in the United States: Data through 2017–2018. *J Safety Res.* 2021;77:288-295. doi:10.1016/j.jsr.2021.03.013
23. Bansal V, Conroy C, Chang D, Tominaga GT, Coimbra R. Rib and sternum fractures in the elderly and extreme elderly following motor vehicle crashes. *Accid Anal Prev.* 2011;43(3):661-665. doi:10.1016/j.aap.2010.10.009
24. Pomidor A, ed. *Clinician's Guide to Assessing and Counseling Older Drivers*. 4th ed. The American Geriatrics Society; 2019. <https://geriatricscareonline.org/toc/clinicians-guide-to-assessing-and-counseling-older-drivers-4th-edition/B047>
25. Sum SK, Peng YC, Yin SY, et al. Using an incentive spirometer reduces pulmonary complications in patients with traumatic rib fractures: a randomized controlled trial. *Trials.* 2019;20(1):797. doi:10.1186/s13063-019-3943-x
26. Wei S, Green C, Truong VTT, et al. Implementation of a multi-modal pain regimen to decrease inpatient opioid exposure after injury. *Am J Surg.* 2019;218(6):1122-1127. doi:10.1016/j.amjsurg.2019.09.032
27. Senekjian L, Nirula R. Rib Fracture Fixation: Indications and Outcomes. *Crit Care Clin.* 2017;33(1):153-165. doi:10.1016/j.ccc.2016.08.009
28. Haines KL, Zens T, Warner-Hillard C, DeSouza E, Jung HS, Agarwal S. Rib Fracture Location Should Be Evaluated When Predicting Morbidity and Mortality in Trauma Patients. *Am Surg.* 2018;84(9):1462-1465. doi:10.1177/000313481808400950
29. Ekpe EE, Eyo C. Effect of analgesia on the changes in respiratory parameters in blunt chest injury with multiple rib fractures. *Ann Afr Med.* 2017;16(3):120-126. doi:10.4103/aam.aam_73_16
30. Burton SW, Riojas C, Gesin G, et al. Multimodal analgesia reduces opioid requirements in trauma patients with rib fractures. *J Trauma Acute Care Surg.* 2021;92(3):588-596. doi:10.1097/ta.0000000000003486
31. Wardhan R. Assessment and management of rib fracture pain in geriatric population: an ode to old age. *Curr Opin Anaesthesiol.* 2013;26(5):626-631. doi:10.1097/01.aco.0000432516.93715.a7
32. Esmailian M, Moshiri R, Zamani M. Comparison of the Analgesic Effect of Intravenous Acetaminophen and Morphine Sulfate in Rib Fracture; a Randomized Double-Blind Clinical Trial. *Emerg (Tehran).* 2015;3(3):99-102.
33. Zink KA, Mayberry JC, Peck EG, Schreiber MA. Lidocaine patches reduce pain in trauma patients with rib fractures. *Am Surg.* 2011;77(4):438-442. doi:10.1177/000313481107700419
34. Peek J, Smeeing DPJ, Hietbrink F, Houwert RM, Marsman M, de Jong MB. Comparison of analgesic interventions for traumatic rib fractures: a systematic review and meta-analysis. *Eur J Trauma Emerg Surg.* 2019;45(4):597-622. doi:10.1007/s00068-018-0918-7
35. O'Connell KM, Patel KV, Powelson E, et al. Use of regional analgesia and risk of delirium in older adults with multiple rib fractures: An Eastern Association for the Surgery of Trauma multicenter study. *J Trauma Acute Care Surg.* 2021;91(2):265-271. doi:10.1097/ta.0000000000003258
36. Cohendy R, Brougere A, Cuvillon P. Anaesthesia in the older patient. *Curr Opin Clin Nutr Metab Care.* 2005;8(1):17-21. doi:10.1097/00075197-200501000-00004
37. Häusler G, van der Vet PCR, Beeres FJP, Kaufman T, Kusen JQ, Poblete B. The impact of loco-regional anaesthesia on postoperative opioid use in elderly hip fracture patients: an observational study. *Eur J Trauma Emerg Surg.* 2022;48(4):2943-2952. doi:10.1007/s00068-021-01674-4
38. Hofstad JK, Klaksvik J, Wik TS. Intraoperatively local infiltration anesthesia in hemiarthroplasty patients reduces the needs of opioids: a randomized, double-blind, placebo-controlled trial with 96 patients in a fast-track hip fracture setting. *Acta Orthop.* 2022;93:111-116. doi:10.2340/17453674.2021.806
39. Denic A, Glasscock RJ, Rule AD. Structural and Functional Changes With the Aging Kidney. *Adv Chronic Kidney Dis.* 2016;23(1):19-28. doi:10.1053/j.ackd.2015.08.004
40. Restrepo RD, Wettstein R, Wittnebel L, Tracy M. Incentive spirometry: 2011. *Respir Care.* 2011;56(10):1600-1604. doi:10.4187/respcare.01471
41. Cho YJ, Ryu H, Lee J, et al. A randomised controlled trial comparing incentive spirometry with the Acapella® device for physiotherapy after thoracoscopic lung resection surgery. *Anaesthesia.* 2014;69(8):891-898. doi:10.1111/anae.12750
42. Brown SD, Walters MR. Patients with rib fractures: use of incentive spirometry volumes to guide care. *J Trauma Nurs.* 2012;19(2):89-93. doi:10.1097/jtn.0b013e31825629ee

43. Todd SR, McNally MM, Holcomb JB, et al. A multidisciplinary clinical pathway decreases rib fracture-associated infectious morbidity and mortality in high-risk trauma patients. *Am J Surg.* 2006;192(6):806-811. doi:10.1016/j.amjsurg.2006.08.048
44. Weinberg BJ, Roos R, van Aswegen H. Effectiveness of nonpharmacological therapeutic interventions on pain and physical function in adults with rib fractures during acute care: A systematic review and meta-analysis. *S Afr J Physiother.* 2022;78(1):1764. doi:10.4102/sajp.v78i1.1764
45. Grammatopoulou E, Belimpasaki V, Valalas A, Michos P, Skordilis E, Koutsouki D. Active cycle of breathing techniques contributes to pain reduction in patients with rib fractures. *Hellenic J Surg.* 2010;82(1):52-58. doi:10.1007/s13126-010-0009-7
46. Neupane I, Mujahid N, Zhou EP, et al. A Model of Care to Improve Survival of Older Trauma Patients: Geriatrics Comanagement. *J Gerontol A Biol Sci Med Sci.* Published online July 22, 2022:glac146. doi:10.1093/gerona/glac146
47. Rostas JW, Lively TB, Brevard SB, Simmons JD, Frotan MA, Gonzalez RP. Rib fractures and their association With solid organ injury: higher rib fractures have greater significance for solid organ injury screening. *Am J Surg.* 2017;213(4):791-797. doi:10.1016/j.amjsurg.2016.08.002
48. Bottlang M, Long WB, Phelan D, Fielder D, Madey SM. Surgical stabilization of flail chest injuries with MatrixRIB implants: a prospective observational study. *Injury.* 2013;44(2):232-238. doi:10.1016/j.injury.2012.08.011
49. Dalton MK, Chaudhary MA, Andriotti T, et al. Patterns and predictors of opioid prescribing and use after rib fractures. *Surgery.* 2020;168(4):684-689. doi:10.1016/j.surg.2020.05.015
50. Gleason SR, Silverstein NM. Challenges and Visions for the Future among Paratransit Providers. *Gerontologist.* 2022;63(4):731-740. doi:10.1093/geront/gnac148
51. Butts CC, Miller P, Nunn A, et al. RIB fracture triage pathway decreases ICU utilization, pulmonary complications and hospital length of stay. *Injury.* 2021;52(2):231-234. doi:10.1016/j.injury.2020.10.008
52. Benoit E, Stephen AH, Monaghan SF, Lueckel SN, Adams CA Jr. Geriatric Trauma. *R I Med J.* 2019;102(8):19-22.
53. Witt CE, Bulger EM. Comprehensive approach to the management of the patient with multiple rib fractures: a review and introduction of a bundled rib fracture management protocol. *Trauma Surg Acute Care Open.* 2017;2(1):e000064. doi:10.1136/tsaco-2016-000064
54. Brasel KJ, Moore EE, Albrecht RA, et al. Western Trauma Association Critical Decisions in Trauma: Management of rib fractures. *J Trauma Acute Care Surg.* 2017;82(1):200-203. doi:10.1097/ta.0000000000001301
55. Choi J, Marafino BJ, Vendrow EB, et al. Rib Fracture Frailty Index: A risk stratification tool for geriatric patients with multiple rib fractures. *J Trauma Acute Care Surg.* 2021;91(6):932-939. doi:10.1097/ta.0000000000003390
56. Fokin A, Wycech J, Crawford M, Puente I. Quantification of rib fractures by different scoring systems. *J Surg Res.* 2018;229:1-8. doi:10.1016/j.jss.2018.03.025
57. Bass GA, Stephen C, Forssten MP, et al. Admission Triage With Pain, Inspiratory Effort, Cough Score can Predict Critical Care Utilization and Length of Stay in Isolated Chest Wall Injury. *J Surg Res.* 2022;277:310-318. doi:10.1016/j.jss.2022.04.001