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Bedside percutaneous cryoneurolysis technique for management of acute rib fracture pain in adult trauma patients

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ABSTRACT

Background Acute pain due to rib fractures causes significant in-hospital morbidity and impacts patients' quality of life after discharge. Intraoperative transthoracic cryoneurolysis of the intercostal nerves can improve postoperative pain; however, non-surgical patients are provided limited analgesia options. Here, we describe our experience with a bedside cryoanalgesia technique for management of acute rib fracture pain.

Methods Five patients at a single level I trauma center completed bedside intercostal nerve cryoneurolysis (INC) using a handheld cryotherapy device and ultrasound guidance. Relative pain ratings (scale 0–10/10) and maximal incentive spirometry (IS_{max}) volumes were taken prior to the procedure as a baseline. Patients were observed for 24 hours after procedure, with relative pain ratings and IS_{max} recorded at 1, 8, 16, and 24 hours after procedure.

Results Our patients were 29–88 years old and had one to five single-sided rib fractures. At baseline, they had high pre-procedure pain ratings (7–10/10) and IS_{max} volumes of 800–2000 mL. Many had improvements in their pain rating but little change in their IS_{max} at 1 hour (1–5/10 and 1000–2000 mL, respectively) and 8 hours (1–5/10 and 1250–2400 mL, respectively). IS_{max} volumes improved by 16 hours (1500–2400 mL) with comparable pain ratings (0–5/10). At 24 hours, pain ratings and IS_{max} ranged from 0 to 8/10 and from 1500 mL to 2400 mL, respectively. Each patient had improved pain control and IS_{max} volumes compared with their pre-procedure values. All patients reported the procedure as an asset to their recovery at discharge.

Conclusions Our study demonstrates patients with rib fractures may experience improved pain ratings and IS_{max} values after INC. Percutaneous INC appears to be a viable adjunct to multimodal pain control for patients with rib fractures and should be considered in patients with difficult pain control. Further studies are required to fully assess INC safety, efficacy, post-discharge outcomes, and utility in patients with altered mental status or on mechanical ventilation.

Level of evidence Level V, case series.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ What is already known on this topicAcute rib fracture pain causes significant morbidity and impacts patients' quality of life. Early studies of intraoperative cryoneurolysis have shown benefit, but data are limited for bedside cryoneurolysis in patients who are not operative candidates.

WHAT THIS STUDY ADDS

⇒ Bedside percutaneous cryoneurolysis has several advantages over other methods of procedural pain control, is feasible and improves patient-reported pain and incentive spirometry in this case series.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Bedside percutaneous cryoneurolysis may prove to be a useful adjunct in the treatment of non-operative acute rib fracture pain.

BACKGROUND

Rib fractures affect 10–20% of trauma patients and pose significant challenges in management.[1–3] Approximately 59% of trauma patients with rib injuries report severe chest wall pain and impairment extending to 8 weeks after injury.[4] Sequelae of poor pain management are most often insufficient respiratory function with increased risk for complications like atelectasis and pneumonia, all contributing to significant morbidity and mortality.[4–6] Continuous intercostal nerve block (CINB) has been shown to decrease pain scores and hospital length of stay.[7] Despite this, CINB requires maintenance of local anesthetic infusion through a foreign body and can be cumbersome.[7] Ultrasound (US)-guided percutaneous intercostal cryoneurolysis (IC) offers potential benefits over CINB. It offers long-acting pain control without the need for catheters, pumps, or medications.[8 9] Intraoperative IC combined with rib fracture fixation has shown promising early results.[10] However, US-guided percutaneous IC at the bedside has only recently been introduced and there are limited data available regarding efficacy in this patient population.[10 11] This technique aims to provide non-opioid, long-term pain relief in patients with rib fractures who are not surgical candidates.[2 12] We present a case series of six patients at our institution, highlighting their pain ratings and incentive spirometry (IS) volumes before and after procedure.

METHODS

Refinement of technique

Prior to patient enrollment, we conducted an iovera° acute rib fracture pain management training

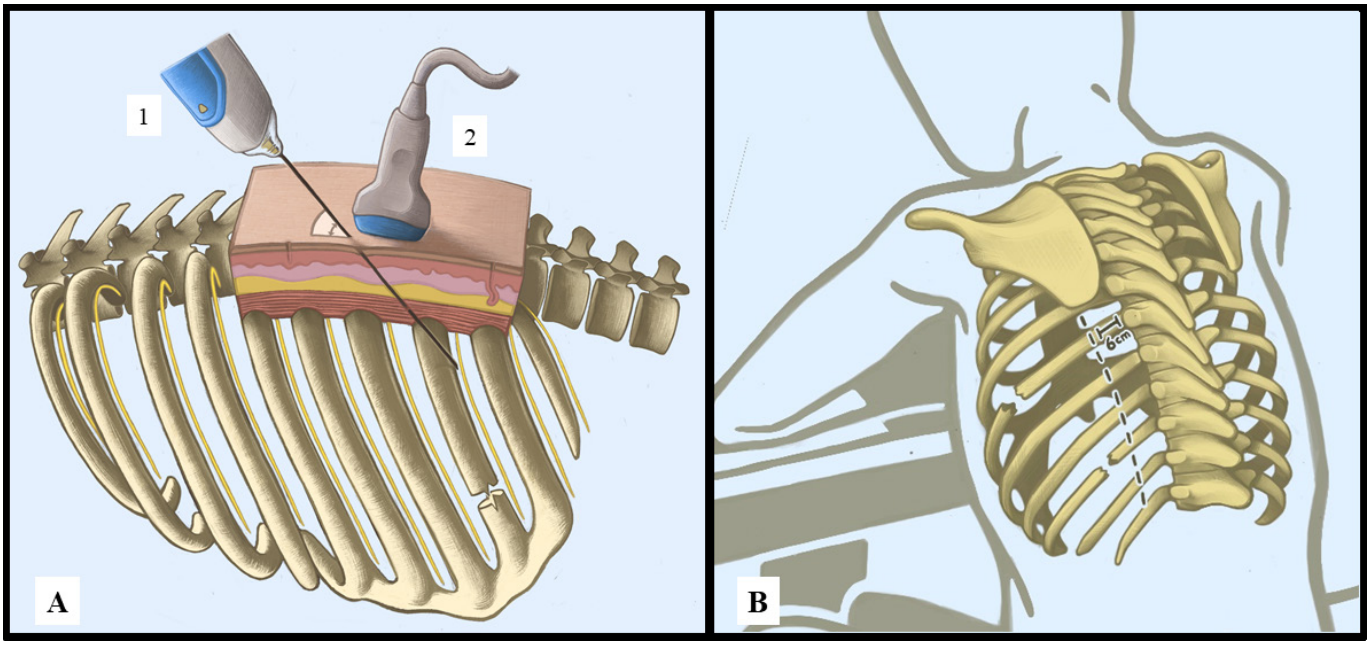

Figure 1 Bedside intercostal nerve cryoneurolysis using the iovera° system instrumentation. Illustration of instrument and patient positioning with unobstructed view. (A) Cryoneurolysis device (1) positioned under ultrasound (2) guidance to target intervention location as determined by physician. (B) For most patients with multiple rib fractures the preference was to use a seated upright position with the patient leaning forward supporting their arms on a table. Each affected rib was treated along the same vertical axis approximately 6 cm from the spine, given the fractures were all distal to the treatment area.

workshop in collaboration with a representative from Pacira and under the guidance of remote subject matter experts. The training event used a cadaveric model and all study team members attended the training event. The cadavers were placed in prone, supine, and lateral recumbent positions to establish the ideal access to each rib level, both posteriorly and anteriorly.

For all patients, each rib and corresponding fracture was identified using a phased array US probe (Venue Point of Care Ultrasound, GE Healthcare, Dallas, TX). A local anesthetic was administered at the treatment site for patient comfort. Once local anesthesia was achieved, the iovera° cryoneurolysis device (Pacira BioSciences Inc., Tampa, FL) was carefully guided under US visualization at a 45-degree angle targeting the neurovascular bundle of each affected rib (figure 1A). The device includes a long closed end needle and requires no incision to insert. Additional rib levels would then be treated sequentially. For most patients with multiple rib fractures our preference was to use a seated upright position with the patient leaning forward supporting their arms on a table. On some patients lateral decubitus positioning was used. We found it beneficial to treat each rib along the same vertical axis approximately 6 cm from the spine, given the fractures were all distal to the treatment area (figure 1B). On identification of the targeted neurovascular bundle, a 106-second freeze-thaw cycle was initiated via the device to achieve cryoneurolysis. In certain instances, if patients had ineffective or incomplete relief one or two additional treatments were administered at the same rib level.

Study design

All patients signed a written informed consent for the US-guided percutaneous IC procedure, follow-up, and publication of relevant non-identifiable information related to the study. The study team collected informed consent and baseline metrics on the morning of the procedure according to our protocol (online supplemental file 1). Patients were informed about possible risks of procedure including infections, bleeding, and pneumothorax. All patients were evaluated for baseline IS and status of rib-associated pain using adaptations from the Numeric Rating Scale (NRS), McGill Pain Questionnaire (MPQ), and Brief Pain Inventory (BPI). Sleep quality was assessed using the Medical Outcomes Study (MOS)-Sleep Interference and Sleep Quality (Pittsburgh Sleep Quality Index, PSQI), functionality by Quality of Life Scale (QOLS), and patient satisfaction by the Picker Patient Experience Questionnaire. Pain assessments[13–15] were completed during the index admission before the procedure at baseline, at 1 hour, then every 8 hours for the first 24 hours after procedure, and on the day of discharge. IS readings were recorded at the same intervals. All recorded pain scores were subjective. After discharge, the study team contacted the patients to assess pain levels, adverse events, and satisfaction with the procedure. Additional assessments[16 17] were completed at baseline and on discharge to assess return to functionality and impact of injuries on quality of life. Patient course of admission was not adjusted to meet study time points. The complete assessment schema is presented in table 1. The CARE case report guidelines were used to ensure proper reporting of patient information and discussion (online supplemental file 2).[18]

Patient enrollment was based on a rolling assessment of patient safety and provider discretion. Enrollment was limited to patients with non-operative rib fractures to ribs 3–10 in adult trauma patients able to provide consent who reported their rib fracture-associated pain to be their most severe source of pain. Only patients with baseline rib fracture pain of greater than 3 out of 10 were considered for enrollment. Patients with fractures closer than 6 cm to the spine were excluded due to associated risk of sympathetic chain neurolysis and incomplete pain relief. The study was designed to conclude after successful treatment of five patients. Each case was documented individually before compiling aggregate data, aiming to identify patterns within the treated group. Due to the nature of this case series study,

Table 1 Prospective case series study design time points and procedures

		After procedure					
Study procedure	**Baseline**	**1 h**	**8 h**	**16 h**	**24 h**	**Discharge**	**14 and 30-day follow-up**
Informed consent	X						
Incentive spirometry	X	X	X	X	X	X	
Pain (NRS)	X	X	X	X	X	X	X
Pain (MPQ)	X					X	X
Pain interference (BPI)	X					X	X
MOS-Sleep Interference	X					X	X
Sleep Quality (PSQI)	X					X	X
QOLS	X						X
Patient satisfaction							X
Additional pain control	X	X	X	X	X	X	X

Procedure included informed consent of the patient, incentive spirometry, pain (NRS and MPQ) scores, pain interference, MOS-Sleep Interference, Sleep Quality (PSQI), quality of life (QOLS), patient satisfaction, and use of additional pain management for rib fracture-associated pain. 1–24 h post-procedure inpatient time points have been demarcated.
BPI, Brief Pain Inventory; MOS, Medical Outcomes Study; MPQ, McGill Pain Questionnaire; NRS, Numeric Rating Scale; PSQI, Pittsburgh Sleep Quality Index; QOLS, Quality of Life Scale.

no statistical analysis was conducted. Patients were followed up at 14 and 30 days after procedure to assess pain via NRS and MPQ, pain interference via BPI, MOS-Sleep Interference, PSQI, QOLS, patient satisfaction, and the use of additional pain control modalities, specifically for pain related to the rib fracture. Pain scores and IS at pre-procedure, procedure, and post-procedure time points (table 2) were reported as median and IQR. QOLS (table 3) and pain interference survey (table 4) were also reported as median and IQR.

Case 1

A patient in their 70s with a medical history of diabetes mellitus, hypertension, and chronic kidney disease presented after slipping and falling on ice with a left-sided 9th rib fracture and left superior and inferior pubic rami fractures. Despite the continued use of analgesics, the patient continued to endorse posterior rib pain at the site of the mildly displaced fracture. The patient's initial reported pain level was 9/10 on the subjective pain scale and initial IS reading was about 800 mL. After just 1 hour, the patient reported their pain level as 1/10 on the subjective pain scale and IS measured as 1000 mL. At the 8-hour follow-up, pain was 0/10 at rest and 7–8/10 with movement and IS was 1250 mL. At 16 hours, pain continued to be 0/10 at rest, 5/10 with movement and IS was up to 1500 mL. Finally, at 24 hours, the patient's pain was 0/10 at rest and with movement and IS remained constant between 1250 and 1500 mL. The patient could not be reached for the 14-day follow-up.

Case 2

A previously healthy patient in their 30s presented after motor vehicle crash (MVC) with multiple injuries including left-sided rib fractures to ribs 2–7, a left hemopneumothorax, left L2–L4 transverse process fractures, bilateral superior and inferior pubic rami fractures, and right comminuted sacral fracture. The patient was in obvious pain due to their rib fractures but was uncomfortable and in much more pain due to the position they had to be placed in to complete the procedure. We asked the patient if they wanted to terminate the procedure; it was our opinion that we could not effectively and safely continue if the patient was so uncomfortable. Ultimately, the patient agreed they were not tolerating the procedure and decided it would be best to terminate the procedure at that time due to concomitant injuries.

Case 3

A previously healthy patient in their 20s presented after MVC with right-sided rib fractures to ribs 3–6. They were admitted to the trauma service for uncontrolled pain. The patient's initial reported pain level was 8/10 on the subjective pain scale and initial IS reading was 1500 mL. After 1 hour, the patient's reported pain level was 5/10 on the subjective pain scale and their IS measured was 1500 mL. At the 8-hour follow-up, pain was 5/10 at rest and IS was 2400 mL. At 16 hours, the pain continued to be 5/10 and IS was 2400 mL. Finally, at 24 hours, the patient's pain was 7/10 at rest and IS remained constant

Table 2 Patient-reported pain rating (Numeric Rating Scale; 0–10/10) and incentive spirometry volumes (milliliters) before and after bedside intercostal nerve cryoneurolysis to treat rib fracture pain

	Pre-procedure		1 h		8 h		16 h		24 h		Post-procedure pain rating	
Patient	**Pain rating**	**IS (mL)**	**Pain rating**	**IS (mL)**	**Pain rating**	**IS (mL)**	**Pain rating**	**IS (mL)**	**Pain rating**	**IS (mL)**	**14 days**	**30 days**
Case 1	8/10	800	0/10	1000	0/10	1250	0/10	1500	0/10	1250		
Case 3	8/10	1500	5/10	1500	5/10	2400	5/10	2400	7/10	2300	2/10	1/10
Case 4	10/10	2000	4/10	2100	1/10	1700	6/10	2000	8/10	2100	3/10	4/10
Case 5	7/10	1000	2/10	1200	2/10	1250	4/10	1250	3/10	1500	6/10	
Case 6	7/10	1000	2/10	1500	4/10	1500	1/20	2000	0/10	2250	2/10	
Median (IQR)	8/10 (7/10–8/10)	1000 (1000–1500)	2/10 (2/10–4/10)	1500 (1200–1500)	2/10 (1/10–4/10)	1500 (1250–1700)	4/10 (1/10–5/10)	2000 (1500–2000)	3/10 (0/10–7/10)	2100 (1500–2250)	2.5/10 (2/10–3.75/10)	2.5/10 (1.75/10–3.25/10)

Missing values indicate loss to follow-up.
IS, incentive spirometry.

Table 3 Quality of Life Scale (QOLS) before and after procedure between baseline and 14-day follow-up of patients with rib fracture(s)

Patient satisfaction with…	Before procedure	After procedure	Percent change
Material comforts of home, food, conveniences, financial security, median (IQR)	7.0 (5.0–7.0)	7.0 (7.0–7.0)	0.0
Health—being physically fit and vigorous, median (IQR)	5.0 (5.0–6.0)	5.0 (4.8–5.3)	0.0
Relationships with parents, siblings, and other relatives, median (IQR)	6.0 (6.0–7.0)	6.0 (5.8–6.3)	0.0
Having and rearing children, median (IQR)	6.0 (6.0–6.3)	6.0 (6.0–6.5)	0.0
Close relationships with spouse or significant other, median (IQR)	6.5 (6.0–7.0)	7.0 (6.8–7.0)	7.7
Close friends, median (IQR)	7.0 (6.0–7.0)	7.0 (7.0–7.0)	0.0
Helping and encouraging others, volunteering, giving advice, median (IQR)	5.0 (5.0–5.0)	6.0 (5.0–7.0)	20.0
Participating in organizations and public affairs, mean±SD	5.0 (5.0–6.0)	5.5 (5.0–6.3)	10.0
Learning—attending school, improving understanding, etc, median (IQR)	6.0 (6.0–7.0)	7.0 (6.8–7.0)	16.7
Understanding yourself—knowing your assets and limitations, mean±SD	6.0 (6.0–7.0)	7.0 (6.8–7.0)	16.7
Work—job or in home, median (IQR)	5.0 (5.0–6.0)	4.5 (3.8–5.3)	–10.0
Expressing yourself creatively, median (IQR)	6.0 (6.0–6.0)	7.0 (6.8–7.0)	16.7
Socializing—meeting other people or doing things, median (IQR)	6.0 (6.0–6.0)	6.0 (4.8–7.0)	0.0
Reading, listening to music, or observing entertainment, median (IQR)	6.0 (5.0–7.0)	7.0 (7.0–7.0)	16.7
Participating in active recreation, median (IQR)	5.0 (3.0–5.0)	5.0 (5.0–5.3)	0.0
Independence, doing for yourself, median (IQR)	7.0 (3.0–7.0)	5.0 (5.0–5.5)	–28.6

The patient lost to follow-up has been excluded. A positive percent change indicates improved patient satisfaction. A negative percent change indicates reduced patient satisfaction. A score of 1 is equal to 'terrible' and a score of 7 is equal to 'very happy'.

between 2300 and 2400 mL. While ongoing subjective pain scores demonstrated minimal reduction, the patient was not in any visible distress or discomfort and was walking normally without guarded behavior. At the 14-day follow-up, the patient reported a complete reduction in pain interference with general activity, normal work, and sleep.

Case 4

A previously healthy patient in their 60s presented after MVC with left-sided rib fractures to ribs 3–7. They were admitted to the trauma service for uncontrolled pain. The patient's initial reported pain level was 10/10 on the subjective pain scale and initial IS was about 2000 mL. After 1 hour, the patient's reported pain level was 2/10 on the subjective pain scale and IS was 2000 mL. At the 8-hour follow-up, pain was 1/10 at rest and IS was 1700 mL. At 16 hours, pain was 5/10 and IS was measured at 1900 mL. Finally, at 24 hours, the patient's pain level was 8/10 at rest and IS remained constant between 1900 and 2100 mL.

Table 4 Pain interference survey before and after procedure between baseline and 14-day follow-up of patients with rib fracture(s)

Pain interference with…	Before procedure	After procedure	Percent change
General activity, median (IQR)	10.0 (10.0–10.0)	4.5 (3.0–5.3)	–55.0
Mood, median (IQR)	7.0 (0.0–8.0)	2.5 (0.8–5.5)	–64.3
Walking, median (IQR)	10.0 (10.0–10.0)	6.5 (4.5–7.0)	–35.0
Normal work (home, work, school), median (IQR)	10.0 (10.0–10.0)	6.0 (4.5–6.3)	–40.0
Relation with other people, median (IQR)	3.5 (0.0–7.3)	0.5 (0.0–3.0)	–85.7
Sleep, median (IQR)	5.0 (5.0–7.0)	4.5 (3.0–6.3)	–10.0
Enjoyment of life, median (IQR)	10.0 (10.0–10.0)	5.0 (3.0–6.8)	–50.0

The patient lost to follow-up has been excluded. A negative percent change indicates reduced pain interference reported from the patient. A score of 0 is equal to no pain and a score of 10 is equal to high pain. Adapted from: McGill Pain Questionnaire (MPQ) and the Cleeland's Brief Pain Inventory (BPI).

At the 14-day follow-up, the patient reported a reduction in pain interference with general activity and normal work, and an increase in pain interference with sleep.

Case 5

A patient in their 30s with a medical history of diabetes mellitus presented after MVC with right-sided posterior rib fractures to ribs 5–8 with moderate right pneumothorax and lung contusion. The patient's initial reported pain level before the procedure was 7/10 on the subjective pain scale and initial IS was about 1000 mL. At 1-hour after cryoneurolysis, pain was 2/10 and IS was 1200 mL. At the 8-hour follow-up, pain was 2/10 and IS was 1250 mL. At 16 hours, pain was 4/10 and IS was 1250 mL. On discharge at 24-hour follow-up, the patient reported rib-specific pain as 3/10 and IS remained stable between 1200 and 1500 mL. At the 14-day follow-up, the patient reported a reduction in pain interference with general activity and normal work, and an increase in pain interference with sleep.

Case 6

A patient in their 80s with a medical history of hypertension, chronic obstructive pulmonary disease, chronic kidney disease, and an L5 vertebra fracture presented with right-sided pneumothorax and fractures to ribs 6–8 on the right side after falling out of bed. Ribs 7 and 8 underwent a second freeze cycle posterior to the fracture and ribs 6 and 7 underwent an additional freeze cycle anterior to the fracture after patient feedback. Follow-up checks were completed after procedure at 1, 8, 16 and 24 hours. The patient's initial reported pain level was 7/10 on the subjective pain scale and initial IS was about 1000 mL. After 1 hour, the patient's reported pain level was 2/10 and IS measured was 1500 mL. At the 8-hour follow-up, pain was 4/10 and IS was 1500 mL. At 16 hours, pain was 1/10 without the need for additional pain medication and IS was up to 2000 mL. Finally, at 24 hours, the patient's pain level was 0/10 and IS was 2000–2500 mL. At the 14-day follow-up, the patient reported a reduction in pain interference with general activity, normal work, and sleep.

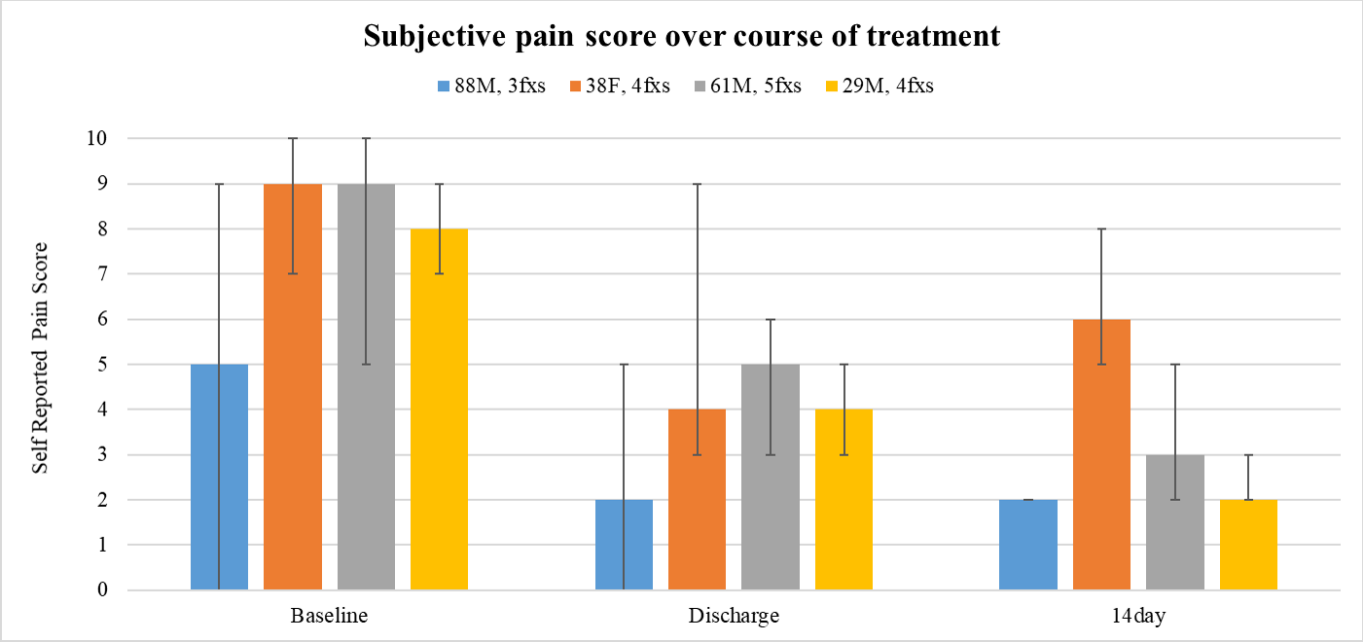

Figure 2 Self-reported subjective pain score by study milestone. The mean pain scores with minimum and maximum pain scores are shown for each time point. Patient lost to follow-up was excluded. F, female; fxs, fractures; M, male.

RESULTS

Five out of six enrolled patients completed the iovera° acute rib fracture pain management procedure. One patient was unable to tolerate the procedure due to positioning challenges from concomitant injuries, therefore, their procedure was terminated. The median age of patients was 61 years with an IQR of 38–76 years. Follow-up included phone call to patient by study team at 14 and 30 days after discharge. One patient was lost to follow-up at 14 days and three patients were lost to follow-up at 30 days. All patients who successfully completed treatment for their rib fractures exhibited improved pain management and IS (table 2). While subjective pain was not eliminated completely, control was universally achieved. The median (IQR) for pre-procedure pain rating was 8/10 (7/10–8/10); at 1 hour 2/10 (2/10–4/10); at 8 hours 2/10 (1/10–4/10); at 16 hours 4/10 (1/10–5/10); at 24 hours 3/10 (0/10–7/10); at 14 days after procedure 2.5/10 (2/10–3.75/10); and at 30 days after procedure 2.5/10 (1.75/10–3.25/10) (table 2). The median (IQR) for pre-procedure IS was 1000 (1000–1500); at 1 hour 1500 (1200–1500); at 8 hours 1500 (1250–1700); at 16 hours 2000 (1500–2000); and at 24 hours 2100 (1500–2250) (table 2). Pain management was also maintained through 30 days after discharge for patients who were not lost to follow-up (figure 2). At the 14-day follow-up (n=4) and 30-day follow-up (n=2), the median (IQR) pain scores were reported as 2.5/10 (2/10–3.75/10) and 2.5/10 (1.75/10–3.25/10), respectively, with no complications or need for pain medication due to their rib fracture(s). Quality of life scoring showed minor improvements as well (table 3), but the greatest impact was seen in reduction of pain interference scores (table 4). Patient satisfaction with their admission and the use of IC for pain control was universally positive. Patients did not experience any complications related to the procedure.

DISCUSSION

In this prospective case series study of six patients, we explored the utility of US-guided percutaneous IC technique for managing acute rib fracture pain using the iovera° handheld cryotherapy device in adult trauma patients. Despite the common occurrence of rib fractures in traumatic injuries leading to substantial pain and respiratory insufficiency, effective pain management remains a challenge.[19] Traditional approaches to pain management in this patient population like systemic opioids, regional anesthesia, and surgical fixation have notable limitations.[2 19] The nature of this study allowed for real-time data collection minimizing the potential biases associated with retrospective studies and provided resolution on patient experience.

Our findings determine this procedure to be feasible for the treatment of non-operative rib fracture pain and contribute preliminary evidence supporting the utility of US-guided percutaneous IC in the context of existing literature. We observed significant pain reduction after procedure, evident from 1 hour and sustained over 24 hours. While immediate lung function improvement was limited, significant enhancement in IS volume was noted after 16 hours. No complications resulted from the utility of this procedure in our patient population. Patient satisfaction was measured at 14 and 30 days after discharge; patients reported satisfaction with their pain management underscoring the potentially positive impact on quality of life.

These data suggest that US-guided percutaneous IC may be a valuable addition to pain management options for traumatic patients with rib fracture. It offers the advantage of providing non-opioid pain relief, particularly at a time when opioid misuse leads to the risk of addiction and respiratory depression.[20 21] Moreover, the procedure appears to be beneficial for trauma patients who require rapid pain control to facilitate proper pulmonary functionality and prevent respiratory complications. The significant reduction in pain reported by patients after undergoing this procedure confirms its effectiveness and highlights its role in facilitating faster patient recovery. Patients may have a more rapid return to daily activities leading to a lower incidence of complications associated with immobility. Therefore, our findings support the inclusion of the US-guided percutaneous IC in pain management plans, aiming to improve patient outcomes while reducing the adverse effects associated

with traditional opioid-based treatments. Subsequent investigations should focus on hypothesis testing the efficacy and generalizability of this intervention in mitigating the pain resulting from a non-operative rib fracture in the trauma patient population.

Despite the promising results, our study has certain limitations. The small sample size, lack of a control group, and loss to follow-up restrict determining safety, efficacy, and the extent to which these results can be generalized to a larger population. Ideally, only patients with isolated rib fractures would have been enrolled in the study. The variation in patient age and mechanisms of injury may influence the response to treatment, affecting the external validity of the study. Opioid usage was not collected in this study which will be a useful adjunct in further assessments of this technique. Additionally, a single proceduralist was used for all interventions within our trial which could impact reproducibility. Future research should further assess the efficacy, reproducibility, and potential adverse events by conducting larger prospective trials with a more diverse patient population.

Our findings suggest that US-guided percutaneous IC is a feasible option with potentially favorable attributes in the management of trauma patients with acute rib fracture pain. Possible benefits of this procedure include rapid pain relief, improved pulmonary functionality, and high patient satisfaction. To evaluate additional applicability in clinical practice, future investigations should study its utility in specific patient populations, such as those with altered mental status or on mechanical ventilation.

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Contributors HMGV and CM conceived the presented idea. HMGV, CIV, RKM, DF, and TCB developed the theory and drafted the article. ZSG created the infographic. CM supervised the findings of this work. All authors discussed the results and contributed to the final article. CM accepted full responsibility for the work and/or the conduct of the study, had access to the data, and controlled the decision to publish.

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Competing interests All JTACS disclosure forms have been supplied and are provided as supplemental digital content.

Patient consent for publication Not applicable.

Ethics approval The WCG Institutional Review Board approval was obtained for the short case series study (Rib Fracture Cryoanalgesia, Study ID 1338374). Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data sharing not applicable as no datasets generated and/or analyzed for this study.

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