Discrepancies in rib fracture severity between radiologist and surgeon: A retrospective review

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BACKGROUND: Chest computed tomography (CT) scans are important for the management of rib fracture patients, especially when determining indications for surgical stabilization of rib fractures (SSRFs). Chest CTs describe the number, patterns, and severity of rib fracture displacement, driving patient management and SSRF indications. Literature is scarce comparing radiologist versus surgeon rib fracture description. We hypothesize there is significant discrepancy between how radiologists and surgeons describe rib fractures.

METHODS: This was an institutional review board–approved, retrospective study conducted at a Level I academic center from December 2016 to December 2017. Adult patients (≥18 years of age) suffering rib fractures with a CT chest where included. Basic demographics were obtained. Outcomes included the difference between radiologist versus surgeon description of rib fractures and differences in the number of fractures identified. Rib fracture description was based on current literature: 1, nondisplaced; 2, minimally displaced (<50% rib width); 3, severely displaced (≥50% rib width); 4, bicortically displaced; 5, other. Descriptive analysis was used for demographics and paired *t* test for statistical analysis. Significance was set at $p = 0.05$.

RESULTS: Four hundred and ten patients and 2,337 rib fractures were analyzed. Average age was 55.6(±20.6); 70.5% were male; median Injury Severity Score was 16 (interquartile range, 9–22) and chest Abbreviated Injury Scale score was 3 (interquartile range, 3–3). For all descriptive categories, radiologists consistently underappreciated the severity of rib fracture displacement compared with surgeon assessment and severity of displacement was not mentioned for 35% of rib fractures. The mean score provided by the radiologist was 1.58 (±0.63) versus 1.78 (±0.51) by the surgeon ($p < 0.001$). Radiologists missed 138 (5.9%) rib fractures on initial CT. The sensitivity of the radiologist to identify a severely displaced rib fracture was 54.9% with specificity of 79.9%.

CONCLUSION: Discrepancy exists between radiologist and surgeon regarding rib fracture description on chest CT as radiologists routinely underappreciate fracture severity. Surgeons need to evaluate CT scans themselves to appropriately decide management strategies and SSRF indications. (*J Trauma Acute Care Surg.* 2021;91: 956–960. Copyright © 2021 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Prognostic/Diagnostic Test, level III.

KEY WORDS: Rib fractures; surgical stabilization of rib fractures; computed tomography scan; radiologist; outcomes.

Rib fractures are a common injury after blunt chest trauma with an incidence of approximately 50%.[1–6] Not only do they lead to significant and prolonged pain, they can result in additional thoracic complications, including pneumonia, pleural effusion, aspiration, severe respiratory compromise, pulmonary emboli, and lobar collapse.[7–10] They are a marker of injury severity with the number of rib fractures correlating exponentially with both morbidity and mortality.[9,11–14] It has been demonstrated in previous literature that the greater the rib fracture burden on the patient, the worse the patient outcomes, especially for those older than 65 years.[11–13,15–17]

Over the last decade, surgical stabilization of rib fractures (SSRFs) has become a viable management modality for patients with rib fractures resulting in improved patient outcomes, especially in relation to the previously mentioned complications.[1,18–20] Despite an increased appreciation for SSRF, there still remains uncertainty about the indications for the procedure.[1,3,9,20] The majority of studies surrounding indications for SSRF has been that of flail chest. While this patient population has seen an increase of SSRF performed from 0.7% to 5.8%, there still remains controversy about the indications for patients without the diagnosis of flail chest.[18,20,21]

Many of the indications for SSRF, as well as decisions regarding rib fracture patient management, are based on the initial chest wall radiographic imaging. Chest X-rays, while commonly obtained for injured patients, miss approximately 75% of all rib fractures.[11] Therefore, computed tomography (CT) scan has become the most effective imaging modality for diagnosing rib fractures and associated injuries.[11,15,22,23] Based on CT findings, the lack of rib fracture displacement is often cited as a reason for nonoperative management for rib fracture patients,[2] or as an indication to send these patients to the surgical ward as opposed to the intensive care unit (ICU). However, there often seems to be discrepancy between how the radiologist describes the severity of rib fractures compared with that of the managing surgeon. Unfortunately, this inconsistency can result in missed opportunities for the utilization of SSRF that could potentially result in improved patient

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outcomes. The purpose of this study was to better analyze the relationship between radiologist and surgeon when describing rib fractures. We hypothesized that there is significant discrepancy between radiologist and surgeon interpretation of the severity of rib fractures on CT scan of the chest.

METHODS

This is an institutional review board–approved retrospective, chart review study conducted at a Level I academic trauma center from December 2016 to December 2017. All adult (≥18 years of age) trauma patients suffering rib fractures were included in the study. Patients were excluded if they did not have a CT scan of their chest completed at the time of trauma evaluation. Basic demographics including age, gender, injury type (blunt vs. penetrating), ICU length of stay (LOS), ventilator days and hospital LOS were obtained for each patient. Furthermore, Injury Severity Score, Abbreviated Chest Injury Scale, and mortality were also included. Finally, bilateral rib fractures and flail chest rib fracture patterns were also assessed. Based on previous studies, flail chest was defined as three or more consecutive ribs with two or more fractures on each rib.[24–27] All patients included in the study underwent CT scanning at our institution using a helical scan with 1.25-mm slices. The CT scan was obtained through the apices of the lung superiorly and the top of the kidneys inferiorly with standard reconstruction. With varying body habitus, the approximate number of CT slices was anywhere from 225 to 250 per patient.

Primary outcome of interest included the difference between how the radiologist described each rib fracture versus how the surgeon described them. Despite a recent proposal to provide new taxonomy for individual rib fracture displacement (undisplaced, offset and displaced),[15] the authors chose to describe rib fractures based on previous SSRF literature, as well as radiographic literature given it has been the basis thus far for creating indications for and against SSRF. Therefore, rib fractures for this study were defined as follows:

Nondisplaced—fracture without any displacement of either cortex.
Minimally displaced—fracture displacement less than 50% of the rib width/height on chest CT.
Severely displaced—fracture displacement 50% or greater of the rib width/height on chest CT.
Bicortically displaced—inner cortex of one fracture fragment either at or beyond the outer cortex of the other fracture fragment.
Other—any fracture not falling into the above categories.[7,18,27–29]

Five different surgeons reviewed the CT scans and described the severity of the rib fractures and their patterns (flail chest and/or bilateral rib fractures) based on the above descriptions. All the surgeons specialize in trauma surgery and were blinded to the radiologist report and description of the rib fractures for each patient. If the rib fracture description was not clear on initial observation, the measurement tools built inside the McKesson Radiology software (12.1.1) were used to determine the exact percentage of rib fracture displacement. The research project principal investigator (Z.B.) then reviewed all radiology reports (both in the final impression and body of the report) for each patient and recorded the radiologist description of rib fractures based on the above categories.

Secondary outcome included the difference between the number of rib fractures identified by the radiologist compared with that of the surgeon. Rib fractures that were identified by the surgeon and not the radiologist were taken back to a radiologist for confirmation they were indeed fractures. Descriptive analysis was used for demographics and rib fracture descriptive categories. Sensitivity and specificity were calculated based on the estimate of the rate that both diagnostic methods were agreeable on severely displaced rib fractures. Statistical analysis was completed using a paired *t* test comparing the mean scores between surgeon description versus radiologist description. Statistical significance was set at a p value less than 0.05.

RESULTS

A total of 410 patients were included for this review with a total of 2,337 rib fractures described for this analysis. Complete demographics for the study population can be found in Table 1. In regard to the primary outcome, looking at the various descriptive categories for the rib fractures themselves, radiologists consistently underreported the severity of rib fracture displacement compared with surgeon assessment (Table 2). Again, descriptive assessment was based on current trauma, surgical, and radiologic literature. Furthermore, 35% (n = 770 fractures) of rib fractures described in the radiology report made no mention at all of the degree or severity of the rib fractures present. Radiologists failed to mention there was a flail chest present in their final report for 25% (n = 6) of the patients based on the aforementioned definition. They also did not report 13% (n = 5) of patients with bilateral rib fractures in their final report. The sensitivity of the radiologist to correctly identify a severely displaced rib fracture is 54.9% with a specificity of 79.9%.

Upon further analysis, each descriptive category was assigned a number; 1, nondisplaced; 2, minimally displaced; 3, severely displaced; 4, bicortically displaced; 5, other. By doing so, the authors were able to calculate a mean score for radiologist versus surgeon in terms of their description of the rib fractures. The

TABLE 1. Demographics

Characteristics	Values
Patients, n	410
Rib fractures, n	2,337
Age, mean (SD)	55.6 (20.6)
Male sex, n (%)	287 (70.5)
Blunt injury type, n (%)	405 (99.5%)
Hospital LOS, mean (SD), d	8.19 (9.03)
ICU LOS, mean (SD), d	2.16 (4.38)
Ventilator days, mean (SD)	1.29 (4.31)
Injury Severity Score, median (IQR)	16 (9–22)
c-AIS, median (IQR)	3 (3–3)
Mortality, n (%)	18 (4.4)
Bilateral rib fractures, n (%)	38 (9.3)
Flail segment pattern, n (%)	24 (5.9)

n, number; SD, standard deviation; IQR, interquartile range; c-AIS, Abbreviated Chest Injury Scale.

TABLE 2. Description of Rib Fracture Severity

Severity	Radiologist	Surgeon	*p*
No mention of severity	770 (35%)	0	NA
(1) Nondisplaced	691 (31.4%)	780 (33.4%)	1.97
(2) Minimally displaced	504 (22.9%)	1,222 (52.3%)	<0.001
(3) Severely displaced	210 (9.5%)	276 (11.8%)	0.014
(4) Bicortically displaced	24 (1.1%)	54 (2.3%)	<0.001
(5) Other	0	5 (0.2%)	<0.001
Total no. rib fractures	2,199	2,337	

NA, not applicable.

mean descriptive score for the radiologist report was 1.58 (±0.63), whereas the mean descriptive score for the surgeon was 1.78 (±0.51) ($p < 0.001$). Again, this would suggest significant discrepancy between radiologist and surgeon descriptive analysis for the severity of rib fractures on CT scan. When looking at the secondary outcome, radiologists missed 138 (5.9%) rib fractures on their initial report, which were all confirmed via a radiologist after surgeon review of the CT scan.

DISCUSSION

To the authors' knowledge, this is first study examining the discrepancy between radiologist and surgeon descriptive analysis of rib fractures on CT scan of the chest. In all descriptive categories, the radiologist underreported the severity of the rib fractures compared with current trauma/surgical literature. In addition, the radiologist failed to comment altogether on the severity of the rib fracture 35% of the time. Furthermore, 25% of the time, a flail chest rib fracture pattern was not reported when one was present, and 13% of the time, bilateral rib fractures were not reported when they were present. Lastly, 5.9% of rib fractures were missed at the initial radiology report, which were later confirmed by the radiologist after being identified by the surgeon.

Despite this discrepancy, the purpose of this study was not for the authors to discredit the abilities of their fellow radiologist colleagues (in fact, we love working with our radiologists and think they do a fantastic job), but rather to bring awareness to surgeons managing rib fracture patients and performing SSRF that these discrepancies do exist. Radiologists do have similar taxonomy for rib fractures in their literature (nondisplaced, minimally displaced, severely displaced, etc.)[28–30]; however, there does not seem to be as definitive descriptive terminology applied (example, severely displaced fracture is ≥50% displacement of the total bone width/height) as there is in the trauma/surgical literature. Although SSRF is now becoming more accepted as a treatment modality for patients with rib fractures worldwide, there still exists controversy over the indications of its use.[18,31] Several of these indications revolve specifically around the degree of rib fracture displacement seen on a CT scan of the chest, as well as the specific rib fracture patterns. Furthermore, several patient outcomes depend on the number, severity of displacement, and patterns of rib fractures these patients encounter,[2,27] hence the importance of the initial CT chest.

Several prospective studies have been conducted demonstrating the efficacy of SSRF in the flail chest population.[24–26,32] Although there are slight variations about how flail chest is described among these studies, the common theme between outcomes after SSRF for these studies is decreased rates of pneumonia, decreased ventilator days, decreased need for tracheostomy, and decreased ICU LOS.[24–26,32] One study even goes on to demonstrate increased rates of return to full-time work for patients undergoing SSRF with a flail chest pattern.[26] Given the potential for failing to describe a flail chest on radiographic reports 25% of the time, it is important for the operating surgeon to review the CT chest imagining as to not miss an opportunity to improve on patient outcomes using SSRF.

Many surgeons performing SSRF have further expanded their indications to include patients with severely displaced (≥50% rib width/height displacement) rib fractures.[7,18] This is often accompanied with the caveat that the patient has three or more rib fractures that are severely displaced.[7,18] A recent prospective trial by Pieracci et al.[18] examined patients undergoing surgical fixation versus those not undergoing SSRF with three or more severely displaced rib fractures. This study demonstrated improvements in pain scores, decreased narcotic requirements, improvements in respiratory disability-related quality of life, and decreased incidence of pleural space–related complications for those patients undergoing SSRF. Based on our study results, the concern is that reliance solely on radiology reporting to determine if the chest wall–injured patient meets the criteria for consideration for SSRF has a sensitivity of only 54.9% and specificity of 79.9%. Therefore, a significant portion of chest wall–injured patients, having severely displaced rib fractures by trauma/surgery literature definition, could be a missed opportunity for SSRF intervention and better patient outcomes. This is further complicated by the fact that 35% of rib fractures found on CT scan had no mention of severity of displacement for our study. Knowing the severity of displacement of rib fractures at initial presentation is extremely important to the management of these injured patients, especially since studies have shown that rib fractures do increase in displacement over time.[2]

Several chest injury scoring systems have also been created to help predict patient outcomes based on factors well known to be associated with increased morbidity and mortality, including number of rib fractures,[9,12,27,33–37] flail chest,[9,20,27,33] and the presence of bilateral rib fractures.[9,27,36] Many of these scoring systems (i.e., the Rib Fracture Score,[38,39] Organ Injury Scale Chest Wall grade,[40] and Chest Trauma Score[41,42]) do not characterize fractures patterns and outcomes beyond the number of fractures and bilaterality.[27] The RibScore, created in 2015, not only considers the number of rib fractures present, as well as bilaterality, but also accounts for the severity of displacement of the rib fractures and presence of a flail chest.[27] The RibScore is a totally radiographic rib fracture severity scoring system that rapidly and objectively predicts the likelihood for the development of pneumonia, respiratory failure, and need for tracheostomy with a higher discriminative ability than other scoring systems.[27] Because of this, physicians can better create management strategies for these injured patients, including potential need for epidural (or other pain management modalities), need for SSRF, and even planning for a significant increase in failure to wean from the ventilator, and therefore, timing of tracheostomy.[27] Based on our study, however, direct input from a radiology report for the CT scan of the chest may lead to an

underappreciation of the severity of the patient's chest wall injury and ultimately affect the care of the patient.

Other studies have also demonstrated a strong association between the severity, pattern, and number of rib fractures described on a CT scan of the chest and associated complications/risk of mortality. A recent study by Chien et al.[43] demonstrated that if a patient had seven or more severely displaced rib fractures on CT scan, they had almost 100% chance of having an associated chest complication. In addition, studies by Sirmali et al.[44] and Liman et al.[33] demonstrated that patients with three or more rib fractures should be given strong consideration for hospital admission given the significant increase in risk of postinjury pulmonary complications and potential for increased mortality, especially if there was a concomitant flail chest.[9,33,44] Lastly, a study by Pape et al.[36] concluded an increased risk of chest wall death in a cohort of 1,495 patients with bilateral rib fractures.[9,36] What all these studies have in common is the reliance on the chest wall radiographic imaging, in which the CT scan was the criterion standard. Again, based on the results of our study, if the previous studies are relying solely on the final radiology report without close examination by the managing healthcare provider, rib fracture severity and various patterns of injury may be underrecognized, leading to missed opportunities for better patient management.

Despite this being a novel study, several limitations still exist. First, it is a retrospective, single institutional analysis with a relatively small sample size. A large multicenter study would be ideal to help minimize institutional biases and processes that may account for various discrepancies between surgeon and radiologist. This study was also performed at an academic institution where many of the CT scans are initially read by a radiology resident. Although the radiology report analyzed was the final, attending signed report, it is unclear to the authors how this might factor into the overall results of the study. Next, there does appear to be some differences in the taxonomy used between radiologist and surgeon when describing rib fractures on CT scan. Given two different specialties were involved in this analysis, there are likely to be differences in the way surgeons versus radiologists are trained in terms of what to look for and how to describe the findings. It is the authors' intentions to look into this process more and understand the process behind the radiology description of rib fractures. However, the authors do feel a more standardized taxonomy between radiologist and surgeon when describing rib fractures could alleviate many of these discrepancies as discussed by Edwards et al.[15] in their recent study. Lastly, there is the issue of time constraint. Radiologists have to review multiple images throughout the workday evaluating several body regions, which is unlike the surgeon, who often has the time to examine a chest CT more carefully, especially if he or she is preparing for SSRF. From a radiologist standpoint, more detailed evaluation of a chest CT may not be practical with hundreds of CTs needing to be read throughout the day.

CONCLUSION

This study suggests there does exists significant discrepancy between radiologist and surgeon regarding the description of rib fractures on chest CT in terms of rib fracture severity, number of rib fractures, and rib fracture patterns. Although future studies are required to confirm these results and better understand this discrepancy, the authors strongly encourage all health care providers managing chest wall injured patients to thoroughly evaluate their own patients' chest CT to provide the most appropriate management strategies based on the severity of chest wall injury. This is even more important if SSRF is being given consideration.

AUTHORSHIP

Z.M.B., G.O., S.C., C.H.E., and E.C. participated in study design and literature search. Z.M.B., J.B., C.J.P., and G.O. participated in chart review and data collection. Z.M.B. and A.R.H. participated in data analysis. Z.M.B., J.B., C.J.P., A.R.-H., S.C., C.H.E., and E.C. participated in data interpretation and writing of the article. Z.M.B., J.B., C.J.P., A.R.H., G.O., S.C., C.H.E., and E.C. participated in the critical revisions.

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DISCLOSURE

Z.M.B. is a paid educator for Zimmer-Biomet and KLS-Martin. All other authors declare no conflicts of interest. No funding source was provided for this study. All authors agreed for publication of this study in its current form.

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