

INTRODUCTION

Cryoneurolysis refers to the application of extreme cold to targeted nerve tissue. This thermal neurolytic technique disrupts the conduction of pain signals from the periphery to the central nervous system to eliminate or diminish the experience of pain.

Modern cryoprobes pass gas at a relatively high pressure down their shaft, through a small orifice and into the closed distal tip at a much lower pressure. Based on the Joule–Thomson effect, a dramatic temperature decrease occurs when the gas moves from the high to low pressure state causing rapid expansion and absorption of heat. The gas is then evacuated back up through a larger-diameter tube in the middle of the shaft; importantly, this closed circuit permits no gas to remain within the body. The extreme cold that is created (approximately  $-70^{\circ}\text{C}$ ) induces Wallerian degeneration—a reversible destruction of the nerve axon but retention of the endo-, peri- and epineurium.

The real-time imaging of ultrasound guidance enables the precise application to specific peripheral nerves, raising the possibility of cryoneurolysis for long-lasting site-specific pain management.<sup>1</sup> Emerging evidence suggests that cryoanalgesia may be superior to regional anesthesia for duration of analgesia and side effects profile.<sup>2</sup> Cryoanalgesia will likely be most applicable to painful conditions expected to last weeks or even months.

In this case, we describe cryoneurolysis for acute rib fracture and postoperative pain management of a trauma patient.

METHODS

- The case report is devoid of patient identifiable information; it is exempt from IRB review requirements as per Maimonides Medical Center Policy.
- The medical record was reviewed in preparation for the case report.
- All imaging was de-identified.

Perioperative Course

- 70-year-old male with PMH of Ulcerative Colitis and glaucoma presented as a stable, Level 2 trauma after mechanical fall.
- Pt sustained acute traumatic right 3, 5-8 rib fractures.
- Right 3,5,6,7,8,9,10 intercostal nerve blocks were performed with 0.5% bupivacaine for initial pain control.
- Patient continued to develop difficulty breathing and CT scan revealed a developing acute traumatic hemothorax with pneumothorax.
- The patient was taken to the OR for thoracotomy with evacuation of hemothorax and rib plating of ribs 6, 7 and 8. A chest tube was left in place.
- In the OR a preoperative T6-7 Thoracic epidural was performed, tested, and initiated for post operative pain control. Days later the epidural was capped, and the patient was transitioned to oral medications. The patient continued to have right sided mid thoracic pain in the distribution of intercostal nerves related to rib repair.
- Cryoneurolysis of T5-8 intercostal nerves was performed under ultrasound guidance. Individual nerves were identified, 2% lidocaine was injected followed by the probe insertion. Cryoneurolysis was performed with compressed N2O device, resulting in successful neurolysis of the nerve.
- Shortly after, the patient reported pain relief in the distribution of the nerves lysed. The epidural catheter was removed.
- On follow-up evaluation, the patient reported good, continued pain control with decreased pain medicine requirements.

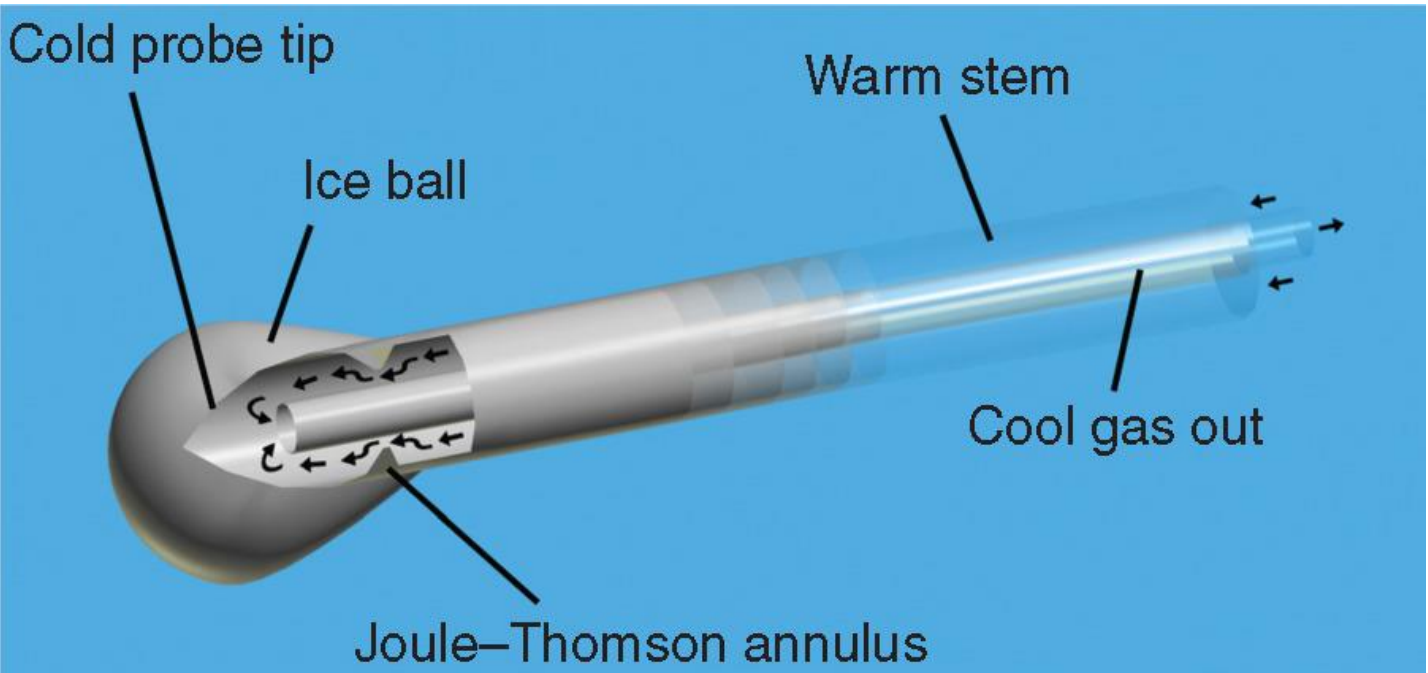


Figure 1a: Joule-Thomson effect

Figure 1b: Modern Cryoneurolysis Cannula

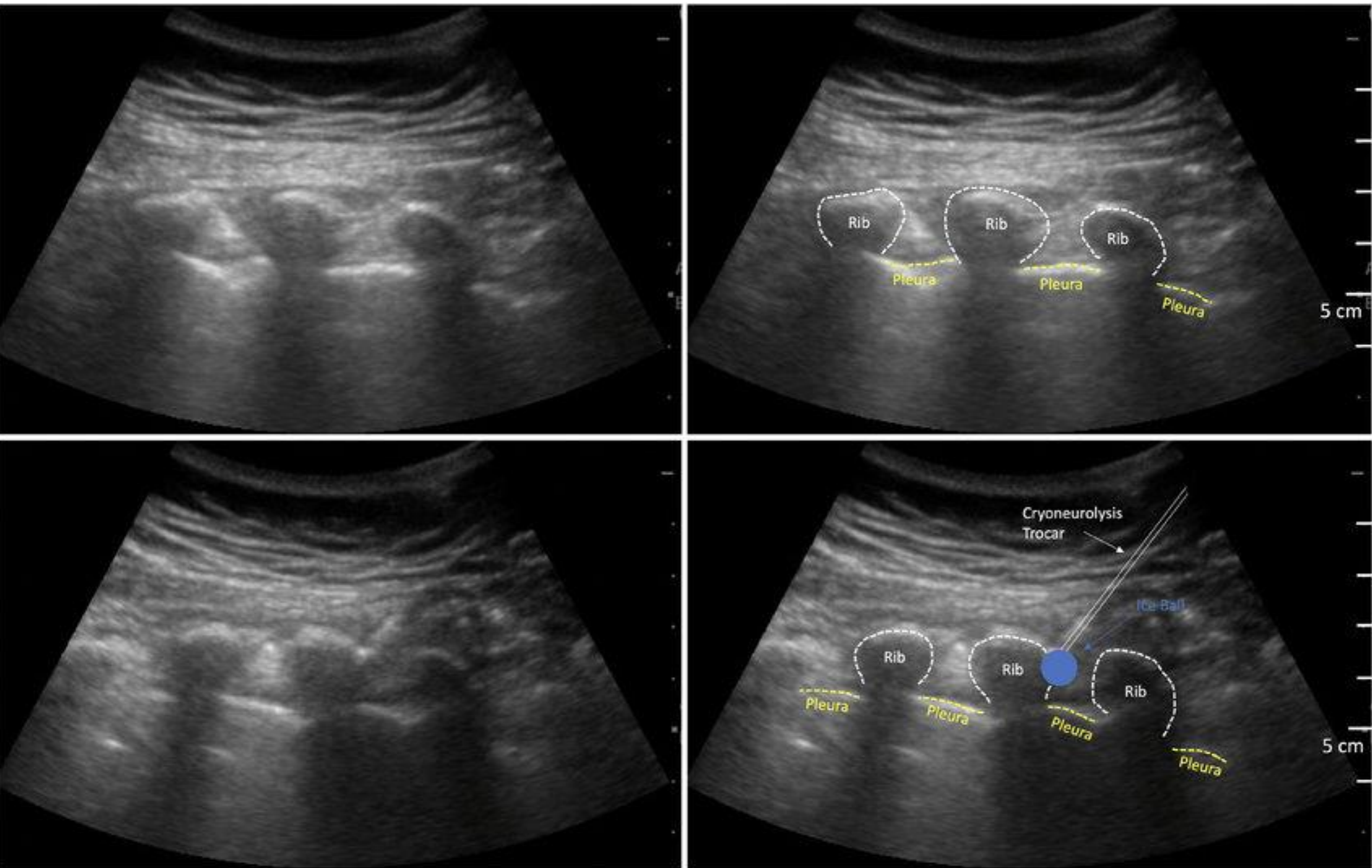


Figure 2: Ultrasound-guided percutaneous cryoneurolysis. (A) Parasagittal ultrasound view of T5-T8 intercostal nerves (B) Labeled anatomy of image A, (C) Parasagittal ultrasound view of cryoneurolysis of T7 intercostal nerve, (D) Labeled anatomy of image C. Cyan circle indicates area of ice ball created from cryoneurolysis, white line: trajectory of cryoneurolysis probe.

| Reversible                              |                                                                                                                                  |                                  |
|-----------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|----------------------------------|
| 1 <sup>st</sup> Degree                  | Neuropraxia – Interruption of conduction; Short recovery time                                                                    | +10 to -20°C                     |
| 2 <sup>nd</sup> Degree                  | Axonotmesis – Loss of continuity of the axon; Wallerian degeneration; Preservation of endo- peri- and epineurium                 | -20°C to -100°C                  |
| Non Reversible                          |                                                                                                                                  |                                  |
| 3 <sup>rd</sup> /4 <sup>th</sup> Degree | Neurotmesis – Loss of continuity; Some loss of continuity of epineurium and perineurium; endoneurium may or may not be disrupted | -140°C and colder                |
| 5 <sup>th</sup> Degree                  | Transection (Severe Neurotmesis) – Gross loss of continuity                                                                      | Not possible with cryoneurolysis |

Figure 3: Nerve injury classification table, organized by temperature.

DISCUSSION

Cryoneurolysis has been described in the literature for the treatment of acute and chronic pain. Chest wall injuries such as rib and sternal fractures, can cause severe acute pain ranging from several days to years. Ultrasound guided intercostal cryoneurolysis using a hand-held device has emerged as a potential technique providing prolonged and targeted analgesia for acute pain compared to current modalities. A few studies exploring the use of cryoneurolysis following thoracotomy demonstrated opioid-sparing analgesia, improved pulmonary functional outcomes, and decreased length of hospital stay.

Regional anesthesia with local anesthetic nerve blocks has limited duration and may not provide effective pain relief for patients with rib fractures. Percutaneous cryoneurolysis of the intercostal nerves may be an excellent adjuvant or substitute for local anesthetic-based nerve blocks. In the case of our patient, the regional block was mildly effective, while the thoracic epidural was very effective in reducing the patient’s pain. Once the thoracic epidural was capped, the patient continued to experience pain that was not well controlled with oral medication. After cryoneurolysis, the patient’s pain was remarkably reduced, and he was appropriate for discharge.

Cryoneurolysis may serve as a promising technique given its safety profile and effectiveness in many acute and chronic pain conditions. We believe our case contributes to the growing literature in support of cryoneurolysis for addressing rib fracture pain and acute pain in the trauma setting.

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