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Case Report

Ultrasound-guided percutaneous cryoneurolysis for management of acute sternal fracture pain

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ABSTRACT

Background: Establishing adequate analgesia for rib and sternal fractures remains a challenge due to the prolonged nature of the associated pain. Historically, cryoneurolysis has demonstrated beneficial in treating chronic pain, and the recent development of hand-held devices has allowed its functionality to expand into the management of acute pain.
Case: We present a polytrauma patient with sternal and multiple rib fractures that underwent ultrasound-guided intercostal cryoneurolysis at bedside, resulting in significant analgesia lasting several weeks and improving mobilization. This is the first report of the utilization of cryoneurolysis to treat acute sternal fracture pain.
Conclusion: The most common sternal fracture pattern is transverse which only requires treatment of four intercostal nerves, making cryoneurolysis feasible in trauma centers. This portable, minimally invasive, and low risk technique has the added benefits of reducing opioid requirements, decreasing length of hospital stay, and improving mobility in polytrauma patients.

Introduction

Chest wall injuries, such as rib and sternal fractures, can cause severe acute pain ranging from several days to years [1]. Pain management is the priority to optimize respiratory mechanics, minimize pulmonary sequelae, and promote ambulation and physical therapy. Only a small percentage of sternal fractures require surgical stabilization if associated with intractable pain, however, most are managed conservatively [2]. A review of patients with acute fractures demonstrated that rib, sternum, and thoracic spine fractures had a significantly higher likelihood of requiring opioid prescriptions after discharge to treat persistent pain [3]. Regional anesthesia techniques such as thoracic epidurals, paravertebral, intercostal, and fascial plane blocks provide analgesia for up to 10 days with an indwelling catheter or up to 4 days with a single injection of liposomal bupivacaine [4]. Although effective for acute pain, analgesic duration provided by these techniques are limited to a few days, thus analgesia for persistent pain is often treated with opioids.

Recently, a portable percutaneous cryoneurolysis device has become available for hospital use and can provide analgesia lasting

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several weeks. Ultrasound-guided intercostal cryoneurolysis (USG-IC) has been reported to improve acute pain management in the setting of multiple rib fractures (MRF) [5]. This is the first report of a polytrauma patient in whom USG-IC provided significant analgesia for sternal fracture. Informed consent for regional anesthesia and inclusion in this case report was obtained.

Case report

A 46-year-old, 85 kg female was transferred from an outside hospital with polytrauma following a motor vehicle accident. Injuries included fractures of the right tibia, sternal body, and left lateral 7th–9th ribs (Figs. 1, 2). On hospital day (HD) 1, bilateral ultrasound-guided superficial parasternal intercostal plane catheters and a left deep serratus plane single-shot block were performed for analgesia of the sternal fracture and left rib fractures, respectively (Fig. 3). There was immediate pain relief and improved respiratory function shown on incentive spirometry.

On HD2, the patient underwent external fixation of the tibial plateau fracture. On HD3, the catheters were turned off and she experienced recurrence of severe sternal pain, thus the decision was made to perform USG-IC of the 4th–5th and 4th–9th left intercostal nerves. A left T8 paravertebral single-shot block was performed to provide anesthesia for subsequent USG-IC. Using sterile technique, a handheld cryoprobe (Iovera Smart Tip, Myoscience, USA) with a 90 mm needle was advanced in-plane under ultrasound guidance into the intercostal space near the neurovascular bundle. Two cycles each lasting 108 s were performed at each intercostal space (Fig. 4). Because the sternal fracture location was not reported on computed tomography, the fracture was identified with ultrasound and the ribs were traced posteriorly. USG-IC was performed at bedside with continuous monitoring on bilateral 4th and 5th intercostal nerves to provide analgesia for the sternal fracture as well as on the left 6th–9th intercostal nerves to provide analgesia for the MRF (Fig. 4).

The following day, after confirming resolution of chest wall anesthesia from the paravertebral block, the patient reported a 0/10 static and 2/10 dynamic numerical pain score with deep inspiration. Once analgesia from the USG-IC was established, both parasternal catheters were removed. The patient only required one dose of tramadol 50 mg for breakthrough pain originating from the tibia during the initial 24-hour post-operative period.

The patient was discharged home and returned for external fixator removal and delayed open reduction and internal fixation of the tibial plateau fracture, which was managed with a perioperative multimodal pain regimen. This marked 10 days after USG-IC, and she reported 0/10 static and 1–2/10 dynamic pain involving physical therapy and the frequent use of a walker for mechanical support. On telephone follow-up 30 days after USG-IC, the patient continued to endorse significant pain relief, with minimal discomfort stemming from the displaced rib and sternal fractures. She noted a sensation of friction at her rib fracture site while using her walker to ambulate but had no associated pain.

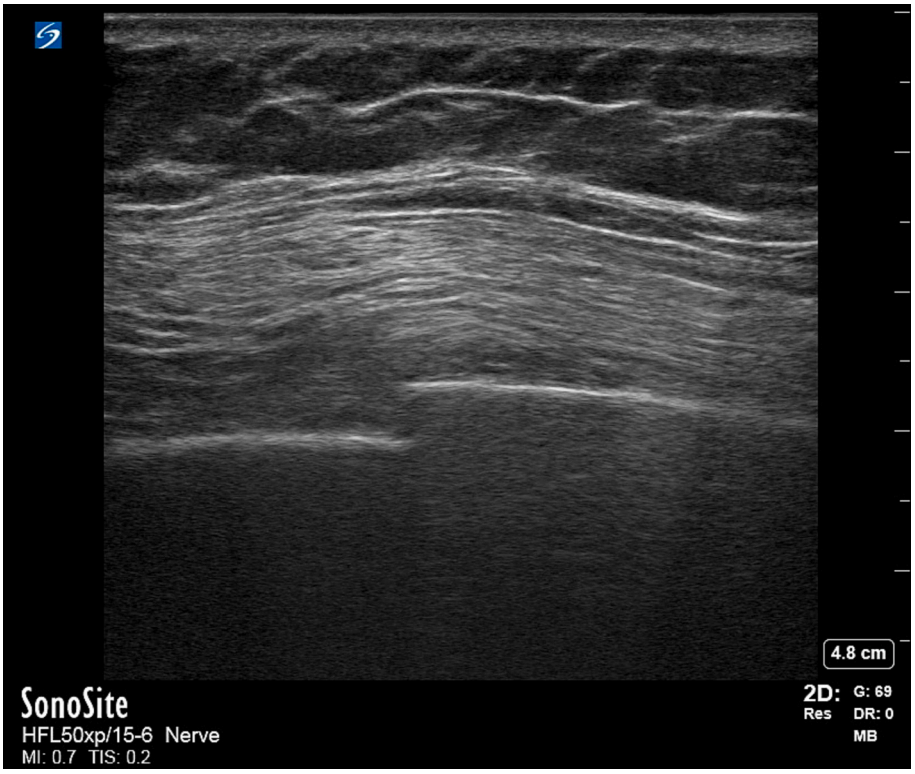

Fig. 1. Ultrasound image of sternal fracture. Fracture sonography demonstrating a mid-body sternal fracture. The orientation indicator is cranial. The fracture site appears as a contour defect in the cortical bone of the sternal body. The upper body of the sternum is displaced posteriorly.

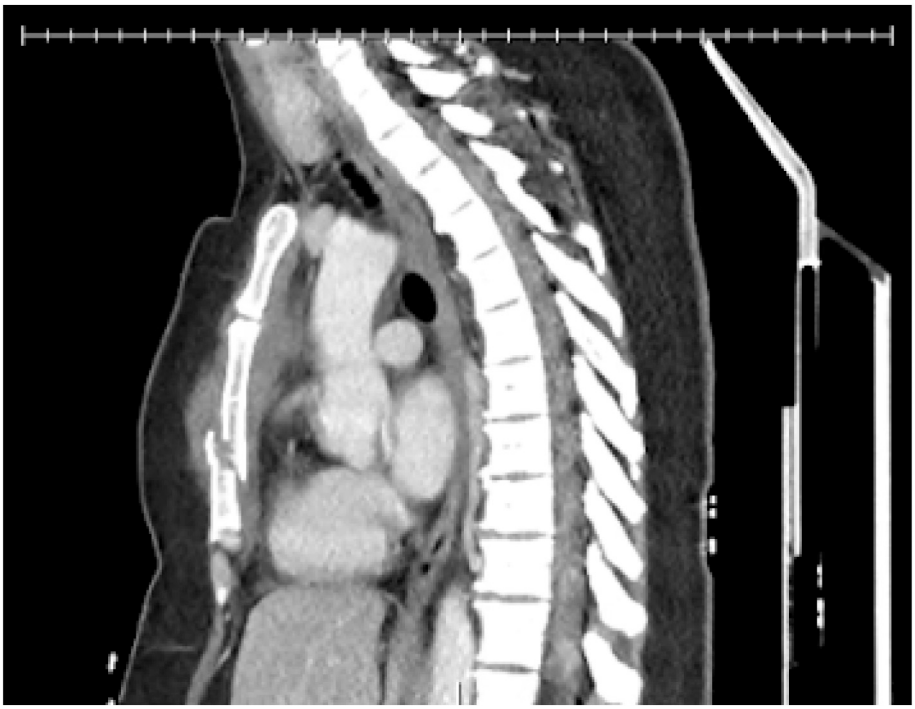

Fig. 2. CT chest of sternal fracture. CT imaging demonstrating our patient's transverse sternal body fracture with anterior-posterior displacement.

Fig. 3. Ultrasound image of superficial parasternal intercostal catheter. The orientation indicator is caudal. The ultrasound probe is held over the 4th parasternal cartilage in a sagittal orientation. The catheter is visualized in-plane going through the subcutaneous tissue, pectoralis major muscle, 4th costal cartilage with the tip lying between the pectoralis major muscle and the intercostal muscles.

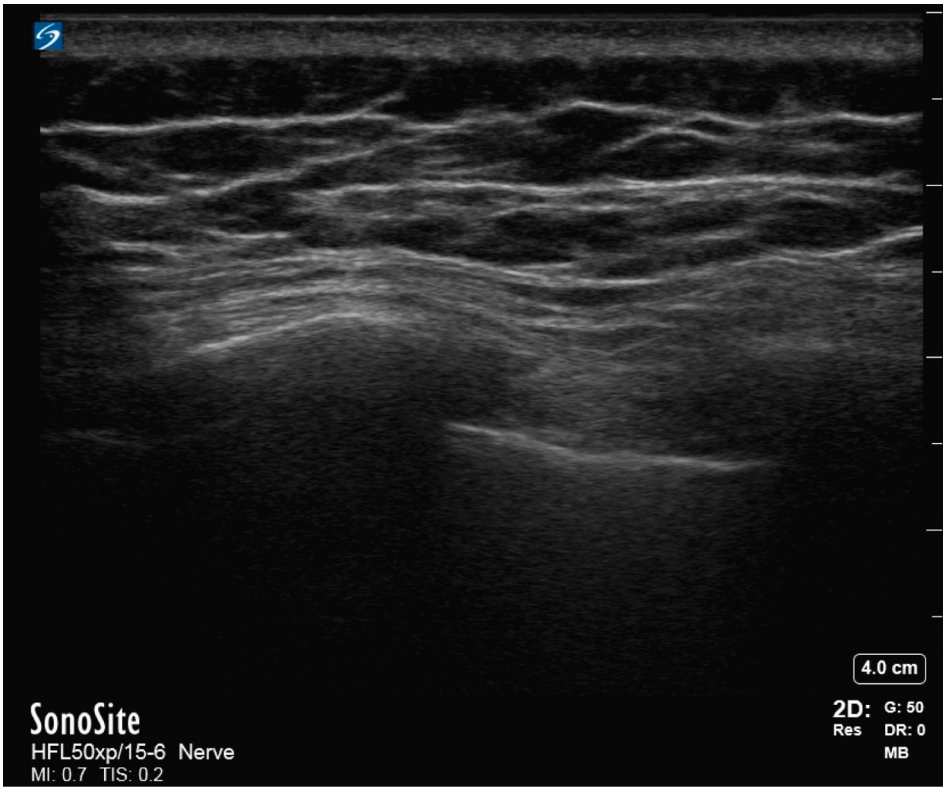

Fig. 4. Ultrasound image of intercostal cryoneurolysis. The orientation marker is caudal. The shadow created by the probe needle can be seen in-plane approaching the caudal end of the 4th rib, which is seen in the center of the ultrasound.

Discussion

Cryoneurolysis is the direct application of cold temperatures (−20 to −100 °C) causing Wallerian degeneration, a reversible neuronal injury characterized by inhibition of nerve signal transmission distal to the site of injury which allows regeneration over weeks to months [6]. Cryoneurolysis has been used extensively for chronic pain conditions including phantom limb pain, postherpetic, occipital, and intercostal neuralgia [7]. Recently, USG-IC using a hand-held device has emerged as a potential technique providing more prolonged analgesia for acute pain as compared to current modalities [8]. A few studies exploring the use of cryoneurolysis following thoracotomy demonstrated opioid-sparing analgesia, improved pulmonary functional outcomes, and decreased length of hospital stay [5]. Cryoneurolysis has few contraindications and low risk for neuralgia and pneumothorax, which may be further reduced with use of ultrasound guidance and percutaneous probes [9].

There have been 2 articles describing the use of IC for multiple rib fracture pain. A retrospective study by Zhao et al. of 13 patients who underwent thoracoscopic-guided IC and surgical stabilization showed a modest improvement in pain with 70 % of patients experiencing dysesthesias [5]. Changes in pain modulation may have been underestimated as retrospective reviews evaluating pain scores in polytrauma patients are not reliable due to concurrent sources of pain. A patient can report 0/10 rib fracture pain while simultaneously experiencing 8/10 pain from an acetabulum fracture. Additionally, the high rate of dysesthesias is likely related to surgical fixation rather than the IC.

Finneran et al. reported a series of 5 patients in which USG-IC was used to provide multiple rib fracture analgesia and found higher efficacy in patients with a lower number of rib fractures [5]. The duration of analgesia varied from 9 to 28 days and thereafter was controlled with nonopioid analgesics. No adverse effects or neuropathic pain were reported at 3 months. These results were in accordance with our practice, particularly that patients with flail segment seemed to only have modest pain relief after USG-IC, possibly due to distorted anatomical location of the intercostal nerves near the flail segment. In our patient, the primary goal was to provide sternal analgesia and with only 3 unilateral rib fractures, it was feasible to perform the additional 3 cryoneurolysis cycles.

In our patient, USG-IC was beneficial in providing extended analgesia for non-operative sternal and rib fractures in the setting of polytrauma, which encouraged mobility using a walker. This technique may be time consuming if several nerves need treatment such as in bilateral MRF. Most traumatic sternal fractures are transverse body fractures, while manubrium and xiphoid fractures occur less frequently [10]. This common fracture pattern only requires treatment of 2 intercostal nerves on each side to provide analgesia, which may be feasible for inpatient pain management. USG-IC could be utilized as a more definitive strategy for management of sternal fracture pain in patients eligible for surgical fixation, but at high risk for anesthetic complications.

Conclusion

We report a case in which USG-IC provided extended analgesia for acute sternal and rib fractures. In polytrauma patients with concurrent thoracic and lower extremity fractures, providing prolonged analgesia to the chest wall can improve ambulation. The most common sternal fracture pattern is transverse and only requires treatment of four intercostal nerves, making this procedure feasible in trauma centers. More studies are indicated to examine the risks and benefits of cryoneurolysis in management of acute thoracic fracture pain.

Conflict of interest

None.

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