Injury, Int. J. Care Injured 50 (2019) 109–112

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

The expedited discharge of patients with multiple traumatic rib fractures is cost-effective

Michael K. Dalton[a,b,*], Michael J. Minarich[a], Kimberly J. Twaddell[a], Joshua P. Hazelton[a], Nicole M. Fox[a]

[a] Division of Trauma, Department of Surgery, Cooper University Hospital, 1 Cooper Plaza, Camden, NJ 08103, United States
[b] Department of Surgery, RWJ Barnabas Health - St. Barnabas Medical Center, 94 Old Short Hills Rd., Livingston, NJ 07038, United States

ARTICLE INFO

Keywords:
Trauma
Rib fracture
Clinical pathway
Length of stay
Cost effectiveness

ABSTRACT

Introduction: Rib fractures are a cause of significant morbidity and mortality in trauma patients. It is well documented that optimizing pain control, mobilization, and respiratory care decreases complications. However, the impact of these interventions on hospital costs and length of stay is not well defined. We hypothesized patients with multiple rib fractures can be discharged within three hospital days resulting in decreased hospital costs.

Methods: A retrospective review of adult patients (≥18yrs) admitted to our Level 1 trauma center (2011–2013) with ≥2 rib fractures was performed. Patients were excluded if they were intubated, admitted to the ICU, required chest tube placement, or sustained significant multi-system trauma. (n = 202) Demographics, clinical characteristics, hospital costs, and outcome data were analyzed. Patients discharged within three hospital days of admission were considered to have achieved expedited discharge (ED). Univariate and multivariate analyses determined predictors of failure to achieve ED. A p value of <0.05 was considered significant.

Results: Study patients (n = 202) were 60 (SD = 19) years of age with an injury severity score (ISS) of 10 (SD = 5), and 4 (SD = 2) rib fractures. Of 202 patients, 127 (63%) achieved ED while 75 (37%) did not. No differences in chest AIS, ISS, smoking status or history of pulmonary disease were identified between the two groups (all $p > 0.05$). Average LOS (2 (SD = 1) vs. 7 (SD = 4) days; $p < 0.001$) and hospital costs ($2865 (SD = 1200) vs. $6085 (SD = 3033)); $p < 0.001$). were lower in the ED group A lower percentage of ED patients required placement in rehabilitation facilities (6% vs. 48%; $p < 0.001$). There were no readmissions within 30 days in either group. After controlling for potential confounding variables, multiple variable logistic regression analysis revealed that advancing age (OR 1.05 per year, 1.02–1.07) independently predicted failure to achieve ED.

Conclusion: The majority of patients admitted to the hospital with multiple rib fractures can be discharged within three days. This expedited discharge results in significant cost savings to the hospital. Early identification of patients who cannot meet the goal of expedited discharge can facilitate improvement in management strategies.

Introduction

Rib fractures cause significant morbidity and mortality and account for 9–10% of admissions to trauma centers [1–3]. A study by Flagel, et al. using the National Trauma Data Bank (NTDB) showed that approximately 13% of patients admitted with rib fractures developed complications [2]. Nearly half of these complications were directly related to the chest wall trauma and the risk of morbidity and mortality was significantly increased with each additional rib fractured. Bulger et al. demonstrated that patients older than 65 years of age with more than 4 rib fractures had higher morbidity and mortality than patients with 4 or more rib fractures in the 15–64 age group [4]. A more recent study from Holcomb, et al. suggests that patients may be at increased risk of morbidity and mortality from rib fractures starting at age 45 [5].

* Corresponding author at: Department of Surgery, RWJ Barnabas Health - St Barnabas Medical Center, 94 Old Short Hills Rd., Livingston, NJ 07038, United States.
E-mail addresses: michael.dalton@rwjbh.org (M.K. Dalton), minarich-michael@cooperhealth.edu (M.J. Minarich), twaddell-kimberly@cooperhealth.edu (K.J. Twaddell), hazelton-joshua@cooperhealth.edu (J.P. Hazelton), fox-nicole@cooperhealth.edu (N.M. Fox).

https://doi.org/10.1016/j.injury.2018.10.014
0020-1383/

Successful treatment of rib fractures includes pain control, use of incentive spirometry, early mobilization, and aggressive pulmonary toilet [6]. Patients with preexisting pulmonary disease are at higher risk of respiratory failure and therefore maintaining adequate respiratory function post-injury is especially important in this population [7]. Achieving effective analgesia has been shown to improve respiratory function as measured by pulmonary function tests as well as arterial blood gas values [8].

Clinical pathways in trauma have been shown to improve outcomes and resource utilization for patients presenting with specific injury patterns [9–13]. Todd, et al. demonstrated that a multidisciplinary treatment pathway for rib fractures significantly decreased ICU length of stay (LOS), hospital LOS, and incidence of pneumonia [14]. It also showed a decrease in mortality, which neared statistical significance. Despite a decrease in LOS, patients on the pathway still had an average hospital LOS of 11.7 ± 10.7 days. This extended length of hospitalization for patients with rib fractures is consistent with other studies [1,2,4]. The optimal or recommended LOS for patients with multiple rib fractures has not been determined in the literature or other published criteria.

At our institution, we implemented an expedited discharge (ED) pathway with a goal of discharge within three hospital days for patients admitted with a primary diagnosis of multiple rib fractures. Three days was chosen based on the clinical experience of our trauma team as there is no widely accepted goal LOS. This pathway consisted of three main components. First is adequate analgesia where early aggressive multimodal pain control includes intravenous narcotics (including patient controlled analgesia (PCA) pumps) which are rapidly tapered to oral medications, non-narcotic pain medications, and topical analgesics such as lidocaine patches. Our treatment pathway did not include routine use of epidural or peripheral nerve blocks or catheters. The second component was aggressive pulmonary toilet with a focus on frequent and adequate incentive spirometry. The third component was early communication with patients to establish realistic goals and expectations, especially as it related to acceptable levels of pain and anticipated length of hospitalization. Readiness for discharge was based on clinical judgement of the attending trauma surgeon. We hypothesized that our expedited discharge treatment pathway would result in successful discharge within three days and would reduce costs associated with treating these injuries.

Methods

This was a retrospective observational cohort study approved by the Cooper University Health System Institutional Review Board. Cooper University Hospital is a combined level 1 adult and level 2 pediatric trauma center located in southern New Jersey. Expedited discharge was defined as a hospital length of stay (LOS) of less than or equal to three days. Patients $\geq$18 years old admitted from January 2011 through December 2013 with a primary diagnosis of two or more rib fractures were placed on the expedited discharge pathway and included in this study. Patients were excluded if they were intubated at admission to the trauma admitting area, had a thoracostomy tube placed, went directly to the operating room from the trauma admitting area, or had non-chest injuries in addition to their rib fractures. Patients requiring epidural or peripheral nerve blocks or catheters were considered outside the standard treatment pathway and were not included in this analysis. Data was abstracted from the local trauma registry and patient electronic medical records.

Statistical methods

Patients who achieved ED (LOS $\leq$ 3 days) were compared to those who did not achieve ED (LOS > 3 days) with respect to demographic and clinical characteristics. Categorical variables are reported as number and percent while continuous variables are presented as mean and standard deviation.

Univariable analysis was carried out with Fisher's exact test for dichotomous variables. Continuous variables were compared with the *t*-test. Stepwise multivariable logistic regression was performed to assess the effects of the potential covariates on outcome always including clinic follow-up. The logistic regression model was tested for linearity by adding quadratic terms of variables our logistic regression to assess the impact on our model. No quadratic terms were statistically significant at the $p \leq 0.05$ level and were not included in the final model. Statistical analyses were performed using SPSS version 24 (IBM Corp: Armonk, NY).

Results

A total of 1000 patients were identified as having been admitted with a diagnosis multiple rib fractures during the study period, of which 202 patients meet inclusion criteria for the rib fracture ED pathway and were included in the analysis. Patients were considered successful if they achieved discharge within three days. On average, patients were 60 years old (SD 19) and predominately male (62%). A total of 127 (63%) patients achieved ED. Patients who did not achieve ED were more likely to be older and have a greater number of ribs fractured. No differences in chest AIS, ISS, smoking status or history of pulmonary disease were identified between the two groups. There was no difference between the two groups with respect to patients receiving a patient-controlled analgesia (PCA) pump (25% vs 32%, p = 0.331). A full comparison between those achieving ED and those who did not is shown in Table 1.

Those who achieved ED were more likely to be discharged directly home (93% vs 52%, p < 0.001). Those achieving ED also had significantly lower costs associated with their hospitalization (mean $2865 [SD $1200] vs. $6085 [$3033], p < 0.001). Mean pain scores (measured on a scale from 1 to 10 [low-high]) during the first 24 h after admission were higher among those who achieved ED (5.5 [2.2] vs. 4.3 [2.2], p = 0.002). Only two patients required escalation of care and were removed from the pathway and no patients required an unplanned intubation. Additionally, no patients were readmitted within 30 days of discharge from either group.

A multivariable logistic regression was performed to control for potential confounders. Increased age was the only variable that predicted, with statistical significance, failure to achieve ED (adjusted OR 2.84, 95% CI 2.78–2.91, p < 0.001). All variables included in our final model are shown in Table 2.

Discussion

We hypothesized that the majority of patients admitted for a primary diagnosis of multiple rib fractures could be safely discharged in within three days of hospital admission. Our data shows that we were successful in achieving ED in the majority of these patients. We found that increased age was the main predictor of failing to achieve ED. No patients in this study were readmitted within 30 days, including those who achieved ED. The average cost of hospitalization for those who achieved ED was less than half of the average cost for those who did not. Taken together, this shows that for patients able to achieve ED, our clinical pathway was successful and cost effective.

We performed a follow-up analysis of patients admitted from 2014 to 2016 who met our previously defined inclusion criteria (n = 221). We found that after implementing our expedited discharge pathway, 71% of patients (n = 157) achieved ED. The average age of patients achieving ED was lower (60 years old

Table 1
Univariable Comparison of Patients Achieving Expedited Discharge and Non-expedited Discharge.

	Expedited Discharge n = 127 n (%)	Non-Expedited Discharge n = 75 n (%)	OR (95% CI)	p value
Age[a]	54.3 (17.6)	70.3 (18.1)		<0.001
Male	89 (70)	37 (49)	2.41 (1.33–4.34)	0.004
BMI[a]	27.9 (4.6)	27.3 (5.5)		0.416
ISS[a]	9.7 (5.1)	10.8 (3.9)		0.112
AIS Chest[a]	2.7 (0.7)	2.93 (0.6)		0.077
Number of Ribs Fractured[a]	3.8 (1.9)	5.1 (2.8)		<0.001
Mean Pain Score in 1st 24 h (1–10 Scale)[a]	5.5 (2.2)	4.3 (2.2)		0.002
Mechanism - Fall	46 (36)	44 (59)	0.40 (0.22–0.72)	0.002
Bilateral Rib Fractures	13 (10)	8 (11)	0.96 (0.38–2.42)	1.000
Sternal Fracture	10 (8)	9 (12)	0.63 (0.245–1.62)	0.332
Flail Segment	1 (1)	1 (1)	0.59 (0.04–9.53)	1.000
Pneumothorax	39 (31)	21 (28)	1.14 (0.61–2.14)	0.751
Hemothorax	19 (15)	20 (27)	0.48 (0.24–0.98)	0.064
Pulmonary Contusion	30 (24)	19 (25)	0.91 (0.47–1.77)	0.865
Smoker	56 (44)	27 (36)	1.40 (0.78–2.52)	0.301
COPD	6 (5)	5 (7)	0.69 (0.20–2.36)	0.541
Asthma	12 (9)	6 (8)	1.20 (0.43–3.34)	0.803
CHF	4 (3)	3 (4)	0.76 (0.16–3.47)	0.712
Prior Opioid Use	13 (10)	6 (8)	1.21 (0.43–3.37)	0.804

[a] Reported as number and standard deviation.

[SD = 19]) compared to those not achieving ED (71 [14]) ($p < 0.001$). Consistent with findings during the study period, age remained a significant factor in failure to achieve ED.

Early identification of patients who are unlikely to achieve expedited discharge should be used to direct efficient resource allocation. Pressley et al. has previously developed a simple scoring system designed to predict the risk of respiratory failure based on early clinical findings [15]. Such a system would be useful in predicting which patients will likely need escalated care, such as mechanical ventilation or ICU admission. Another such proposed scoring system is the "RibScore" which is based on radiographic findings and also predicts clinical outcomes [16]. Though neither existing model can necessarily be used to predict length of admission, the risk of complications is certainly closely related to the ability to achieve an ED.

Our finding that patients of advanced age were less likely to achieve ED may indicate that patients of advanced age could benefit from different treatments or management strategies than their younger counterparts. At our institution, we have become more aggressive with involvement of social workers and case managers early in the hospital course to ensure that discharge placement and service availability do not delay discharge when patients are clinically ready. Further study would be necessary to determine the impact on clinical outcomes, length of stay, and cost effectiveness these and other changes would have among older patients with multiple rib fractures.

Our three day timeframe for discharge is significantly shorter than the average length of hospitalization reported in the literature. Reducing the length of stay logically leads to decreased costs. However, patients receive other benefits from rapid discharge including earlier return to their normal routines and spending less time at risk of acquiring a nosocomial infection.

Table 2
Logistic Regression Showing Predictors of Failing to Achieve Expedited Discharge.

	Adjusted OR	95% CI	p value
Age	1.05	1.02–1.07	<0.001
Gender	0.53	0.26–1.07	0.078
MOI - Fall	1.29	0.63–2.62	0.491
Hemothorax	1.74	0.75–4.06	0.201
ISS	1.06	0.97–1.14	0.188
Mean Pain in 1st 24 h	0.92	0.78–1.80	0.325
Number of Fractures	1.17	0.99–1.138	0.058

This study is limited by both its single institution nature and retrospective design. Given these limitations and considering our sample size, it is plausible that other variables such as the number of rib fractures may have clinical significance while not achieving statistical significance in our model. It is also important to note that the majority of patients seen at our institution with multiple rib fractures did not meet inclusion/exclusion criteria for this study, most commonly due to polytrauma. This was not unexpected, as this treatment pathway was tailored to a specific patient population. We found that age is a significant predictor of failing to achieve ED, however age may be a surrogate for other variables such as frailty. Direct measurement of such variables is beyond the scope of this study but should be included in future prospective studies.

We also acknowledge that our treatment pathway has many significant exclusion criteria that limit its use. We do not regularly use epidural or continuous peripheral nerve blocks in our patients with rib fractures, though these modalities were available to patients based on the clinical judgment of our providers. Patients receiving this treatment were not considered to be on the ED pathway. While studies have shown improved analgesia from these techniques [8,17–20], studies have also shown that use of these techniques were associated with longer hospitalizations [21,22]. In our practice, we achieve adequate early pain control using a combination of both narcotic and non-narcotic medications, initially through IV pain medication and then quickly transition patients to oral analgesic medications in anticipation of discharge.

Current practice management guidelines from the Eastern Association for the Surgery of Trauma conditionally recommend operative rib fixation for patients with flail chest and do not make a recommendation for patients with non-flail pattern rib fractures. However, they cite a low quality of evidence in making those recommendations [23]. Some select patients at our institution undergo operative rib fixation, however these patients were not included in this study as it is not part of our standard treatment pathway.

Patient motivation likely has a significant effect on patients' ability achieve ED, though the ability to directly measure this is beyond the scope of our study. It is important to establish appropriate expectations for pain management and eventual discharge early in the hospitalization. We believe that the fact that those who were able to achieve ED had higher average pain scores

suggests that with good patient education and management of expectations regarding pain, long term pain control can be managed as an outpatient and does not require prolonged hospital stay.

Conclusion

The main finding of our study is that when adequate pain control is achieved and aggressive pulmonary toileting is performed, the majority of patients admitted with multiple rib fractures can be discharged within three days. This expedited discharge significantly decreases hospital costs associated with these admissions.

Author contributions

Conception and design: MKD, MJM, NJT, JPH, NMF.
Data collection: MKD, MJM, NJT.
Data analysis: MKD, NMF.
Drafting the manuscript: MKD, NMF.
Critical revision of the article: MKD, MJM, NJT, JPH, NMF.

Conflicts of interest

None.

Funding disclosures

None.

References

[1] Kerr-Valentic M.A., Arthur M, Mullins RJ, Pearson TE, Mayberry JC. Rib fracture pain and disability: can we do better? J Trauma 2003;54(6)1058–63 discussion 63–4.
[2] Flagel BT, Luchette FA, Reed RL, Esposito TJ, Davis KA, Santaniello JM, et al. Half-a-dozen ribs: the breakpoint for mortality. Surgery 2005;138(4)717–23 discussion 23–5.
[3] Ziegler DW, Agarwal NN. The morbidity and mortality of rib fractures. J Trauma 1994;37(6):975–9.
[4] Bulger EM, Arneson MA, Mock CN, Jurkovich GJ. Rib fractures in the elderly. J Trauma 2000;48(6)1040–6 discussion 6–7.
[5] Holcomb JB, McMullin NR, Kozar RA, Lygas MH, Moore FA. Morbidity from rib fractures increases after age 45. J Am Coll Surg. 2003;196(4):549–55.
[6] Koenig GJ, Efron DT. Thoracic trauma.. In: Yuh DD, Vricella LA, Yang SC, Doty JR, editors. Johns hopkins textbook of cardiothoracic surgery. New York, NY: McGraw-Hill Education; 2014.
[7] Ali J. Torso trauma. In: Hall JB, Schmidt GA, Kress JP, editors. Principles of critical care. New York, NY: McGraw-Hill Education; 2015. p. 4e.
[8] Mackersie RC, Karagianes TG, Hoyt DB, Davis JW. Prospective evaluation of epidural and intravenous administration of fentanyl for pain control and restoration of ventilatory function following multiple rib fractures. J Trauma 1991;31(4)443–9 discussion 9–51.
[9] Spain DA, McIlvoy LH, Fix SE, Carrillo EH, Boaz PW, Harpring JE, et al. Effect of a clinical pathway for severe traumatic brain injury on resource utilization. J Trauma 1998;45(1)101–4 discussion 4–5.
[10] Vitaz TW, McIlvoy L, Raque GH, Spain D, Shields CB. Development and implementation of a clinical pathway for severe traumatic brain injury. J Trauma 2001;51(2):369–75.
[11] Fakhry SM, Trask AL, Waller MA, Watts DD, Force INT. Management of brain-injured patients by an evidence-based medicine protocol improves outcomes and decreases hospital charges. J Trauma 2004;56(3)492–9 discussion 9–500.
[12] Tallis G, Balla JI. Critical path analysis for the management of fractured neck of femur. Aust J Public Health 1995;19(2):155–9.
[13] Gholve PA, Kosygan KP, Sturdee SW, Faraj AA. Multidisciplinary integrated care pathway for fractured neck of femur. A prospective trial with improved outcome. Injury 2005;36(1)93–8 discussion 9.
[14] Todd SR, McNally MM, Holcomb JB, Kozar RA, Kao LS, Gonzalez EA, 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):806–11.
[15] Pressley CM, Fry WR, Philp AS, Berry SD, Smith RS. Predicting outcome of patients with chest wall injury. Am J Surg 2012;204(6)910–3 discussion 3–4.
[16] Chapman BC, Herbert B, Rodil M, Salotto J, Stovall RT, Biffl W, et al. RibScore: a novel radiographic score based on fracture pattern that predicts pneumonia, respiratory failure, and tracheostomy. J Trauma Acute Care Surg 2016;80 (1):95–101.
[17] Moon MR, Luchette FA, Gibson SW, Crews J, Sudarshan G, Hurst JM, et al. Prospective, randomized comparison of epidural versus parenteral opioid analgesia in thoracic trauma. Ann Surg 1999;229(5)684–91 discussion 91–2.
[18] Ullman DA, Fortune JB, Greenhouse BB, Wimpy RE, Kennedy TM. The treatment of patients with multiple rib fractures using continuous thoracic epidural narcotic infusion. Reg Anesth 1989;14(1):43–7.
[19] Wisner DH. A stepwise logistic regression analysis of factors affecting morbidity and mortality after thoracic trauma: effect of epidural analgesia. J Trauma 1990;30(7)799–804 discussion –5.
[20] Wu CL, Jani ND, Perkins FM, Barquist E. Thoracic epidural analgesia versus intravenous patient-controlled analgesia for the treatment of rib fracture pain after motor vehicle crash. J Trauma 1999;47(3):564–7.
[21] Gage A, Rivara F, Wang J, Jurkovich GJ, Arbabi S. The effect of epidural placement in patients after blunt thoracic trauma. J Trauma Acute Care Surg 2014;76(1)39–45 discussion –6.
[22] Zaw AA, Murry J, Hoang D, Chen K, Louy C, Bloom MB, et al. Epidural analgesia after rib fractures. Am Surg 2015;81(10):950–4.
[23] Kasotakis G, Hasenboehler EA, Streib EW, Patel N, Patel MB, Alarcon L, et al. Operative fixation of rib fractures after blunt trauma: a practice management guideline from the Eastern Association for the Surgery of Trauma. J Trauma Acute Care Surg 2017;82(March (3)):618–26.