Readmission for pleural space complications after chest wall injury: Who is at risk?

Annika B. Kay, PA-C, MPAS, David S. Morris, MD, FACS, Scott Gardner, PA-C, MMSc, Sarah Majercik, MD, MBA, FACS, *and* **Thomas W. White, MD, FACS**, *Murray, Utah*

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BACKGROUND: Little is known about patient characteristics predicting postdischarge pleural space complications (PDPSCs) after thoracic trauma. We sought to analyze the patient population who required unplanned hospital readmission for PDPSC.

METHODS: Retrospective review of adult patients admitted to a Level I Trauma Center with a chest Abbreviated Injury Scale (AIS) score of 2 or greater between January 2015 and August 2020. Those readmitted within 30 days of index hospitalization discharge for PDPSC were compared with those not readmitted. Demographics, injury characteristics, surgical procedures, imaging, and readmission data were retrieved.

RESULTS: Out of 17,192 trauma evaluations, 3,412 (19.8%) suffered a chest AIS score of 2 or greater injury and 155 experienced an unplanned 30-day hospital readmission. Of those, 49 (1.4%) were readmitted for the management of PDPSC (readmit PDPSC) and were compared with patients who were not readmitted (no readmit, n = 3,257). The readmit PDPSC group was significantly older age, heavier, comprised of fewer men, and suffered a higher mean chest AIS score. The readmit PDPSC group had a significantly higher incidence of rib fractures, flail chest, pneumothorax, hemothorax, scapula fractures, and a higher rate of tube thoracostomy placement during index admission. The discharge chest X-ray in the readmit PDPSC group demonstrated a pleural space abnormality in 36 (73%) of patients. Mean time to readmission was 10.2 (7.2) days, and hospital length of stay on readmission was 5.8 (3.7) days. Pleural effusion was the most common readmission diagnosis (44 [90%]), and 42 (86%) required tube thoracostomy.

CONCLUSION: We describe the subset of chest wall injury patients who require hospital readmission for PDPSC. Characteristics from index hospitalization associated with PDPSC include older age, female sex, heavier weight, presence of rib fractures, pleural space abnormality, scapular fracture, and chest tube placement. Further studies are needed to characterize this at-risk chest wall injury population, and to determine what interventions can facilitate outpatient management of postdischarge pleural space complications and mitigate readmission risk. (*J Trauma Acute Care Surg.* 2021;91: 981–987. Copyright © 2021 Wolters Kluwer Health, Inc. All rights reserved.)

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KEY WORDS: Chest wall injury; readmission; pleural space complications.

Chest wall trauma affects 10% of injured patients and carries significant morbidity and mortality that increases with age and number of ribs fractured.[1–6] Pulmonary and pleural space complications, including pneumonia, acute respiratory distress syndrome, empyema, pneumothorax, hemothorax, retained hemothorax, and pulmonary embolus, will affect more than one third of patients.[1,4,6–11]

Unplanned hospital readmissions are associated with annual US health care costs of an estimated $423 million.[12] Because of the significant morbidity associated with unplanned readmission, emphasis has been placed on readmission rates as an area for financial and quality improvement.[13] Thirty-day readmission rates after traumatic injury range from 4.3% to 7.56%, with documented risk factors that include social vulnerabilities, comorbid disease, age, psychiatric conditions, infections and septicemia, weight loss, and trauma recidivism.[13–15] One analysis evaluated hospitalized rib fracture patients and identified an 8.3% unplanned 30-day reevaluation rate and 3.2% readmission rate for chest wall–related complaints.[16]

The definition of "delayed complications" in the literature typically describes pleural space issues that are recognized after the admission workup, but still during the inpatient phase of the initial hospitalization. Pleural space complications that develop after discharge, particularly those that necessitate hospital readmission, have not been well described. For the purpose of this analysis, they will be referred to as "postdischarge pleural space complications" (PDPSCs), defined as unexpected progression of symptoms and/or radiographic pleural space findings. Little is known about patient characteristics, injury, and management patterns that might predict PDPSC. We sought to describe and analyze the chest wall injury population who required hospital readmission within 30 days specifically for PDPSC.

PATIENTS AND METHODS

We performed a retrospective review of adult trauma patients admitted to an American College of Surgeon–verified Level I Trauma Center between January 2015 and August 2020 with a chest AIS score ≥2. We compared those who were readmitted within 30 days of index hospitalization discharge specifically for the management of PDPSC (Readmit PDPSC group) to those who were not readmitted to the hospital (no readmit group). Pregnant women, patients younger than 18 years, and prisoners were excluded (Fig. 1).

Data collected from the institutional trauma registry included age, sex, weight, comorbid conditions, including smoking, diabetes, congestive heart failure, and the use of preinjury anticoagulation. Injury data included mechanism of injury, Injury Severity Score (ISS), and Abbreviated Injury Scale (AIS) scores by body region. Abbreviated Injury Scale chest score 2 or greater was used to define the presence of thoracic injury for the purpose of defining the entire study population, and an AIS score of 3 or greater in any other body region was collected to differentiate polysystem injury from isolated chest injury patients. Details specific to the chest injury included presence of rib fractures, radiographic flail, hemothorax, pneumothorax, pulmonary contusion, clavicle, and scapular fracture. Tracked procedures included tube thoracostomy, video-assisted thoracoscopic surgery (VATS), surgical stabilization of rib fractures (SSRFs) and thoracotomy. The readmit PDPSC group was analyzed further via individual chart review to determine the exact number of ribs fractured, and quality of chest imaging. Chest

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From the Division of Trauma Services and Surgical Critical Care, Intermountain Medical Center, Murray, Utah.

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Address for reprints: Annika Bickford Kay, MPAS, PA-C, Division of Trauma Services and Surgical Critical Care, Intermountain Medical Center, 5121 South Cottonwood St, Murray, UT 84157; email: Annika.kay@imail.org.

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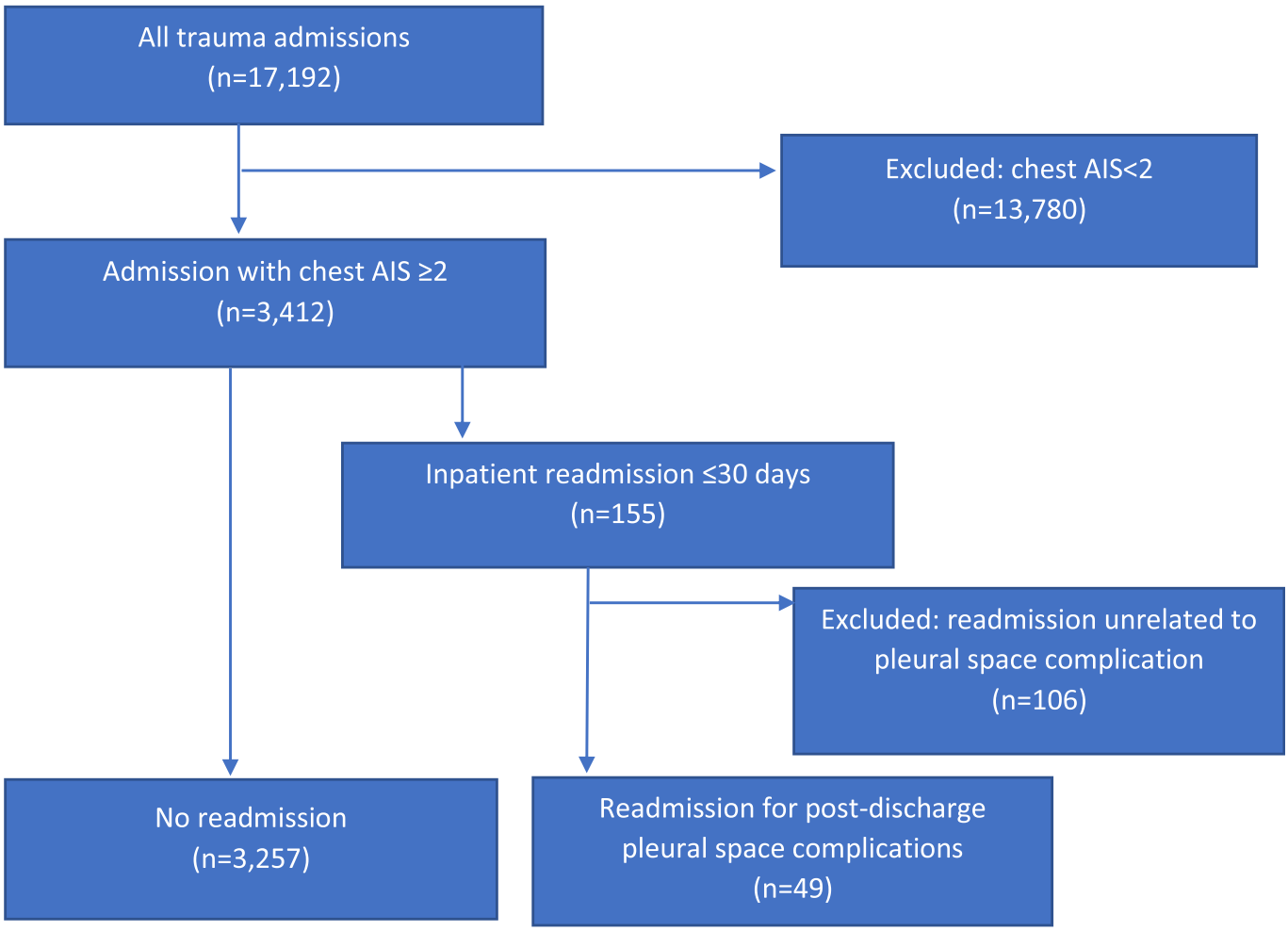

Figure 1. Consort flow diagram.

imaging was reviewed using both dictated radiology reports and visualization by the authors of all relevant images using IMPAX software. The discharge chest X-ray (CXR), which had to be performed within 24 hours of discharge, was evaluated for presence and size (small, moderate, large) of a pleural space abnormality, and was determined to be either stable, improved, or worse in comparison to the previous CXR. Hospital data included ventilator days, intensive care unit (ICU) and hospital length of stay (LOS), in-hospital venous thromboembolism (VTE) chemoprophylaxis, and discharge disposition.

Descriptive data were collected from the readmission hospitalization for the Readmit PDPSC group and included location of presentation (emergency department or trauma clinic), time from discharge to readmission, readmission indication, pleural space intervention, and hospital LOS.

For comparative analyses, patients were divided into two groups: the chest AIS ≥2 patients who did not require 30-day readmission and the chest AIS ≥2 patients who did require 30-day readmission for PDPSC. Continuous data were presented as median (interquartile range [IQR]) or mean (standard deviation) as appropriate. Discrete data were presented as a number and percent. Bivariate analyses were performed using Fisher's exact test. Two-sided tests of hypothesis were evaluated using 0.05 as the level of significance. Statistical analyses were performed using Statistical Analysis Software (SAS Institute Inc., Cary, NC).

RESULTS

Study Population Characteristics During Index Admission

During the study period, 17,192 trauma patients were admitted to the hospital after injury. There were 3,412 (19.8%) patients that suffered a chest AIS score of 2 or greater injury, 155 (4.5%) of which were readmitted to the hospital within 30 days from discharge. Of those, 49 (1.4%) were readmitted to the trauma service specifically for management of PDPSC (readmit PDPSC group) and were compared with patients who did not undergo 30-day hospital readmission (no readmit group, n = 3,257). The readmit PDPSC group was significantly older in years of age (63.1 [15.6] vs. 53.8 [21.0], $p = 0.002$), significantly heavier by weight in kilograms (84.3 [67] vs. 67.1 [40], $p = 0.003$) and comprised of significantly fewer men (27 [55%] vs. 2247 [69%], $p = 0.043$). No differences existed between groups with regard to preinjury anticoagulation or presence of in-hospital VTE chemoprophylaxis. There was no difference in ISS (16.8 [9.6] vs. 16.9 [11.7]), but mean chest AIS score was

significantly higher in the readmit PDPSC group (3.31 [0.65] vs. 2.86 [0.74], $p = <0.001$). The index hospital LOS was similar between groups, as was discharge disposition (Table 1).

Chest Wall Injury Patterns and Interventions During Index Admission

Comparing the two groups, there was a significantly higher incidence of rib fractures (46 [94%] vs. 2,606 [80%], $p = 0.017$), flail chest (16 [32.7] vs. 354 [11.1], $p = 0.0002$), pneumothorax (36 [73.5] vs. 1,359 [42.5], $p < 0.0001$), hemothorax (22 [44.9] vs. 634 [19.8], $p < 0.0001$), and scapula fractures (9 [18.3%] vs. 274 [8.4%], $p = 0.03$) in the readmit PDPSC group (Table 2). Patients in the readmit PDPSC group were also more likely to endure isolated chest injury, with just 9 (18.4%) suffering an AIS score of 3 or greater to other body regions compared with 1,055 (33%) ($p = 0.031$). A significantly higher incidence of tube thoracostomy placement during index admission was observed in the readmit PDPSC group (22 [45%] vs. 749 [23%], $p = 0.003$) (Table 3).

Looking specifically at the readmit PDPSC group from the index admission, mean number of ribs fractured was 5.7 (3.4), with 39 (79.6%) suffering four or more total fractures. Three (6%) patients did not have a pleural space abnormality on admission imaging, but all three developed a delayed hemothorax on 24-hour CXR. Discharge CXR demonstrated a pleural space abnormality in 36 (76.6%) of patients, and was worse than the previous CXR in seven (14.3%) patients, unchanged in 32 (68.1%) patients and improved in eight (16.3%) patients; two patients did not receive a CXR within 24 hours of discharge. The pleural space abnormality was described as "small" in the dictated radiology report in 34 of the 36 (94.4%) patients with an abnormal finding, including all seven patients with worsening findings compared with previous imaging (Table 4). Two patients had a "moderate" but stable pleural effusion. During the study period, a total of 222 SSRF cases was performed. Three of these patients required hospital readmission and were in the readmit PDPSC group: one patient did not undergo intraoperative pleural space lavage, and another was on full anticoagulation with warfarin postoperatively requiring reversal for hemothorax progression and pleural drainage during both the index and readmission hospital stays.

TABLE 1. Demographics Comparison

	Readmit PDPSC (n = 49)	No Readmit (n = 3,257)	*p*
Age: mean (SD), y	63.1 (15.6)	53.8 (21.0)	0.002
Male, n (%)	27 (55)	2,247 (69)	0.043
Weight: mean (SD), kg	84.3 (67)	67.1 (40)	0.003
CHF, n (%)	3 (6.1)	124 (3.8)	0.44
Smoking history, n (%)	7 (14)	586 (18)	0.71
Diabetes, n (%)	6 (12)	415 (13)	1.00
Preinjury anticoagulation, n (%)	6 (12.2)	201 (6.2)	0.12
Blunt mechanism, n (%)	48 (98)	3,066 (94)	0.37
MCC/MVC	17 (35)	1,168 (36)	1.0
Fall	24 (49)	1,155 (36)	0.07
ISS, mean (SD)	16.8 (9.6)	16.9 (11.7)	0.96
Chest AIS score, mean (SD)	3.31 (0.65)	2.86 (0.74)	<0.001
AIS ≥3 other, n (%)	9 (18.4)	1,055 (33.0)	0.031
VTE chemoprophylaxis (in-hospital), n (%)	35 (71.4)	1,863 (57.2)	0.056
Ventilator days, median (IQR)	0 (0)	0 (0)	1.0
ICU LOS, median (IQR)	1.67 (3.47)	1.48 (4.10)	0.746
ICU admission, n (%)	21 (43)	1075 (33)	0.148
Hospital LOS, mean (SD)	6.0 (5.6)	5.1 (6.1)	0.27
Discharge disposition			
Home (self or home health)	35 (71.4)	2,041 (62.7)	0.24
SNF	11 (22.4)	824 (25.3)	0.74
Other	3 (6.1)	386 (11.9)	0.27

CHF, congestive heart failure; MCC, motorcycle collision; MVC, motor vehicle collision; SNF, skilled nursing facility.

TABLE 2. Comparison of Chest Injury Characteristics

	Readmit PDPSC (n = 49)	No Readmit (n = 3,257)	*p*
Rib fracture(s), n (%)	46 (94)	2,606 (80)	0.017
Flail chest (radiographic), n (%)	16 (32.7)	354 (11.1)	0.0002
Hemothorax, n (%)	22 (44.9)	634 (19.8)	<0.0001
Pneumothorax, n (%)	36 (73.5)	1,359 (42.5)	<0.0001
Pulmonary contusion, n (%)	21 (42.9)	947 (29.6)	0.057
Scapula fracture, n (%)	9 (18.3)	274 (8.4)	0.03
Clavicle fracture, n (%)	5 (10.2)	376 (11.6)	1.0
AIS ≥3 other, n (%)	9 (18.4)	1,055 (33.0)	0.031

Characteristics of the Readmission Hospital Stay for the Readmit PDPSC Group

Looking at the 49 subjects in the readmit PDPSC, the majority were readmitted to the hospital from the emergency department (31 [63%]). Mean time to readmission was 10.2 (7.2) days. Pleural effusion was by far the most common readmission diagnosis (44 [90%]). Drainage with tube thoracostomy was performed in 42 (85.7%) patients. Other interventions included VATS (2 [4%]), SSRF (3 [6%]), thoracotomy (1 [2%]). Two (4.1%) patients were managed with observation alone. Mean hospital LOS on readmission was 5.8 (3.7) days, and there were no in-hospital deaths (Table 5).

DISCUSSION

We report a descriptive analysis of a cohort of chest wall injury patients who were readmitted to the trauma service within 30 days of hospital discharge for management of PDPSC. In this

TABLE 3. Comparison of Procedures During Index Hospitalization

	Readmit PDPSC (n = 49)	No Readmit (n = 3,257)	*p*
Tube thoracostomy, n (%)	22 (45)	749 (23)	0.003
SSRF, n (%)	3 (6.1)	219 (6.7)	1.0
Thoracotomy, n (%)	2 (4.1)	28 (0.86)	0.07
VATS, n (%)	0 (0)	30 (0.92)	1.0
Exploratory laparotomy, n (%)	3 (6.1)	125 (3.8)	0.44

TABLE 4. Imaging Details for the Readmitted PDPSC Group

	Readmit PDPSC (n = 49)
Discharge CXR status, n (%)	
Worse	7 (14.3)
Stable	32 (68.1)
Improved	8 (16.3)
Discharge CXR with pleural space abnormality, n (%)	36 (76.6)
"Small" abnormality, n (%)	34 (94.4)

study, 1.4% of patients admitted with thoracic injury were readmitted for management of PDPSC. Patients requiring readmission for PDPSC were significantly older, heavier, and more likely to be women than chest wall injury patients who did not get readmitted. They suffered a significantly higher chest AIS score, a higher incidence of rib fractures, flail chest, hemothorax, pneumothorax, scapular fractures, and more often experienced isolated chest injuries compared with those who were not readmitted. Index hospital LOS was similar.

All 49 patients in the readmit PDPSC cohort had either a hemothorax or pneumothorax (or both) identified on imaging during the index hospitalization. Three quarters had a persistent pleural space abnormality noted on hospital discharge imaging. In 94% of cases, the pleural space findings were "small," and 82% were considered to be "stable" compared with previous imaging. This, combined with clinical stability or improvement, made them suitable for discharge in our opinion at the time. The readmit PDPSC group underwent readmission on average 10 days postdischarge (16 days postinjury). Nearly two thirds were readmitted from the emergency department where they presented primarily with pain and shortness of breath. The clinical and cost implications of this readmission burden indicate a critical opportunity for improvement in the identification and management of patients who develop PDPSC.

The characteristics of this unique and very specific subset of chest wall injury patients suffering PDPSC can inform our development and validation of a decision algorithm on hospital discharge to better identify and monitor the at-risk patient for PDPSC. Identification of this high-risk patient on hospital discharge to trigger more vigilant outpatient follow-up may facilitate earlier diagnosis and possible outpatient management of PDPSC, and perhaps reduce hospital readmission. In addition, management practices in the outpatient setting need to be reevaluated given that a portion of the patients who presented to the emergency department were seen in the trauma clinic. Scoring systems looking at both radiographic characteristics and dynamic physiologic data have been previously developed and validated in rib fracture patients to predict hospital complications[17,18]; however, these predictive tools have not been designed for the patient at risk for longer-term complications, such as PDPSC.

Recently, Baker and colleagues[16] investigated the reevaluation and readmission rates in hospitalized patients with rib cage injury, identifying an 8.3% unplanned 30-day reevaluation rate and 3.2% readmission rate for chest wall injury-related issues. While higher than the readmission rate we observed, they included readmission for any chest-related complaint, and was most commonly pneumonia (27%), followed by pleural effusion (25.5%) and pneumothorax (10%). There was no difference regarding presence of pleural space abnormalities found on index hospitalization between those reevaluated after discharge and those that were not. Contrary to our findings and also what has been previously described regarding risk factors for readmission after trauma,[13,14] they identified younger age (15–35 years), current smoker, unplanned return to ICU and unplanned reintubation, and segmental fracture patterns to be predictive of reevaluation for chest-related complaints. They did not evaluate for the influence of scapular fractures on readmission rates, which we found to be associated with PDPSC in the current study and has been identified as a common injury in patients with severe chest wall injury undergoing SSRF of subscapular ribs.[19]

The number of ribs fractured has been shown to predict adverse hospital outcomes after chest injury, from greater than or equal to 3 up to greater than or equal to 7.[4–6] Alternatively, other groups have failed to identify a predictive relationship between the number of ribs fractured and reevaluation or readmission.[16,20–22] While we were unable to perform comparative analyses regarding the specific number of ribs fractured, we did find a significantly higher incidence of rib fractures in the readmit PDPSC group compared with the no readmit group. In addition, mean number of total rib fractures in the readmit PDPSC group was 6, above the commonly used cutoff of 5. Further analysis is warranted to determine the utility of a rib fracture threshold in predicting longer-term complications related to the pleural space.

Incidence of delayed pleural effusion or hemothorax, generally occurring during the index hospitalization, has been reported in 30% of adult blunt thoracic trauma patients and in 40% of elderly rib fracture patients.[6,9] Independent predictors for delayed hemothorax include greater than six rib fractures, displaced rib fractures or flail chest, low albumin levels, pulmonary contusion, and motor vehicle collision.[6,9,23] Delayed pneumothorax is less common, with an incidence of up to 5% after even minor thoracic injury, and has been associated primarily

TABLE 5. Characteristics of the Readmission Hospital Stay

	Readmit PDPSC (n = 49)
Clinic follow up, n (%)	29 (59.2)
Readmission location, n (%)	
ED	31 (63.3)
Clinic	18 (36.7)
Clinical presentation on readmission, n (%)	
Shortness of breath	29 (59.2)
Pain	19 (38.8)
Asymptomatic	6 (18.4)
Days to hospital readmission, mean (SD)	10.2 (7.2)
Readmission indication pleural effusion, n (%)	42 (85.7)
Procedure, n (%)	
Tube thoracostomy	42 (85.7)
VATS	2 (4.1)
SSRF	3 (6.1)
Thoracotomy	1 (2.0)
Observation	2 (4.1)
Hospital LOS	5.8 (3.7)

ED, emergency department.

with the presence of subcutaneous emphysema.[24,25] Related is the progression of known pleural space abnormalities from admission on subsequent imaging, which has been found to be one of the most common reasons for failed observation.[25,26] While some of the significant differences between the readmit PDPSC and the No Readmit groups in this study are similar to what others have found, it is unclear whether or not much of the previous work focusing on delayed in-hospital pleural space complications can be applied to the unique subset of chest wall injury patients who suffer unexpected symptomatic pleural space disease well beyond hospital discharge.

The rate of chest tube placement during the index hospitalization was significantly higher in the readmit PDPSC group (45% vs. 23%), and has also been previously identified as a risk factor for in-hospital delayed pleural effusion in elderly rib fracture patients.[6] It is important to note that despite all patients in the readmit PDPSC group having a traumatic pleural space abnormality during the sentinel hospital admission, 45% did not undergo pleural space intervention of any kind. Upon readmission, all but two patients (96%) underwent pleural space drainage, primarily by tube thoracostomy placement. Interestingly, no patients were readmitted with empyema. Based on our findings, it seems prudent to ensure close outpatient follow-up not only in patients managed with tube thoracostomy but also in those managed with observation who have abnormal pleural space findings on the discharge CXR. Other groups have described pleural space abnormalities that may be safely treated with observation,[26,27] and highlight the 19% risk of complications with tube thoracostomy placement that should be considered in the nuanced management decision algorithm.[28] The current study highlights a group of patients who failed both intervention and observation for management of traumatic hemopneumothorax, rendering the relationship between prior chest tube placement or observation and readmission risk for PDPSC unclear and in need of further investigation.

Surgical stabilization of rib fractures, which allows for intraoperative hemothorax evacuation and pleural space irrigation, has gained popularity over the past two decades as a management strategy in patients with severe complex chest wall injuries, varying by region and American College of Surgeons verification level.[29] In our previously published work evaluating the impact of SSRF, we found that SSRF patients were less likely to develop retained hemothorax, empyema or require hospital readmission for PDPSC.[30,31] In the current study, three patients in the Readmit PDPSC group underwent SSRF during their index hospitalization, but two of these cases had reasonable explanations for their PDPSC (full anticoagulation, and lack of pleural space lavage). While this study did not specifically evaluate the SSRF patient population, the observed extremely low readmission rate may implicate a possible protective effect of SSRF in reducing delayed pleural space issues and warrants further investigation.

There are several important limitations to this study. This is a single-center, retrospective chart review and is subject to the many limitations inherent to the study design. The sample size in the Readmit PDPSC group was much smaller than the No Readmit group, precluding adequate power for analysis and increasing the risk of a type II error when comparing outcomes. Variables requiring individual chart review, including number of ribs fractured and quality of imaging, could not feasibly be collected for the No Readmit group given the sample size, limiting the comparative analysis of these variables. Readmissions were only reviewed if they were to our hospital, and so it is possible patients were missed patients who were readmitted to other hospitals. Our trauma center is part of a large hospital system, however, and most trauma patients who represent within that system are funneled back to our service for readmission, making the numbers lost to other institutions likely small. We aimed to include a broad definition of thoracic trauma patients using the AIS score of 2 or greater, and therefore did not differentiate between injury patterns such as isolated rib fractures. It has been our common practice to readmit patients requiring management of pleural space complications, which may differ from other centers who rely more heavily on outpatient thoracentesis and render readmission burden in this patient population less generalizable. However, the descriptive characteristics of patient population at risk for PDPSC may be generalizable to other centers.

In conclusion, we described a unique subset of chest wall injury patients who required hospital readmission specifically for PDPSCs, which has not been well described previously. Clinical and cost implications may indicate a timely area for improvement given the focus on readmission rates as a quality metric. Characteristics, including older age, female sex, heavier weight, presence of rib fractures, pleural space abnormality, scapular fracture, and chest tube placement during index hospitalization, are associated with PDPSC. This analysis will allow us to develop and validate a standardized decision algorithm to better identify chest injury patients on hospital discharge who would benefit from earlier and more diligent outpatient follow-up to facilitate outpatient management of PDPSC and decrease readmissions to the hospital. Further studies are needed to more fully characterize this at-risk subset of chest wall injury patients and to determine what interventions can facilitate outpatient management of postdischarge pleural space complications and mitigate readmission risk.

AUTHORSHIP

A.B.K. contributed in the conception and design, data collection, data interpretation, drafting and critical revision of the article, final approval of version to be published. D.S.M. contributed in conception and design, data interpretation, drafting and critical revision of the article. S.G contributed in data interpretation, drafting and critical revision of the article. S.M. contributed in conception and design, data collection, data interpretation, drafting and critical revision of the article. T.W.W. contributed in conception and design, data interpretation, drafting and critical revision of the article.

DISCLOSURE

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