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Chest trauma clinical practice guideline protects against delirium in patients with rib fractures

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ABSTRACT

Introduction Traumatic rib fractures present a considerable risk to patient well-being, contributing to morbidity and mortality in trauma patients. To address the risks associated with rib fractures, evidence-based interventions have been implemented, including effective pain management, pulmonary hygiene, and early walking. Vancouver General Hospital, a level 1 trauma center in British Columbia, Canada, developed a comprehensive multidisciplinary chest trauma clinical practice guideline (CTCPG) to optimize the management of patients with rib fractures. This prospective cohort study aimed to assess the impact of the CTCPG on pain management interventions and patient outcomes.

Methods The study involved patients admitted between January 1, 2021 and December 31, 2021 (post-CTCPG cohort) and a historical control group admitted between November 1, 2018 and December 31, 2019 (pre-CTCPG cohort). Patient data were collected from patient charts and the British Columbia Trauma Registry, including demographics, injury characteristics, pain management interventions, and relevant outcomes.

Results Implementation of the CTCPG resulted in an increased use of multimodal pain therapy (99.4% vs 96.1%; p=0.03) and a significant reduction in the incidence of delirium in the post-CTCPG cohort (OR 0.43, 95% CI 0.21 to 0.80, p=0.0099). There were no significant differences in hospital length of stay, ICU (intensive care unit) days, non-invasive positive pressure ventilation requirement, ventilator days, pneumonia incidence, or mortality between the two cohorts.

Discussion Adoption of a CTCPG improved chest trauma management by enhancing pain management and reducing the incidence of delirium. Further research, including multicenter studies, is warranted to validate these findings and explore additional potential benefits of the CTCPG in the management of chest trauma patients.

Level of evidence IIb.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Traumatic rib fractures pose risks, and evidence-based interventions are crucial.

⇒ Current literature lacks high-quality guidance for optimal thoracic trauma management.

WHAT THIS STUDY ADDS

⇒ Vancouver General Hospital's implementation of a chest trauma clinical practice guideline (CTCPG) significantly increased multimodal pain therapy and reduced delirium incidence in patients with rib fracture, highlighting the guideline's positive impact.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The study emphasizes the CTCPG's role in enhancing chest trauma management, preventing delirium, and underscores the need for further research, including multicenter studies, to validate and explore additional benefits of CTCPG adoption.

INTRODUCTION

Traumatic rib fractures are a common diagnosis, found in approximately 6% to 10% of admitted trauma patients.[1 2] These fractures, whether occurring alone or in conjunction with other injuries, have significant clinical implications, including pulmonary morbidity, mortality, and a reduced quality of life.[3–5] Recent population-wide research revealed an overall mortality rate of 6.9% among patients with rib fractures.[2]

To address the risks of morbidity and mortality associated with rib fractures, previous research has established the importance of prioritizing interventions such as effective pain management, pulmonary hygiene, and early walking.[6 7] These measures aim to prevent chest wall splinting, which may restrict pulmonary function and contribute to the development of pneumonia and respiratory failure. As such, numerous institutions have incorporated evidence-based intervention recommendations into early intervention clinical practice guidelines (CPGs) for patients with high-risk rib fracture.[8–10] Notably, the implementation of these CPGs have been associated with reduced pulmonary complications, mechanical ventilator days, and mortality.[8 9] However, despite published guidelines, there is still a paucity of high-quality literature guiding optimal management of thoracic trauma patients.[7]

On conducting a review of chest trauma management at Vancouver General Hospital, a level 1 trauma center, the importance of early patient identification and the implementation of evidence-based interventions for pain management and pulmonary hygiene became evident. A multidisciplinary team of trauma surgeons, anesthesiologists, nursing staff, and respiratory therapists developed a comprehensive multidisciplinary chest trauma clinical practice guideline (CTCPG). We implemented the CTCPG

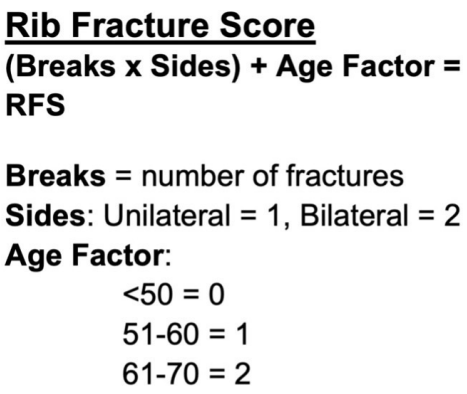


Figure 1 Rib Fractures Score (RFS) formula.

in September 2020. The CTCPG incorporates the Rib Fracture Score (RFS) (figure 1) to categorize patients into low-risk and high-risk groups for chest trauma-related morbidity and mortality (figure 2). Patients are then directed along a personalized treatment pathway, determined by their risk levels and clinical course. This pathway encompasses therapeutic guidelines for pain management, respiratory support, and monitoring. The objective of this retrospective cohort study was to assess the impact of implementing the chest trauma CPG on pain management interventions and relevant patient outcomes.

METHODS

Study design

This was a prospective, observational, pre-post cohort study of chest trauma patients with one or more rib fractures who were admitted to the trauma service at Vancouver General Hospital in British Columbia, Canada.

Patients were stratified into risk categories in the emergency department at admission to the trauma service using the RFS. Those qualifying for the low-risk category, defined as an RFS ≤6, received standard multimodal pain therapy and regular reassessment of pain.[11] The standard therapy consisted of standing acetaminophen, non-steroidal anti-inflammatory drug and as needed opioid pain medication for breakthrough pain. In this study, multimodal pain therapy was defined as prescription of more than one pharmacological class of analgesic medication. Patients meeting high-risk criteria (ie, RFS >6) were referred to the Perioperative Pain Service (POPS) for consideration for advanced pain management strategies in addition to standard multimodal analgesia therapy. Additionally, these high-risk patients underwent respiratory assessment with calculation of a modified Pain Inspiration Cough (PIC) score filtering patients into either close reassessment, non-invasive pulmonary positive ventilator therapy (NIPPV), or critical care consultation.

A prospective cohort of patients admitted between January 1, 2021 and December 31, 2021, after CTCPG inception, served as the study group (ie, post-CTCPG cohort). For comparison, a historical control group (pre-CTCPG cohort) was composed of patients admitted between November 1, 2018 and December 31, 2019, prior to the implementation of CTCPG. Patients admitted in 2020 during the height of the COVID-19 pandemic were excluded due concerns regarding accurate documentation. Furthermore, patients with substance use disorder who received methadone prescriptions during admission were excluded from the study to prevent any potential skewing of morphine equivalent calculations.

Patient data were collected from patient charts and the British Columbia Trauma Registry (BCTR). Patients were identified using the International Classification of Diseases Tenth Revision (ICD-10) diagnosis codes S22.3 for single rib fractures, S22.4 for multiple rib fractures, and S22.5 for flail chest. All admitted patients documented in the BCTR, aged 18 years or older with one or more traumatic rib fractures or flail chest, were eligible for inclusion.

Study data

The BCTR was used to collect the following patient demographic and injury-related characteristics: age, sex, type of injury (blunt or penetrating), Injury Severity Score (ISS), and number and laterality of rib fractures. RFS was calculated from this data source.

Patient intervention data, including analgesia modality, regional anesthetic technique, and pulmonary support, were collected through a thorough manual chart review. For pain management, we collected data on the prescription of the following medications: acetaminophen, non-steroidal anti-inflammatories, ketamine, gabapentin, opioids, and regional anesthesia technique used (thoracic epidural anesthesia (TEA) or non-neuraxial regional anesthesia techniques). Additionally, we tabulated opioid administration during the first 72 hours of admission and calculated a total oral morphine equivalent for each patient. Initial pain scores at admission to the trauma unit and adverse drug reactions (ie, opioid-related nausea/vomiting, constipation, and/or respiratory depression) were recorded. Additionally, respiratory therapy records from the patient chart were reviewed to measure the use of NIPPV.

Outcome data were collected from the BCTR and included in-hospital complications (ie, pneumonia and delirium), in-hospital mortality, hospital length of stay (LOS), intensive care unit length of stay (ILOS), and duration of days requiring mechanical ventilation (MVD). Pneumonia was defined as an acute respiratory infection affecting one or both lungs necessitating antibiotic therapy. Delirium was defined in the registry using the Confusion Assessment Method diagnostic algorithm, which requires the presence of the first two cardinal features and either feature 3 or 4 for a diagnosis of delirium:

1. Acute onset and a fluctuating course.
2. Inattention.
3. Disorganized thinking.
4. Altered level of consciousness.

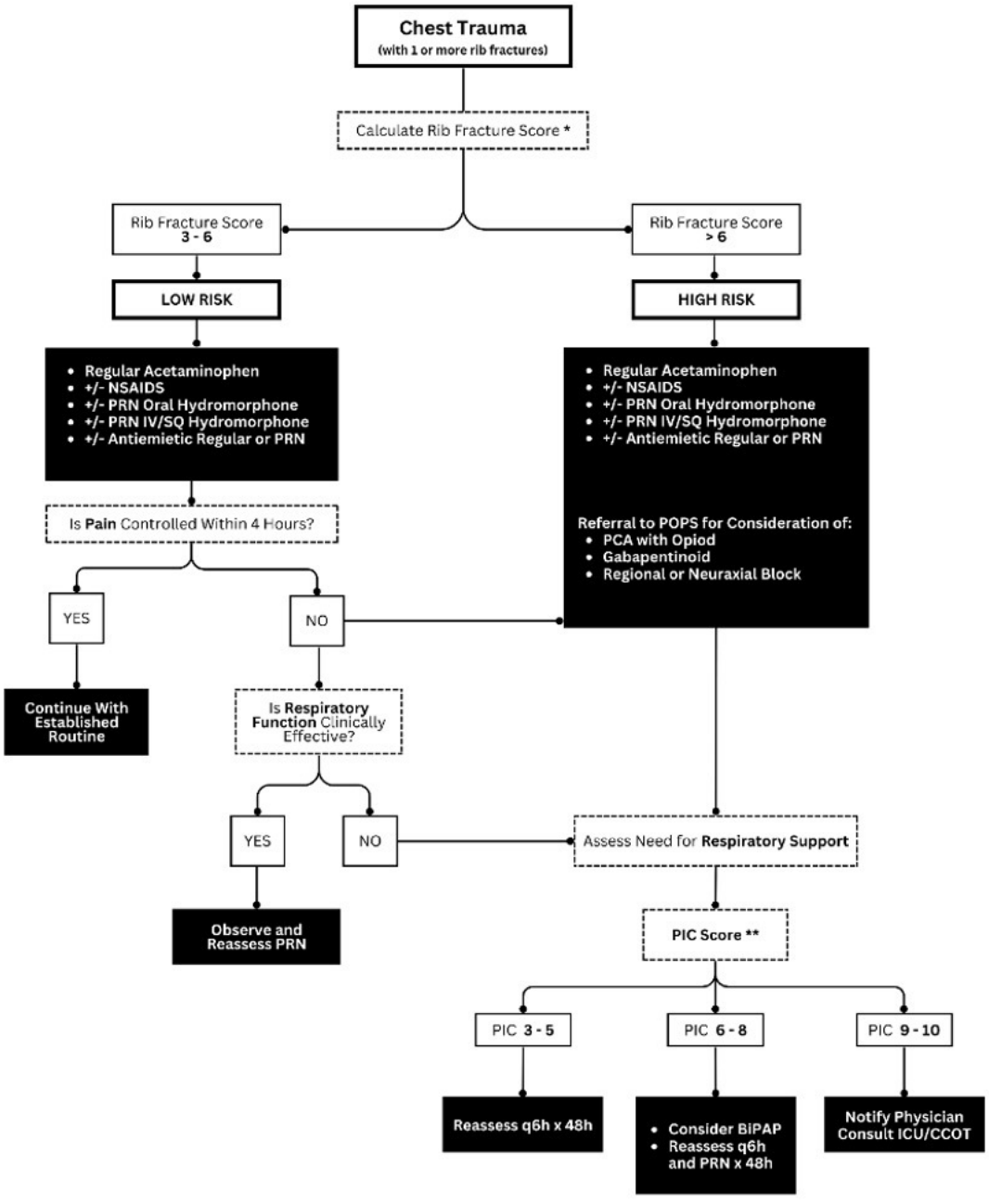
Statistical analysis

Statistical analyses were performed using RStudio V.2023.03.1. Patient demographics and injury characteristics were compared between the two study groups (ie, pre-CTCPG and post-CTCPG cohorts). Continuous variables were summarized as mean±SD or median with IQR, and categorical variables as frequencies and percentages. Two-sample t-test or Wilcoxon's rank-sum test was used for continuous variables, whereas Fisher's exact test or χ^2 test was used for categorical variables.

To determine the association between CTCPG utilization and hospital LOS, ILOS, and MVD, univariate negative binomial regression was applied. Univariate and multivariable logistic regression was used for analyzing mortality, pneumonia, and delirium outcomes. All statistical tests were two-sided, and a p value <0.05 was considered to indicate statistical significance. ORs and 95% CIs were calculated where appropriate.

RESULTS

A total of 465 patients were included in the study, with 286 patients in the pre-CTCPG study group and 179 patients in



Rib Fracture Score *

- **Breaks** = # of Fractures
- **Sides**
  - Unilateral = 1
  - Bilateral = 2
- **Age Factor**
  - < 50 = 0
  - 51 - 60 = 1
  - 61 - 70 = 2
  - 71 - 80 = 3
  - > 80 = 4

* *If pt is ≥ 65 & ≥ 3 rib#s, they are automatically HIGH RISK*

PIC Score (Modified) **

Pain Score Scale (0 - 10)	Inspiration (Vital Capacity) Goal is 20 mL/kg	Cough Strength
1 - Controlled (0 - 4)	1 - Above Goal Volume	1 - Strong
2 - Moderate (5 - 7)	2 - Goal Volume	2 - Weak
3 - Severe (8 - 10)	3 - Below Goal Volume	3 - Absent
	4 - Unable to Perform	

Figure 2 Vancouver General Hospital's chest trauma clinical practice guideline (CTCPG). PRN, pro re nata or "when necessary"; PCA, patient-controlled analgesia; NSAID, non-steroidal anti-inflammatory drug; PIC score, Pain Inspiration Cough score.

the post-CTCPG study group (table 1). Age and gender distribution did not differ significantly between the groups (p=0.53, p=0.68). ISS was comparable (median 21, IQR 14 to 29 and 15 to 29 for pre-CTCPG and post-CTCPG groups, respectively; p=0.63). The median RFS was 6 (IQR 3 to 11) for the entire cohort, and the frequency of high RFS (>6) was similar in both

Table 1 Baseline patient and injury characteristics of the two study groups

	Total cohort N=465	Pre-CTCPG n=286	Post-CTCPG n=179	P value
Age (mean±SD)	55.3±21.2	55.8±21.6	54.5±20.5	0.53
Gender, n_{male} (%)	324 (69.7%)	197 (68.9%)	127 (70.9%)	0.68
Mechanism of injury, n_{blunt} (%)	439 (94.4%)	270 (94.4%)	169 (94.4%)	0.98
Injury Severity Score, median (IQR)	21 (14–29)	21 (14–29)	22 (15–29)	0.63
Rib Fracture Score >6, n (%)	215 (44.1%)	142 (49.7%)	73 (40.8%)	0.22
Pulmonary contusion, n (%)	145 (31.9%)	94 (33.3%)	52 (29.1%)	0.41
Flail chest, n (%)	70 (15.1%)	42 (14.7%)	28 (15.6%)	0.79

CTCPG, chest trauma clinical practice guideline .

groups (pre-CTCPG: 49.7%, post-CTCPG: 40.8%; p=0.22). The prevalence of pulmonary contusion and flail chest did not differ significantly between the two groups (pulmonary contusion: 33.3% vs 29.1%, p=0.41; flail chest 14.7% vs 15.6%, p=0.79).

Intervention/management features

In terms of intervention and management, there were no significant differences in mean initial pain scores between the pre-CTCPG and post-CTCPG groups (p=0.87) (table 2). Most patients in both groups received multimodal analgesia with a statistically significant increase in its utilization in the post-CTCPG group (96.1% vs 99.4%; p=0.03).

Prescription rates of opioids, acetaminophen, NSAIDs, ketamine, and gabapentin did not show significant differences. Additionally, there was no significant difference in opioid administration (ie, oral morphine equivalents over 72 hours) between the two study groups (41.5 mg vs 54 mg; p=0.08).

The use of regional anesthesia increased after the implementation of CTCPG; however, this increase was not statistically significant (9.1% vs 12.3%; p=0.28). Notably, there was a statistically significant rise in the adoption of non-neuraxial regional anesthesia techniques after CTCPG implementation (1.4% vs 6.4%; p=0.006), with the placement of a serratus anterior plane (SAP) catheter being the most frequently employed technique (8/11 (73%) in the post-implementation group).

Outcomes

Univariate analysis revealed no statistically significant differences in hospital LOS, ICU days, NIPPV requirement, ventilator days, pneumonia incidence, or mortality between the pre-CTCPG and post-CTCPG groups (p>0.05) (table 3). However, there was a significant difference in the incidence of delirium, with a lower occurrence in the post-CTCPG group (OR 0.44, 95% CI 0.23 to 0.82, p=0.012). Multivariate logistic regression analysis, after adjusting for age, showed that the post-CTCPG group had significantly lower odds of developing delirium compared with the pre-CTCPG group (OR 0.43, 95% CI 0.21 to 0.80, p=0.0099) (table 4).

DISCUSSION

This prospective study is the first to demonstrate a reduction in delirium incidence subsequent to the introduction of a chest trauma protocol. Rates of delirium have been reported between 20% and 25% in patients with rib fractures, especially in the elderly.[12 13] Delirium is a clinical condition that is associated with significant adverse outcomes, including increased hospital LOS, complications, and all-cause mortality and is associated with hospital costs ranging from $806 to $24,509 per patient.[14–20] However, delirium is preventable in up to 40% of cases, and therefore, guidelines reducing its incidence may significantly improve patient care and healthcare costs.[17–20]

Table 2 Management features of the two study groups

	Total cohort N=465	Pre-CTCPG study group n=286	Post-CTCPG study group n=179	P value
Pain consultation, n (%)	106 (22.8%)	59 (20.6%)	47 (26.3%)	0.17
Pain score, mean±SD	6.4±2.8	6.4±2.6	6.5±3.1	0.87
Multimodal analgesia, n (%)	451 (97.4%)	273 (96.1%)	178 (99.4%)	0.03
Opioid prescribed, n (%)	447 (96.1%)	277 (96.9%)	170 (95.0%)	0.33
Oral morphine equivalents administered, mg (IQR)	43.5 (16–94.5)	41.5 (15–81.5)	54 (16.5–98)	0.08
Regional anesthesia, n (%)	48 (10.3%)	26 (9.1%)	22 (12.3%)	0.28
Thoracic epidural anesthesia	33 (6.8%)	22 (7.8%)	11 (6.4%)	0.71
Non-neuraxial regional anesthesia	15 (3.2%)	4 (1.4%)	11 (6.4%)	0.006
Serratus anterior plane	11	3	8	
Erector spinae plane	1	1	0	
Paravertebral	2	0	2	
Rectus sheath	1	0	1	
Acetaminophen, n (%)	442 (95.5%)	267 (94.0%)	175 (97.8%)	0.07
NSAIDs, n (%)	151 (32.6%)	84 (29.6%)	67 (37.4%)	0.08
Ketamine, n (%)	92 (19.9%)	55 (19.4%)	37 (20.7%)	0.81
Gabapentin, n (%)	81 (17.5%)	44 (15.5%)	37 (20.7)	0.17

CTCPG, chest trauma clinical practice guideline; NSAIDs, non-steroidal anti-inflammatory drugs.

Table 3 Univariate analysis of outcomes of the two study groups

	Pre-CTCPG n=286	Post-CTCPG n=179	OR or IRR	95% CI	P value
Hospital LOS	7 (5.75–17.75)	13 (6.5–26.5)	0.92	(0.76 to 1.11)	0.38
ICU	68 (23.8%)	42 (23.5%)	0.95	(0.61 to 1.48)	0.83
ICU days	8.0 (1.5–10.5)	6.0 (4–9)	0.91	(0.68 to 1.23)	0.55
NIPPV	15 (5.2%)	10 (5.6%)	1.07	(0.34 to 2.57)	0.87
Ventilator days	7 (0–13.25)	8 (3.25–14.5)	1.12	(0.77 to 1.65)	0.56
Pneumonia	37 (12.9%)	18 (10.1%)	1.13	(0.56 to 2.22)	0.73
Delirium	34 (11.9%)	15 (8.4%)	0.44	(0.23 to 0.82)	0.012
Mortality	16 (5.6%)	9 (5.0%)	0.86	(0.38 to 1.86)	0.91

CI, confidence interval; CTCPG, chest trauma clinical practice guideline; ICU, intensive care unit; IRR, incidence rate ratio; LOS, length of stay; NIPPV, non-invasive pulmonary positive ventilator therapy; OR, odds ratio.

The observed decrease in delirium risk is likely a result of the combined benefits conferred by the CTCPG. The CTCPG, as implemented in our institution, emphasizes regular assessments of pain control and respiratory function. This approach facilitates timely and targeted interventions, thereby mitigating the development of delirium in high-risk patients. Additionally, a significant increase in the prescription of multimodal pain therapy was noted in the post-CTCPG cohort, which aligns with the emphasis on pain control.

In a study by O'Connell *et al*, reduced delirium rates were observed in elderly patients with rib fracture after incorporation of regional analgesia techniques.[21] This was thought to be due to a decrease in morphine equivalents in the regional analgesia group.[21 22] Although our study demonstrated an upward trend in regional techniques, this did not translate into a significant decrease in oral morphine equivalents administered to patients. The limited sample size of our study is a key factor in this lack of statistical significance, with only 48 out of 487 patients receiving regional techniques. Furthermore, selective nerve blocks using local anesthetics in lieu of opioids, such as SAP catheters, were administered to just 11 patients in total. Additionally, clinicians may have adjusted their practices to align with published recommendations even before the implementation of the CTCPG.

Comparing traditional TEA to non-neuraxial regional anesthesia techniques, the increase in adoption of novel fascial plane nerve block techniques (SAP and erector spinae plane) after CTCPG implementation suggests a transition toward alternative non-opioid pain management. Concurrent spine and head injuries in multi-trauma patients may limit the routine use of TEA.[17 22] Trauma patients may also have associated hemodynamic instability, coagulopathy, neuraxial, and/or neurological injury, all of which are contraindications for epidural anesthesia.[23] Furthermore, TEA is associated with side effects, such as hypotension and urinary retention, and at our institution, the infusate is a mixture of local anesthetic and opioid, all of which may contribute to delirium development.[17 21 22]

Conversely, fascial plane nerve blocks, such as the SAP catheters, offer several advantages. The catheters are more superficial and they may be placed in patients with associated neuraxial injuries in the supine position. The risk and potential sequelae of bleeding is lower than TEA, enabling concurrent chemical venous thromboembolism prophylaxis.[17 21 22] In addition, the infusate is a local anesthetic alone delivered in programmed intermittent boluses to allow for marked dermatomal spread.

This transition toward advanced pain management methods underscores the importance of tailoring pain therapy to each patient's individual needs. It hinges on integrating close patient assessments and collaborating with pain service consultations within the CTCPG framework. Overall, striking the right equilibrium between effective pain management and optimized respiratory function enables patients to engage in respiratory physiotherapy and early mobilization, expediting the acute healing process and averting in-hospital complications, such as delirium.

Our study aligns with prior research affirming the positive impact of implementing chest trauma CPGs on patient outcomes.[24 25] Several previous studies have investigated the implementation of chest trauma CPGs and their impact on outcomes. For instance, Todd *et al* demonstrated that implementing a chest trauma CPG for patients over 45 years old with more than four rib fractures resulted in a reduced incidence of pneumonia and mortality at their institution.[10] Similarly, Kelley *et al* conducted a similar study in patients over 45 years old with more than two rib fractures and concluded that implementing a chest trauma CPG led to a decrease in pulmonary adverse events, including pneumonia.[8] The results of our prospective (PR6) study did not find any difference in pneumonia or mortality rates in the chest trauma population after implementation of the CTCPG.[10] Like these previous studies, the implementation of the CTCPG in our study involved a multidisciplinary approach, incorporating pain consultation, respiratory therapy support, and close patient assessment, all aimed at improving outcomes. One distinguishing feature of our study was the use of the RFS for patient stratification, which allowed inclusion of younger patients to the pathway if they had a significant fracture burden. The RFS was designed

Table 4 Multivariate analysis of delirium

	Pre-CTCPG cohort OR, 95% CI, P value	Age OR, 95% CI, P value
Delirium	0.43 (0.21 to 0.80) 0.0099	1.03 (1.02 to 1.05) <0.001

OR, odds ratio; CI; confidence interval
CTCPG, chest trauma clinical practice guideline .

HIGHLIGHTS

⇒ A multidisciplinary chest trauma clinical practice guideline enhances chest trauma management.
⇒ Increased use of multimodal analgesia with clinical practice guideline adoption.
⇒ Optimizing chest trauma pain management and pulmonary hygiene reduces delirium incidence in trauma patients.

to be integrated into a protocol; however, no research has been published describing its utility and impact as part of a CTCPG.[11]

Despite the promising results of our study, it is important to acknowledge its limitations. First, the study was conducted at a single center and it serves as a referral base for the province. Consequently, some patients may have been transferred from outlying hospitals for treatment and could have received analgesics and chest trauma care prior to their arrival at the trauma center. Second, the small patient cohort treated with regional anesthesia limited our statistical analysis in comparing these techniques. Finally, practice differences between consultants and the impact of the COVID-19 pandemic during the study period could have influenced outcomes and introduced bias.

Further investigations could expand on our findings by exploring the feasibility of disseminating similar protocols in a multicenter milieu. Additionally, a closer examination of the potential impact of each individual component (eg, regional anesthesia techniques, use respiratory support adjuncts) of the CTCPG on patient outcomes could provide valuable insights into the advantages of this approach.

CONCLUSION

In conclusion, the implementation of the CTCPG facilitated early multidisciplinary intervention and patient tailoring of pain medication prescriptions, leading to improved delirium rates in chest trauma patients.

Contributors JK contributed to data collection and provided leadership for data analysis and interpretation. Drafted the manuscript. YY contributed to statistical data analysis and data interpretation. AB, VC, NL, JS, and RS contributed to the study design, participated in the development of the chest trauma clinical practice guideline (CTCPG) and reviewed the manuscript for intellectual content. AB, PB, and HU contributed to data collection and manuscript preparation, including figure development. performed statistical analysis, and critically revised the manuscript. EJ, NG, RT, AW, and PR provided project supervision and lended expertise in trauma care and anesthesia. Reviewed the manuscript for intellectual content. EJ is the Primary Investigator (PI) and overall guarantor. All authors have read and approved the final manuscript.

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Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval Ethics approval was received from the University of British Columbia (H21-01698). Waived consent was granted for the study by the UBC ethics board as patients would not experience any change in management or therapy due to their inclusion in this study. Additionally, data collection for the pre-intervention cohort was retrospective, and obtaining informed consent would not have been practical or feasible.

Provenance and peer review Not commissioned; internally peer reviewed.

Data availability statement Data is not publicly available. The data for this study were obtained from the Trauma Registry via Trauma Services BC and patient charts at Vancouver General Hospital. These data include deidentified participant information related to demographics, injury characteristics, pain management interventions, and relevant outcomes for patients with rib fractures. Trauma Services BC serves as the repository for comprehensive patient data collected during the study period. The data are available from the data administrator, and permission to access and reuse the data is required from the data administrator. To request access or inquire about reuse permissions, individuals can contact the data administrator at BCTraumaRegistry@phsa.ca.

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