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A Novel Introducer for Ultrasound-Guided Cryoneurolysis Administration to Improve Patient Safety and Functionality

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Background: Percutaneous cryoneurolysis provides prolonged postoperative analgesia by placing a probe adjacent to a peripheral nerve and cooling the probe tip, inducing a reversible block that lasts weeks to months. Unfortunately, freezing the nerve can produce significant pain. Consequently, local anesthetic is generally applied to the nerve prior to cryoneurolysis, which, until now, required an additional needle insertion increasing both the risks and duration of the procedure.

Case Presentation: Three patients underwent ultrasound-guided percutaneous cryoneurolysis of either the sciatic and saphenous nerves or the femoral nerve. In all patients, the local anesthetic injection and cryoneurolysis were accomplished with a single needle pass using the novel probe introducer.

Conclusion: This introducer allows perineural local anesthetic injection followed immediately by cryoneurolysis, thereby sparing patients a second skin puncture, lowering the risks of the procedure, and decreasing the overall time required for cryoneurolysis.

Key words: Cryoablation, cryoanalgesia, peripheral nerve block, postoperative analgesia, ultrasound

BACKGROUND

Ultrasound-guided percutaneous cryoneurolysis provides prolonged analgesia measured in weeks to months with a single application; it has been successfully used to treat pain following major limb amputation (1) and a wide variety of other painful conditions (2). The technique involves the application of extreme cold (approximately -70°C) to peripheral nerves producing reversible axonal injury and Wallerian degeneration distal to the point of treatment (3). The epineurium, perineurium, and endoneurium all remain intact allowing axon regeneration at a rate of approximately 1 to 2 mm per day (4,5). The duration of the induced analgesia is, therefore, dependent on the distance between the site of cryoneurolysis and the painful stimulus. Local anesthetic blocks are generally performed prior to cryoneurolysis as direct application of extreme cold to a nerve may produce significant, temporary pain, both at the ablation site and in the distribution of the nerve (2). Usually, local anesthetic blocks are also performed in

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order to evaluate whether proceeding to cryoneurolysis would prove clinically beneficial, but this practice varies greatly (2).

The most common technique for ultrasound-guided percutaneous cryoneurolysis is to first administer a local anesthetic-based block via a conventional nerve block needle, followed by the cryoneurolysis procedure with a probe inserted through an additional introducing needle/angiocatheter (1,2). This technique necessitates 2 separate needle passes, thereby increasing both the procedure risk and time requirement. A recently developed and novel cryoneurolysis introducer contains a side-port for injecting local anesthetic via the introducer (Fig. 1), which subsequently allows for insertion of the cryoneurolysis probe, eliminating the need for 2 needle passes. We report here the successful use of this novel introducer during cryoneurolysis of the sciatic and saphenous nerves in 2 patients with significant pain following below-knee amputation, and during cryoneurolysis of the femoral nerve in a patient with a nonhealing wound after patella open reduction and internal fixation.

CASES

Consent for Publication

The University's Institutional Review Board (University of California San Diego) waives review requirements for short case series. Written informed consent for the cryoneurolysis procedure and publication of relevant, nonidentifiable history and imaging in the form of a case series was obtained from each patient.

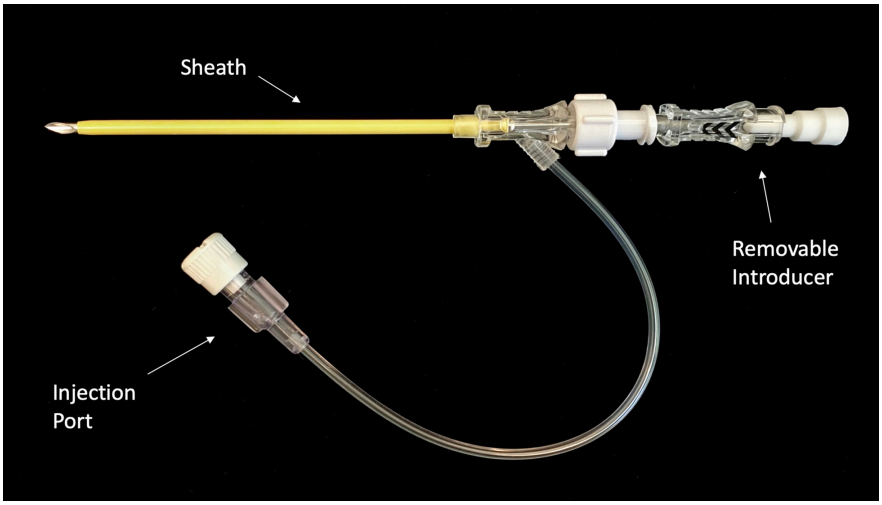

Fig. 1. Novel cryoneurolysis introducer demonstrating the sharp removable introducer needle, flexible sheath for probe insertion, and injection port.

Description of Procedure

Patients were positioned prone (sciatic) or supine (femoral/saphenous) with American Society of Anesthesiologists monitors applied. The target nerve was identified using a 13- to 6-MHz 38-mm linear array ultrasound transducer (Edge II; SonoSite, Bothell, WA). The cryoneurolysis probe insertion site was prepped with chlorhexidine gluconate and the entry site was anesthetized with lidocaine 1% (1-2 mL). The introducer (Fig. 1) was inserted under direct ultrasound guidance using an in-plane technique to lie in the plane superficial to the epineurium of the target nerve (Fig. 2A). Lidocaine 1% (3 mL) was administered via the introducer and perineural spread was confirmed via ultrasound (Fig. 2B). Without removing the introducer, the cryoneurolysis probe (Epimed International, Farmers Branch, TX) was inserted through the introducer until the probe was visualized with ultrasound protruding slightly from the end of the introducer. Three cycles of cryoneurolysis (2-minute freeze followed by one-minute thaw) were applied to the target nerve, moving the tip of the probe between each cycle to ensure complete coverage of the nerve (Fig. 2C). In cases with more than one treated nerve, the patient was then repositioned and the procedure was repeated for the second target nerve.

Case 1

A 44-year-old man with a history of stage IV chronic renal disease, peripheral arterial disease, diabetes mellitus, and diabetic neuropathy underwent below-knee amputation for dry gangrene of the foot. Both a traditional continuous sciatic nerve block and a single injection femoral nerve block were performed prior to the surgery. On the first postoperative day, the patient complained of severe pain localized to the saphenous distribution. A continuous adductor canal block was administered, and the patient experienced no pain while the catheters remained in place. When the catheters were removed prior to discharge on the fourth postoperative day, the patient had a severe resurgence of pain. Sciatic and saphenous cryoneurolysis were offered and administered as described above.

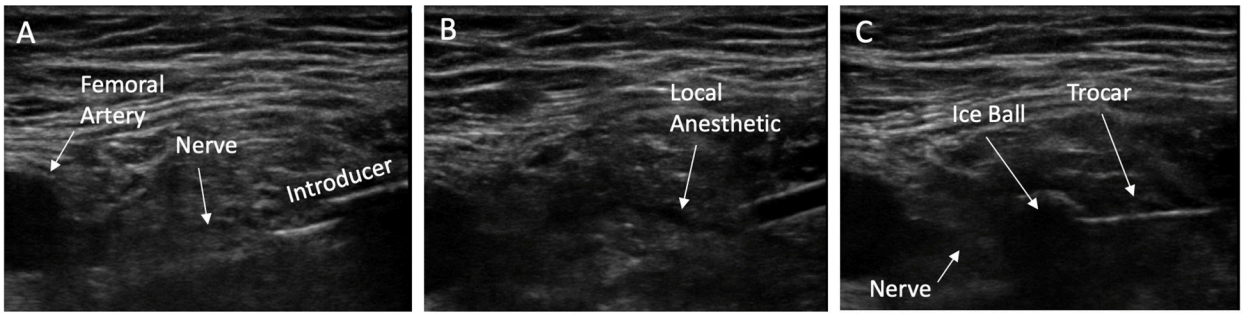

Fig. 2. (A) The introducer is positioned under ultrasound guidance adjacent to the femoral nerve. (B) Local anesthetic is administered via the introducer to anesthetize the femoral nerve. (C) The ice ball is visualized encompassing part of the femoral nerve at the tip of the cryoneurolysis trocar inserted through the sheath.

Case 2

A 55-year-old man with history of heart failure, stage III chronic renal disease, narcotic abuse, diabetes mellitus, and diabetic neuropathy underwent below-knee amputation for osteomyelitis. His pain was moderately well controlled perioperatively with single-injection femoral and sciatic nerve blocks, but continuous nerve blocks were not placed due to bacteremia. The patient complained of significant pain following the resolution of the nerve blocks. Due to continuing bacteremia the patient was offered sciatic and saphenous cryoneurolysis instead of continuous peripheral nerve blocks with their higher risk of infection (6). Cryoneurolysis of the sciatic and saphenous nerves was administered as described above.

Case 3

A 36-year-old man with a history of type-1 diabetes mellitus, left transmetatarsal amputation, and right below-knee amputation required repeated debridements of a nonhealing wound following right patella open reduction and internal fixation. A continuous femoral nerve block was utilized for analgesia during the course of the patient's hospitalization. The patient experienced uncontrollable pain following discontinuation of the femoral block prior to discharge. Femoral nerve cryoneurolysis was therefore offered and administered as described above.

DISCUSSION

Cryoneurolysis of peripheral nerves offers the potential for weeks of analgesia following painful surgical procedures or trauma. However, most techniques require administering a local anesthetic block via a conventional nerve block needle, removing that needle, inserting an introducer for the cryoneurolysis probe, and then inserting the cryoneurolysis probe itself. The requirement for 2 insertions of separate needles increases the risks of infection, bleeding, and trauma for patients undergoing cryoneurolysis. Consolidating the injection of local anesthetic and the placement of the cryoneurolysis probe has the potential to increase safety while decreasing the time burden of the procedure, which can be significant.

While cryoneurolysis has the benefit of providing analgesia that far surpasses conventional local anesthetic nerve blocks, the time requirement for the procedure can be substantial. This is due not only to the repeated applications (2 or 3 cycles each requiring 3 minutes) to each nerve, but also due to the fact that some of the optimal patients for cryoneurolysis will require many nerves to be treated, i.e., multiple and possibly bilateral applications to intercostal nerves for postmastectomy pain or rib fracture analgesia (7,8). Considering that a major drawback of cryoneurolysis is its time-consuming nature (9), this new introducer may increase the willingness of providers to perform cryoneurolysis by decreasing the time required for the procedure.

The recently developed cryoneurolysis probe introducer described in this report offers the potential to consolidate 2 separate procedures (local anesthetic block and cryoneurolysis) into a single needle insertion and therefore has the potential to decrease the overall risk and time requirement. Describing the real-world application of any novel technology is important, especially early on in its implementation. Hence, we describe here 3 successful cases of this novel introducer being used to both anesthetize and administer cryoneurolysis to the sciatic, saphenous, and femoral nerves.

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