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Emergency department management of patients with rib fracture based on a clinical practice guideline

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ABSTRACT

Background Clinical practice guidelines (CPGs) have the ability to increase efficiency and standardize care. A CPG based on forced vital capacity (FVC) for rib fractures was developed as a tool for triage of these patients. The objectives of this study were to assess the efficacy and compliance of physicians with this rib fracture CPG.

Methods Patients >18 that were discharged from an urban level 2 trauma center emergency department (ED) between the dates of January 1, 2014, to December 31, 2016, were eligible for the study. Demographics, mechanism, outcomes and FVC were abstracted by review of the electronic medical record. Compliance with the CPG was examined, and comparisons were made between patients successfully discharged and patients who returned.

Results 455 patients met were identified during the study period. 233 were eligible after exclusions. 64% of the cohort was male with median age of 53 years. Falls were the most common mechanism (59.6%). The median number of rib fractures was 2 and median FVC 2500 mL. 28 (12.0%) of the 233 returned to the ED after discharge. The groups were well matched with no significant differences. The most common reason for return was pain (95%). Adjusted analysis showed that increasing age (adjusted OR (AOR) 0.968) and FVC (AOR 0.999) were independent predictors. Adherence with the CPG was good for hemothorax/pneumothorax and bilateral fractures (96%), but lagged with the number of fractures (74%).

Conclusions This study confirms that the rib fracture CPG is safe and an FVC of 1500 mL is a safe criterion for discharging patients with rib fractures. Interestingly, it appears that older age is protective. More work needs to be done on effective pain control to decrease return to ED visits using this CPG.

Level of evidence IV.

Type of study Therapeutic.

BACKGROUND

Blunt mechanism accounts for the majority of trauma in most centers and for >15% of emergency department (ED) trauma visits worldwide.[1] Approximately 35% of blunt trauma patients are diagnosed with one or more rib fractures.[2] The risk of pulmonary complications such as pneumonia, pulmonary effusion, atelectasis and lobar collapse is drastically increased in patients with rib fractures.[3] It has been widely documented that mortality rates in patients with rib fractures are high for young adults (10%) and even higher for the elderly (22%).[3] Patients with chest wall injury are managed by surgical and emergency medicine teams that use protocols to dictate interventions and disposition.[4] Decision-making in patients with severe blunt trauma and rib fractures is less complicated if mechanical ventilation or emergent surgical intervention is required.[4] When injuries are less severe, it becomes difficult to decipher who may require more aggressive management and who is appropriate for discharge from the ED. Symptoms are insufficient to determine appropriate discharge. Additionally, symptoms are not considered accurate in predicting the outcome and morbidity in patients with thoracic trauma. There are no current nationally recognized clinical practice guidelines (CPGs) for the management in this population.[1 5]

The blunt trauma patient with rib fractures can present with few or no respiratory symptoms, but within 48–72 hours associated respiratory complications can develop.[1 6] A CPG enables physicians to use an accepted algorithmic approach to patient care. That model can then be used to place patients into risk categories of a prespecified outcome.[7] Current CPGs and prognostic models that exist for blunt chest trauma are mostly intended for use in patients with multiple injuries.[1 8–10] It remains a difficult task to determine the appropriateness of discharging a patient with non-life-threatening blunt chest trauma with rib fractures.

The forced vital capacity (FVC) is a well-known physiological quantitative parameter used widely to assess pulmonary function. At our institution, a CPG based on FVC for rib fractures was developed as a tool for triage of these patients. The CPG being tested was created and implemented in September 2013. The algorithm is based on three components: early bedside FVC, early analgesia and early identification of respiratory compromise. The components are centered around the goal of early identification of rib fractures and use of FVC as a guide to determine appropriate triage. The inpatient arm of this CPG was validated and was shown to decreased hospital length of stay by 2 days in patients admitted to the intensive care unit.[11] An arm of this CPG was developed for discharge from the ED in patients with FVC >1500 mL, two or fewer unilateral fractures in the absence of hemothorax or pneumothorax, and after ensuring adequate pain control is eligible for discharge(figure 1) The objectives of this study were to assess the safety, efficacy and adherence of providers with this rib fracture CPG. We hypothesize that trauma patients who meet the criteria for

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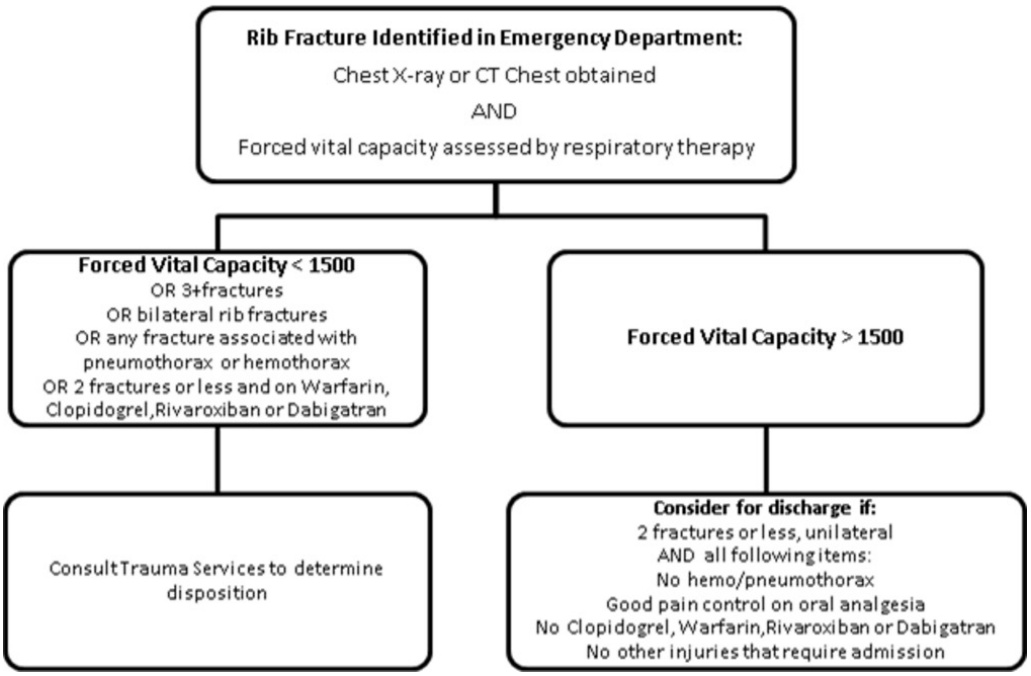

Figure 1 Clinical practice guideline for rib fracture algorithm—emergency department management.

discharge using the rib fracture CPG could be safely discharged from the ED.

METHODS

A retrospective review of patients 18 years and older who presented to the ED from January 1, 2014 to December 31, 2016, with traumatic rib fractures were screened for study eligibility. Patients included in the study cohort needed a measured FVC followed by discharge from the ED using the institutional CPG. Patients transferred from outside hospitals, fractures identified as non-traumatic rib fractures, absence of a documented FVC and patients who returned to the ED >14 days from initial visit were excluded from the study population. The study was conducted at Memorial Hospital, a Level II Trauma Center in Colorado Springs, Colorado.

Demographic information was collected from the hospital's trauma registry (TraumaOne, Lancet Technology, Boston, MA) and electronic health record (EPIC, Verona, WI). Variables included mechanism, number of fractures, laterality of fractures, presence of hemothorax or pneumothorax, FVC, ED length of stay (LOS) and discharge disposition. Patients successfully discharged from the ED were compared with those who returned after discharge.

Categorical variables were compared with χ^2 and Fisher's exact test where appropriate and continuous variables were compared with Student's t-test and the Wilcoxon rank-sum test based on distribution. After excluding collinear variables using correlation analysis, a multivariable logistic regression model was then constructed to adjust for confounders. Variables with a $P<0.2$ on bivariate analysis were selected for entry into the multivariable model. Stepwise backward regression was used to construct the final model. The Hosmer-Lemeshow goodness-of-fit test was then used to analyze the final model. A P value of <0.05 was considered significant.

RESULTS

There were a total of 455 patients who met inclusion criteria during the 36-month study period. In total, 222 patients (49%) were excluded due to missing FVC, leaving a study population of 233. The overall study cohorts had a median age of 53 and most were male (64%). The median number of rib fractures was 2, and the most frequent mechanism was fall (60%). The median FVC was 2500 mL and median LOS 232 minutes.

Twenty-eight (12.0%) of the 233 managed with the CPG returned to the ED after discharge. The groups were well matched with no significant differences. The most common reason for return was inadequate pain control (95%), and only three (10.7%) required admission to the hospital (table 1).

Multivariable logistic regression models were then constructed. After adjusting for age, assault and FVC, only FVC was protective for return to ED after discharge. The Hosmer-Lemeshow goodness-of-fit test verified an adequate model with $P=0.092$ (table 2).

Stepwise backward regression was then used to determine independent predictors. After excluding assault from the model, both FVC and age were independent predictors for return to ED (table 3).

Although the initial adherence with the CPG that required measured FVC (51%) was poor, most that had a measured FVC were >1500 mL (92%). Adherence with the other components of the CPG was good for pneumothorax, hemothorax and bilateral fractures at 96% (223/233). When looking at the number of fractures, adherence was lower at 74% (173/233).

DISCUSSION

CPGs are designed to reduce inappropriate practice and improve efficiency of care. Physician surveys have shown high satisfaction with CPGs and a belief that they improve quality of care.[12] CPGs are often attributed to the increase in efficiency in streamlining decision-making processes.[13] There is minimal evidence concerning the impact of rib fracture CPGs, especially for all adult trauma patients irrespective of age. There are clinical pathways for subsets of patients with rib fracture that have shown impact in reducing hospital and intensive care unit LOS.[14 15] This study has verified the safety of a CPG for predicting discharge criteria based on FVC.

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Table 1 Demographics and comparisons of successful discharge and return to the emergency department (ED)

	Total study (n=233)	Return ED– (n=205)	Return ED+ (n=28)	P
Male	64%	65%	57%	0.394
Age	53 (43–62)	54 (44–63)	49.5 (38–57)	0.133
FVC (mL)	2500 (1900–3200)	2550 (1950–3270)	2300 (1735–2600)	0.074
ED LOS (minutes)	232 (180–301)	232 (182–299)	225 (154–330)	0.900
Rib fractures	2 (1–3)	2 (1–2)	2 (1–3.5)	0.217
Pulmonary contusion	1.7%	1.5%	3.6%	0.403
MVC	11.2%	11.7%	7.1%	0.749
MCC	3.9%	3.4%	7.1%	0.295
Fall	60.9%	62.0%	53.6%	0.394
Assault	11.6%	10.2%	22.2%	0.109

Categorical variables are presented as percentages. Continuous variables are presented as median (IQR).
FVC, forced vital capacity; LOS, length of stay; MCC, motorcycle collision; MVC, motor vehicle collision.

This CPG is composed of three components: early measurement of FVC, early identification of respiratory compromise from rib fractures and adequacy of analgesia. The CPG uses an algorithm to stratify patients with rib fractures based on FVC measurements, number of fractures and age. The current study had 92% of patients with an FVC of at least 1500 mL with the majority safely discharged without returning to the ED (88%). Fewer patients had hemothorax, pneumothorax or bilateral fractures (4%), and usually these patients are admitted for aggressive pulmonary hygiene and pain control. Occasionally, these patients may be discharged, but that should be done on a case-by-case basis after consultation with trauma services. A CPG is only useful, however, if it is clinically applicable and easy for clinicians to use. The first obstacle to applying this CPG is actually obtaining the measured FVC. A robust educational effort is under way for the ED providers about the CPG. Additionally, the hospital has increased the dedicated respiratory therapists present in the ED to assist with this algorithm. The component of the algorithm that providers followed the least was the absolute number of fractures ≤2. Interestingly, an increase in the number of rib fractures did not result in a higher return rate to the ED. This will be excluded from future versions of this CPG.

This study found that the most common reason for return was inadequate pain control. Due to the current opioid epidemic, there is likely hesitancy among providers to prescribe large amounts of opioid medications for pain control in any patient populations including patients with rib fracture. Including a pain control protocol in our CPG may increase provider comfort with prescribing appropriate amounts of opiates or alternatives to patients with rib fractures and further reduce return visits to the ED.

Pain control in patients with rib fracture has been shown to improve pulmonary function and prevent complications.[16 17] Rib fractures lead to somatic chest pain that is associated with self-imposed limitation of tidal volume during inspiration and decrease in forceful exhalation to remove secretions. This impairs pulmonary mechanics leading to atelectasis and pneumonia.[18 19] For hospitalized patients, epidural anesthetics and intercostal nerve blockade have been shown to be equal in reduction of pain and improve patient outcome after rib fractures.[20 21] Generally, multimodal pain management is preferred.[22] There is scarce research concerning pain management in patients with rib fracture who are discharged from the ED. There have been case reports of treating patients with multiple rib fractures with a paravertebral catheter in an outpatient setting, but there is no current practice guideline or recommendation.[23]

This study has the inherent limitations to all retrospective database studies including accurate data entry, accurate coding, selection bias and inability to account for confounders. One of the main limitations to the study was the poor initial adherence (51%) with obtaining a measured FVC. Multiple reasons identified for the poor adherence include education and familiarity with the outpatient arm of the algorithm by ED providers, lack of available respiratory therapists to measure the FVC and lack of time to implement due to disruption of ED throughput of patients. Several additional limitations to this study include that the inpatient population was not considered or analyzed and patients who were discharged and returned to other facilities would not have been identified in this study. There may have been patients who met the CPG criteria for discharge home, but were admitted due to other variables. These variables would likely not have been addressed by the CPG and, therefore, the CPG may be missing certain patient populations and cannot be generalizable to that demographic. The measurements of FVC and volume goals may not have been optimal. Studies have shown that FVC is significantly related to age and it may be beneficial to include this factor in the CPG.[24] It is also reasonable to consider that young patients were more likely to return to the ED after rib fractures because an FVC close to 1500 mL is a greater degree of impairment compared with an elderly individual with a similar FVC. A better way to quantitate respiratory effort and function may be to calculate the percent predicted of the FVC based on

Table 2 Regression analysis predicting return to the emergency department

	AOR	CI	P
Age	0.973	0.944 to 1.002	0.065
FVC	0.999	0.999 to 1.000	0.027
Assault	1.640	0.549 to 4.989	0.375

AOR, adjusted OR; FVC, forced vital capacity.

Table 3 Independent predictors of return to the emergency department

	AOR	CI	P
Age	0.968	0.942 to 0.996	0.025
FVC	0.999	0.999 to 1.000	0.018

AOR, adjusted OR; FVC, forced vital capacity.

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individual patient characteristics to more accurately assess true impairment or adequate function.

Further research is needed to determine what can be considered as appropriate pain control for patients with rib fractures. Additionally, future research should be performed to determine whether these guidelines are maintained as part of routine clinical care with similar incidence of return to the ED after rib fractures.

Conclusion

This study confirms that the ED discharge pathway of the rib fracture CPG is safe and an FVC of 1500 mL is a safe minimum criterion for discharge in the absence of hemothorax, pneumothorax or bilateral fractures. Adherence with the number of fractures lagged, but number of fractures did not predict return to the ED and will be excluded from the CPG. Interestingly, it appears that older age is protective. Finally, more work needs to be done on effective pain control to decrease return to the ED using this CPG.

Contributors CH, LB, AT and TS conceived the study and designed the investigation. CH, LB, AT, AO, AB and DC conducted data collection. LB and AT oversaw quality control of the data collection. TS provided statistical analysis of the collected data. CH drafted the article and all authors contributed to its revision. CH takes responsibility for the article as a whole.

Competing interests None declared.

Ethics approval The Institutional Review Board of University of Colorado Health approved the study.

Provenance and peer review Not commissioned; externally peer reviewed.

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REFERENCES

1 Battle C, Hutchings H, Lovett S, Bouamra O, Jones S, Sen A, Gagg J, Robinson D, Hartford-Beynon J, Williams J, *et al*. Predicting outcomes after blunt chest wall trauma: development and external validation of a new prognostic model. *Crit Care* 2014;18:R98.
2 Liman ST, Kuzucu A, Tastepe AI, Ulasan GN, Topcu S. Chest injury due to blunt trauma. *Eur J Cardiothorac Surg* 2003;23:374–8.
3 Bulger EM, Arneson MA, Mock CN, Jurkovich GJ. Rib fractures in the elderly. *J Trauma* 2000;48:1040–7.
4 Blecher GE, Mitra B, Cameron PA, Fitzgerald M. Failed emergency department disposition to the ward of patients with thoracic injury. *Injury* 2008;39:586–91.
5 Dubinsky I, Low A. Non-life-threatening blunt chest trauma: appropriate investigation and treatment. *Am J Emerg Med* 1997;15:240–3.
6 Simon BJ, Chu Q, Emhoff TA, Fiallo VM, Lee KF. Delayed hemothorax after blunt thoracic trauma: an uncommon entity with significant morbidity. *J Trauma* 1998;45:673–6.
7 Moons KG, Altman DG, Vergouwe Y, Royston P. Prognosis and prognostic research: application and impact of prognostic models in clinical practice. *BMJ* 2009;338:b606.
8 Pressley CM, Fry WR, Philp AS, Berry SD, Smith RS. Predicting outcome of patients with chest wall injury. *Am J Surg* 2012;204:910–4.
9 Bakhos C, O'Connor J, Kyriakides T, Abou-Nukta F, Bonadies J. Vital capacity as a predictor of outcome in elderly patients with rib fractures. *J Trauma* 2006;61:131–4.
10 Maxwell CA, Mion LC, Dietrich MS. Hospitalized injured older adults: clinical utility of a rib fracture scoring system. *J Trauma Nurs* 2012;19:168–76.
11 Flarity K, Rhodes WC, Berson AJ, Leininger BE, Reckard PE, Riley KD, Shahan CP, Schroeppel TJ. Guideline-driven care improves outcomes in patients with traumatic rib fractures. *Am Surg* 2017;83:1012–7.
12 Farquhar CM, Kofa EW, Slutsky JR. Clinicians' attitudes to clinical practice guidelines: a systematic review. *Med J Aust* 2002;177:502–6.
13 Higgins TL, McGee WT, Steingrub JS, Rapoport J, Lemeshow S, Teres D. Early indicators of prolonged intensive care unit stay: impact of illness severity, physician staffing, and pre-intensive care unit length of stay. *Crit Care Med* 2003;31:45–51.
14 Todd SR, McNally MM, Holcomb JB, Kozar RA, Kao LS, Gonzalez EA, Cocanour CS, Vercruysse GA, Lygas MH, Brasseaux BK, *et al*. A multidisciplinary clinical pathway decreases rib fracture-associated infectious morbidity and mortality in high-risk trauma patients. *Am J Surg* 2006;192:806–11.
15 Gonzalez KW, Ghneim MH, Kang F, Jupiter DC, Davis ML, Regner JL. A pilot single-institution predictive model to guide rib fracture management in elderly patients. *J Trauma Acute Care Surg* 2015;78:970–5.
16 Fabricant L, Ham B, Mullins R, Mayberry J. Prolonged pain and disability are common after rib fractures. *Am J Surg* 2013;205:511–6.
17 Osinowo OA, Zahrani M, Softah A. Effect of intercostal nerve block with 0.5% bupivacaine on peak expiratory flow rate and arterial oxygen saturation in rib fractures. *J Trauma* 2004;56:345–7.
18 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;76:39–46.
19 Dhillon TS, Galante JM, Salcedo ES, Utter GH. Characteristics of chest wall injuries that predict postrecovery pulmonary symptoms: A secondary analysis of data from a randomized trial. *J Trauma Acute Care Surg* 2015;79:179–87.
20 Mohta M, Verma P, Saxena AK, Sethi AK, Tyagi A, Girotra G. Prospective, randomized comparison of continuous thoracic epidural and thoracic paravertebral infusion in patients with unilateral multiple fractured ribs-a pilot study. *J Trauma* 2009;66:1096–101.
21 Simon BJ, Cushman J, Barraco R, Lane V, Luchette FA, Miglietta M, Roccaforte DJ, Spector R. EAST Practice Management Guidelines Work Group. Pain management guidelines for blunt thoracic trauma. *J Trauma* 2005;59:1256–67.
22 Galvagno SM, Smith CE, Varon AJ, Hasenboehler EA, Sultan S, Shaefer G, To KB, Fox AD, Alley DE, Ditillo M, *et al*. Pain management for blunt thoracic trauma: a joint practice management guideline from the eastern association for the surgery of trauma and trauma anesthesiology society. *J Trauma Acute Care Surg* 2016;81:936–51.
23 Murata H, Salviz EA, Chen S, Vandepitte C, Hadzic A. Case report: ultrasound-guided continuous thoracic paravertebral block for outpatient acute pain management of multilevel unilateral rib fractures. *Anesth Analg* 2013;116:255–7.
24 Gólczewski T, Lubiński W, Chciałowski A. A mathematical reason for FEV1/FVC dependence on age. *Respir Res* 2012;13:57.

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