

Cryoneurolysis for Digital Neuralgia in Professional Baseball Players

A Case Series

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Background: Thumb injuries are common in baseball players and can sometimes be challenging to effectively manage. A subset of patients experience failed nonoperative management yet do not have a clear indication for surgery. Cryoneurolysis or cryoanalgesia is a form of neuromodulation for pain that has been approved by the US Food and Drug Administration; it has been used safely and effectively on a variety of peripheral nerves. The mechanism of action involves percutaneous introduction of a small probe under local anesthetic to nerve tissue using ultrasound guidance. The probe is then cooled to -88°C using nitrous oxide, which results in secondary Wallerian degeneration. Axonal and myelin regeneration occurs completely in 3 to 6 months.

Purpose: To describe a nonsurgical approach to refractory digital neuralgia using cryoneurolysis in a series of professional baseball players.

Study Design: Case series; Level of evidence, 4.

Methods: Included were 3 professional baseball players, each presenting with thumb pain in his top batting hand refractory to nonoperative modalities. Visualization of the superficial radial sensory and ulnar digital nerves was obtained using ultrasound. The skin was prepared in sterile fashion. A 22-gauge, 1.5-inch (3.8-cm) needle was then advanced using ultrasound guidance, and local anesthetic was applied. Both treatment sites were marked using a skin marker. Cryoneurolysis was performed using a 5-mm tip, and 60-second treatment cycles were performed at each site. Each of the cycles resulted in a roughly 5×7 -mm lesion visible as hypoechoic signal.

Results: All 3 players endorsed significant and prolonged relief and were able to return to an elite level of play.

Conclusion: Study findings indicated marked efficacy and safety of using cryoneurolysis of the ulnar digital nerve and the superficial radial sensory nerve in a small group of elite baseball players with refractory digital neuralgia.

Keywords: cryoneurolysis or cryoanalgesia; digital neuralgia or thumb pain; baseball

Thumb injuries, whether soft tissue or bony, are common in baseball players and can sometimes be challenging to effectively manage. Digital neuralgia is a common but under-reported pathology associated with repetitive use and compression of the ulnar digital nerve. The principal lesion involves perineural or intraneural fibrosis or reactive hyperplasia of the nerve fibers, support elements, or special end-organs resulting in pain and sensory symptoms in the distribution of the thumb. A neuroma or mass may or may not be visible on magnetic resonance imaging (MRI) studies; however, if seen, such a mass is diagnostic in conjunction with positive symptoms.² Current treatments include oral and topical non-steroidal anti-inflammatories, immobilization, physical therapy, corticosteroid injections, and/or surgery.⁶ A subset of patients, however, experience failed

nonoperative management yet do not have a clear indication for surgery. Cryoneurolysis or cryoanalgesia is a form of neuromodulation that has been approved by the US Food and Drug Administration for the treatment of pain in a peripheral sensory nerve distribution.⁴ We hypothesized that use of cryoneurolysis on sensory nerves innervating the thumb would reduce pain symptoms. Our purpose was thus to investigate and report the safety and efficacy of a nonsurgical approach to refractory digital neuralgia using cryoneurolysis in a series of 3 professional baseball players.

We used the Iovera System designed by Pacira Biosciences for the patients in this case series. There are no financial relationships to disclose between the authors and either the manufacturer or the device itself. The mechanism of action involves percutaneous introduction of a 5-mm probe under local anesthetic to the nerve tissue target using ultrasound guidance. The probe is then cooled to -88°C using nitrous oxide, which results in secondary Wallerian degeneration: that is, axonotmesis with preservation

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of the epineurium, perineurium, and endoneurium. Complete axonal and myelin regeneration occurs in 3 to 6 months.⁵ Contraindications include cryoglobulinemia, paroxysmal cold hemoglobinuria, cold urticaria, Raynaud disease, and open or infected wounds at or near the treatment site. Potential complications at the treatment site include ecchymosis, edema, erythema, local pain or tenderness, localized dysesthesia, cold- or heat-related injury to the skin, hyper- or hypopigmentation, or skin dimpling. Outside the treatment site, loss of motor function may occur with inaccurate targeting. In this article, we describe a nonsurgical approach to refractory digital neuralgia using cryoneurolysis in a series of 3 professional baseball players.

CASE 1

A 30-year-old, right-handed, male professional baseball player reported refractory pain of the right thumb for 17 months. He described the pain as sharp, shooting, and burning, primarily associated with batting but also intermittently with other activities such as throwing, shaking hands, or writing. Onset was gradual; however, symptoms progressed to the point they were significantly affecting his performance and were rated up to a 7 of 10 in intensity on the numeric rating scale (NRS). He had undergone extensive trials of nonoperative therapy with bracing, specialized padding, topical and oral non-steroidal anti-inflammatories, iontophoresis, and corticosteroid injections to little or no avail.

On examination, no abnormalities were found on visual inspection. Palpation yielded moderate tenderness focused predominantly over the right thumb metacarpophalangeal (MCP) joint. No tenderness over the anatomic snuffbox was noted, and the patient had no allodynia or hyperpathia. Two-point discrimination was preserved at 10 mm on both the palmar and the dorsal aspects of the thumb. Muscle bulk and tone were normal. Strength was preserved at 5 of 5 throughout the hands and upper extremities. Range of motion was normal without excess laxity. Reflexes were normal and symmetrical. Diagnostic ultrasound at our institution demonstrated a small, focal area of soft tissue inflammatory change adjacent to the MCP joint, which corresponded to the area of peak tenderness. There was a weakly positive Tinel sign at this site resulting in shooting and burning in both the volar and the dorsal aspects of the web space. MRI images without contrast of the right thumb (at an outside facility) demonstrated findings consistent with a likely ulnar digital neuroma just distal to the MCP joint as well as a low-grade adductor pollicis strain.

Based on these findings, we decided to provide a trial of cryoanalgesia with the patient's consent. Visualization of the right superficial radial sensory nerve at the wrist was obtained under ultrasound using a Samsung LM4-15B linear array transducer. The skin was prepared in the normal sterile fashion using betadine and alcohol. A 22-gauge, 1.5-inch needle was then advanced via ultrasound guidance. Negative heme aspiration was confirmed, and a solution containing 1% lidocaine and 0.5% bupivacaine was gradually injected. Next, the area of chief concern at the base of the thumb was anesthetized using ultrasound guidance with 0.75 mL of the same solution. Both treatment sites were marked using a skin marker. After sufficient time was allowed to achieve local anesthesia, the Iovera System was employed using a 5-mm tip (Figure 1A). Three 60-second treatment cycles were performed across each of the 2 previously marked treatment sites. Each of the 3 cycles resulted in a 5.7 × 7.8-mm lesion visible as hypochoic signal under ultrasound (Figure 1B). The patient tolerated the procedure well without complication.

At 1-week follow-up, the patient reported significant improvement in his NRS pain score to 3 of 10 and had returned to batting practice with minimal symptoms. Approximately 4 months later, the patient began to have recurrence of severe pain symptoms and returned for repeat cryoneurolysis of the right superficial radial sensory nerve, which once again provided significant benefit. Subsequent identical treatments were provided after an additional 4 months, 9 months, and 4 months, respectively. Each provided significant but temporary relief with preservation of tactile sensation identified subjectively by the patient and objectively via 2-point discrimination at 10 mm.

At 28 months after initial presentation and 7 months after the most recent procedure, the ulnar digital nerve at the first webspace, in addition to the right superficial radial sensory nerve, was treated with cryoneurolysis. After this intervention, the patient had prolonged, complete resolution of his symptoms. At the last follow-up visit 16 months later, the patient had remained pain-free, and his batting average had improved to pre-morbid baseline.

CASE 2

A 33-year-old, right-handed, male professional baseball player reported 1.5 months of right thumb pain of gradual onset without clear inciting event or trauma. He reported pain on the NRS as 10 of 10, which had been intermittent with batting and throwing but was constant by time of presentation. He described the pain as sharp, aching, throbbing, and shooting from the ulnar aspect of the MCP joint and radiating distally.

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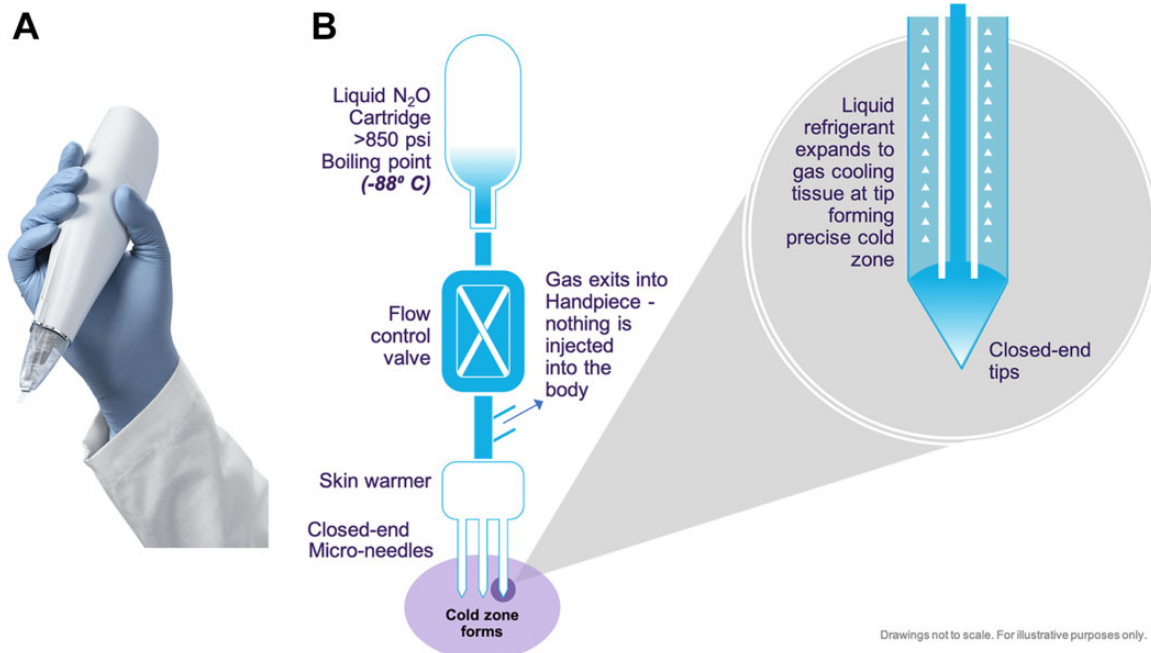


Figure 1. (A) Iovera System with 5-mm tip. (B) Schematic demonstrating cryoneurolysis lesion formation (images not to scale). Authorization to reprint copyrighted images obtained from Pacira BioSciences, Inc.

He endorsed numbness and paresthesia in the same distribution with mild weakness. He had modest initial improvement with use of oral and topical non-steroidal anti-inflammatory medications. He did not improve after a corticosteroid injection. Frequent icing was beneficial, and he used ethyl chloride topical spray before at-bats. He had not tried physical therapy or immobilization.

Examination revealed increased radial deviation of the right thumb compared with the left but with a firm endpoint. Significant tenderness was noted over the ulnar digital nerve at the level of the MCP joint. Strength was preserved at 5 of 5 throughout the hands and upper extremities. No evidence of atrophy or fasciculation was found, and reflexes were normal. Sensation was diminished to pinprick over the superficial radial sensory nerve distribution of the right thumb. Radiographs of the hand were obtained and were positive only for a small bony fleck adjacent to the scaphoid distal pole.

With patient consent, diagnostic local anesthetic injections of the superficial radial nerve and ulnar digital nerve were performed using ultrasound. The patient reported significant relief upon returning to clinic the following day, and cryoneurolysis was performed at each location using the previously described protocol. The procedure was well tolerated and without complication. The player missed 3 games in total. At 1-week follow-up, the patient reported complete pain relief, which persisted at 12-month follow-up.

CASE 3

A 30-year-old, left-handed, male professional baseball player reported left thumb pain for 5 weeks after “getting



Figure 2. (A) Axial and (B) sagittal short tau inversion recovery (STIR) magnetic resonance imaging scans of a left hand showing evidence of strain in the adductor pollicis (circled).

“jammed” during batting practice. The pain was localized to the base of the left thumb near the MCP joint and was characterized as sharp and aching. Pain on the NRS was rated 0 of 10 at rest but could be 7 of 10 and severe in the thumb with use (eg, gripping, batting). He experienced mild relief from “shaking out” his hand. He had tried oral and topical non-steroidal anti-inflammatories as well as a cortisone injection of the thumb with marginal improvement. He was using a padded batting glove, which provided some benefit, although pain was still severe at impact.

Examination revealed tenderness to palpation over the left thumb MCP joint and ulnar digital nerve as well as over the abductor pollicis brevis. No weakness or sensory change was noted. The thumb MCP joint was stable to radial and ulnar stress. MRI scans without contrast of the left thumb demonstrated a strain of the adductor pollicis (Figure 2).

Given these findings and with patient consent, we obtained ultrasound images of the left wrist at the proximal and medial aspects of the 1-2 interdigital space using appropriate transverse and longitudinal scanning motions. Ultrasound-guided cryoablation of the left 1-2 interdigital space was administered via a proximal short-axis approach. Next, 1 mL of 1% lidocaine and 1 mL of 0.5% bupivacaine were injected using a 25-gauge, 1.5-inch needle. A total of 2 mL was injected around each nerve. Additionally, 0.5 mL of 1% lidocaine and 0.5 mL of 0.5% bupivacaine trigger point injections were introduced into each of the left adductor pollicis and flexor pollicis brevis muscles.

At follow-up 3 weeks later, the patient reported improvement in NRS pain score to 4 of 10; however, he still experienced significant pain on the palmar-ulnar aspect of the left thumb near the MCP joint when batting. He also reported cold sensation in the thumb compared with the right, which spared the other digits of the left hand. Cryoneurolysis was repeated for the superficial radial sensory nerve and ulnar digital nerve, and the patient was placed on the 10-day injured list to convalesce. He began exercising with the trainers after 1 day of rest. On day 5, he began a hitting progression and was participating in full fielding and batting practice by day 7; he returned to the starting line-up on day 11. He reported 24 hours of postprocedure injection-site tenderness, but he denied experiencing any further pain or temperature change in the thumb throughout the 10-day recovery period and continued to be pain-free at 2 weeks after the procedure.

DISCUSSION

Each athlete was ultimately able to return to an elite level of play approximating premorbid performance with resolution of pain symptoms. The procedure was well tolerated, and no adverse events were reported. Notably, all players developed neuralgia in their top, power hand used for batting, which may be consistent with the forcible and repetitive compression of the ulnar digital nerve thought to underlie the pathology.

In the first case, significant but incomplete reduction in pain symptoms occurred with cryoneurolysis of the superficial radial sensory nerve alone. Although this allowed the athlete to manage his pain and return to a high level of play, it was not until the ulnar digital nerve was targeted that the patient reported complete pain relief. Both the radial and the ulnar digital nerves are important for tactile sensation and dexterity in the thumb and infrequently anastomose.^{3,8} It is conceivable that both nerves were involved in pain transmission, although the ulnar digital nerve was never lysed in isolation. No depreciation was identified subjectively by the player or more objectively via 2-point discrimination in tactile sensation. The second player had both superficial radial sensory and ulnar digital cryoneurolysis from the outset and reported a complete resolution in pain symptoms that persisted at least 12 months after the procedure. The third player's presentation may have been confounded by evidence of an adductor pollicis strain on MRI scans and a 10-day relative rest period; however, the patient also endorsed immediate relief after the

procedure, including reduction in neuropathic symptoms (eg, "cold" sensation in the thumb and shooting pain).

Cold for medical use was described as early as 460 BC by Hippocrates, who noted analgesic and anti-inflammatory properties.¹ The use of freezing temperatures on sensory nerves, or cryoanalgesia, began to gain traction in the 1970s and has shown reasonably good success. Technological advancements have allowed discernment of specific ranges of temperatures for cellular application (eg, temporary inactivation near 10°C, apoptosis in the range of -5° to -15°C, necrosis or Wallerian degeneration at <-20°C).⁵ Peripheral nerves are unique in that freezing the axon results in degeneration distal to the treatment site while the proximal axon and cell body remain intact, allowing for regeneration at rates of about 1 to 4 mm/d.⁵ Furthermore, freezing spares acellular epineurial and perineurial structures that are important for axonal growth and remyelination. This contrasts with thermal or mechanical lesions, which compromise structural proteins. A variety of animal models have indicated that peripheral nerves regain their typical functionality, electrophysiology, and pathological structure with temperatures as low as -120°C.⁵

In cases of refractory digital neuralgia, prolonged rest and/or immobilization may be helpful, although this is not guaranteed, as suggested in the first case. Additionally, athletes may jeopardize their position with prolonged or repeated absences or underperformance secondary to chronic pain. As Swanson et al⁷ remarked regarding ulnar digital neuroma in bowlers, there is a need for rapid and definitive therapy to minimize time away from sport for the competitive athlete. Swanson et al described a surgical intervention for the treatment of bowler's thumb that involves dorsal translocation of the ulnar digital nerve (containing a neuroma) with reattachment of the adductor pollicis. In our case series, microsurgical exploration was not considered in any of the cases because the patients improved with cryoneurolysis. If improvement had not been seen, microsurgical exploration would have been considered.

This study is subject to all the limitations of a case series, and large, rigorous studies are needed to illuminate causal inferences. Novel, complex technologies may also be more susceptible to placebo effect. Nonetheless, we can report marked efficacy and safety using an US Food and Drug Administration-approved cryoneurolysis device on the ulnar digital nerve and the superficial radial sensory nerve in a small group of professional baseball players with refractory digital neuralgia.

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REFERENCES

1. Cooper S, Dawber R. The history of cryosurgery. *J R Soc Med.* 2001; 94:196-201.
2. Dobyms J. Digital nerve compression. *Hand Clinics.* 1992;8(2):359-367.
3. Falconer D, Spinner M. Anatomic variations in the motor and sensory supply of the thumb. *Clin Orthop Relat Res.* 1985;195:83-96.

4. Gabriel RA, Ilfeld BM. Novel methodologies in regional anesthesia for knee arthroplasty. *Anesthesiol Clin*. 2018;36(3):387-401. doi:10.1016/j.anclin.2018.05.002
5. Hsu M, Stevenson FF. Wallerian degeneration and recovery of motor nerves after multiple focused cold therapies. *Muscle Nerve*. 2015;51(2):268-275. doi:10.1002/mus.24306
6. Lehman JD, Krishnan KR, Stepan JG, Nwachukwu BU. Prevalence and treatment outcomes of hand and wrist injuries in professional athletes: a systematic review. *HSS J*. 2020;16(3):280-287. doi:10.1007/s11420-020-09760-w
7. Swanson S, Macias LH, Smith AA. Treatment of bowler's neuroma with digital nerve translocation. *Hand (N Y)*. 2009;4(3):323-326. doi:10.1007/s11552-009-9170-2
8. Wu K, Aibinder WR, Richards RS, Suh N. A new surface landmark for thumb digital nerve bifurcation: a cadaveric study. *J Hand Surg Am*. 2020;45(4):362.e1-362.e4. doi:10.1016/j.jhsa.2019.09.004