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A Case Series: Thermal Modulation for Suspected Intracranial Hypotension and Post-Traumatic Cervical Syndrome

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Background: Thermal modulation exploits phase shift and was previously examined for proof of concept in the animal model. We aimed to generate nerve blocks similarly in humans at moderate nerve temperatures in a non-destructive manner. We examined patients who experienced a traumatic mechanism of injury followed by debilitating positional headache, suspicious for cerebrospinal fluid (CSF) leak.

Case Report: Thermal modulation may be helpful in treating painful conditions of areas of superficial peripheral nerves as they are easily targeted by application of heat and cold to the skin. We applied the protocol to patients with traumatic cervical syndrome and headaches secondary to CSF leak. Using the therapy as an abortive measure reduced scores on the Numeric Rating Scale (NRS-11) for pain in both patients by 88%. One patient experienced long-term relief after consistent use of the therapy.

Conclusion: The thermal modulation technique may be effective in targeting superficial nerves and can be useful in treating difficult headache conditions resulting from traumatic injury.

Key words: Low pressure syndrome, CSF leak, secondary headache, thermal modulation, thermal nerve block

BACKGROUND

Thermal- and cryo-ablative techniques are used to block axonal conduction through nerve destruction. Zhang et al (1) demonstrated a thermal nerve block protocol that enables nerve conduction block at a safe 15°C (59°F) room temperature by first warming the nerve to 45°C (113°F). The insight that a nerve block could be achieved in a reversible fashion is compelling for its therapeutic potential for conditions modulated by peripheral nerves. Traumatic cervical syndrome describes a complex array of symptoms caused by neck trauma (2). Cerebrospinal fluid (CSF) leaks are caused by a dural tear and typically result in positional headaches. Chronic CSF leak patients may experience migrainous features related to intracranial vasodilation secondary to low CSF pressure. This underdiagnosed phenomenon has also been explained by cerebellar descent causing traction on the C2-3 nerve roots (3). We present 2 cases of traumatic cervical syndrome with symptoms of intracranial hypotension with intractable occipital and neck pain managed with an occipital thermal nerve block.

CASE

The first patient is a 51-year-old woman with a his-

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tory of a rear-end motor vehicle accident. The patient was diagnosed with a traumatic brain injury and underwent kyphoplasty for vertebral fracture at T7. The patient experienced daily occipital pain that improved significantly when she was supine and hydrated. She was diagnosed with postconcussional syndrome. A posttraumatic chronic CSF leak was considered based on the mechanism of injury and positional headache symptoms. The results of a fluid and caffeine challenge were suspicious for intracranial hypotension. Magnetic resonance imaging (MRI) of the brain was significant for low-lying cerebellar tonsils with no other evidence of SEEPS signs signs (subdural fluid collection, enhancement of the pachymeninges, engorgement of venous structures, pituitary hyperemia, or sagging of brain). Epidural blood patch improved her symptoms temporarily. She trialed pregabalin, amitriptyline, topiramate, erenumab, and duloxetine without significant relief.

Patient 2 is a 41-year-old woman with a history of a backward mechanical fall with loss of consciousness, followed by severe daily positional headaches with nausea, emesis, intractable belching, cloudy cognition, and neck pain. She was unable to work and needed assistance with most activities for months after the trauma. Given the mechanism of injury and symptomatology, putative diagnoses of postconcussional syndrome and suspected intracranial hypotension were made. Epidural blood patch, third occipital nerve block, and C2-3, C3-4 medial branch thermal ablation provided minimal pain relief. Gabapentin and duloxetine did not improve symptoms. Head computed tomography (CT) showed a heavily attenuated left transverse sinus, though imaging studies were negative for SEEPS signs.

Patients were administered a proprietary institutional review board-approved thermal nerve block protocol (Thermaquil, Inc., Philadelphia, PA). Thermal nerve block was initiated and maintained using ice and a thermal therapy unit (ThermaZone Model #003-11 with Occipital Head Relief Pads, Innovative Medical Equipment LLC, Cleveland, OH).

Patient 1 self-administered therapy with remote video coaching. Although she initially experienced no reduction in her NRS-11 score, she continued to use the therapy for about 100 minutes per day for 7 days as her pain gradually reduced down to no pain: 100% reduction in her NRS-11 pain score, as can be seen in Fig. 1A. She continued therapy daily for another week, without any headaches, to build a stronger and longer-lasting block, which led to 53 days headache-free without additional therapy. The patient also experienced reduced nausea, light and sound sensitivity, and cognitive impairment during this period. As positional headaches returned, each thermal treatment reduced the NRS-11 score by 87% on average. The patient continues to use therapy at home.

Patient 2 suffered from posttraumatic chronic neck pain with ~12 severe headache days per month that exacerbated her neck pain and made it difficult to function. She underwent an in-office Thermaquil treatment and experience pain reduction from 8 of 10 to 0 of 10 across her entire head and neck during 2 hours of treatment. The patient continued therapy for 2 more hours with no pain and then remained pain free for > 24 hours. She now typically uses therapy at home once or twice daily for 1 to 2 hours per session, and her headache has dramatically improved, seen in Fig. 1B. The patient's nausea, light and sound sensitivity, fatigue, and dizziness have subsided. Since beginning daily treatments, the patient has returned to work as a nurse. Working increased her headache frequency, but regular therapy decreases headache severity. On average, she experienced 88% pain relief from each thermal treatment, and she achieved complete relief 61% of the time.

DISCUSSION

Occipital nerve blocks are broadly used in the treatment of migraine and nonmigraine headache conditions, including occipital neuralgia, tension-type, cervicogenic, and Chiari-associated headaches. The C2-4 central neurons innervate the dura of the posterior fossa, while the cutaneous receptive fields associated with these levels are in the occipital skin and neck muscles (4). Blockade or modulation of these receptive fields could desensitize the meningeal nociceptors via an extracranial pathway (4). There is a convergence of intracranial and extracranial inputs to the trigeminal cervical complex that are essential to the nociceptive transmission and higher-level pain processing, and the occipital cutaneous fields are prototypical of these extracranial inputs. Pain related to traumatic cervical syndrome with features of intracranial hypotension and postconcussional syndrome responded reliably to thermal nerve block in these 2 cases.

Occipital input to the trigeminal nucleus caudalis (TNC) contributes to cranial neural hyperexcitability. Periodically blocking occipital input to the TNC reduces neural excitability, thus reducing perceived pain while

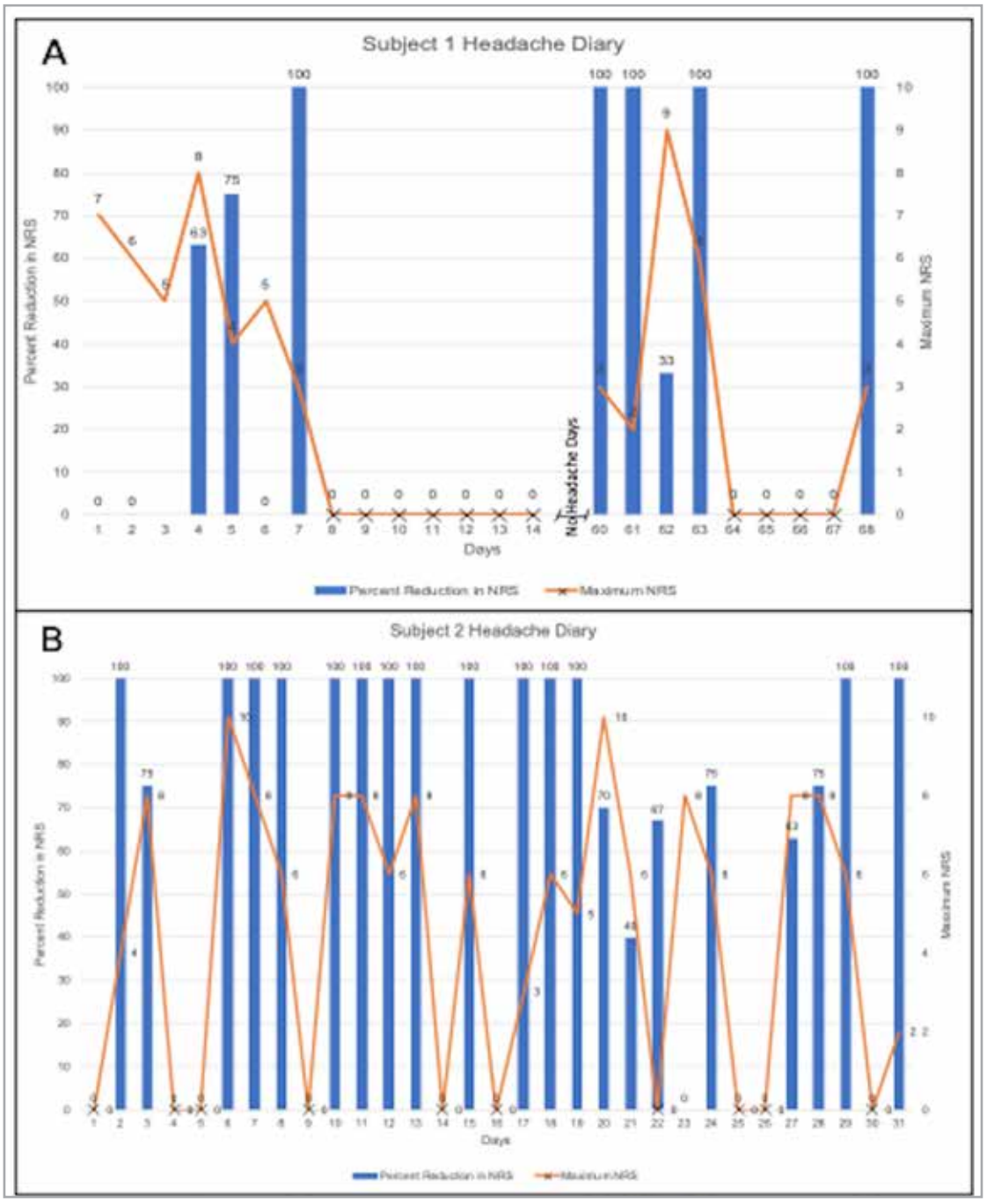

Fig. 1. Effect of Thermal Nerve Block on Headache NRS reduction for patients 1 and 2. (A) Patient 1 formed a block after 7 days of using the device. Patient 1 experienced S3 headache-free days while she was incapacitated by possible coronavirus infection and other unrelated health problems. When headaches returned for Patient 1, they were well controlled with an average 87% decrease in NRS. (B) Patient 2 reported complete relief of head and neck pain after 61% of treatment sessions with an average of 88% reduction of head and neck pain across all sessions. Both patients utilized the device to maintain the block on days represented with a black X.

increasing the threshold that causes migraine or breakout head pain. Increased threshold reduces susceptibility to triggers, and this is exactly the effect seen in both patients as a result of thermal occipital nerve block. In the cases above, the triggers were somewhat atypical. We see in both patients that regular use of thermal therapy has a cumulative effect, in which neural hyperexcitability is gradually reduced with subsequent nerve block treatments. Pain is seen to gradually reduce over the course of hours (Patient 2) or days (Patient 1). Furthermore, we see that thermal nerve blocks are an effective abortive treatment in the event of a headache flare, seen in patient 2, while providing prophylactic benefit reducing frequency, severity, and duration of head/neck pain with regular use.

CONCLUSION

This case series represents the translation of a rational therapy hypothesis from thermal nerve block in animals to a signal of efficacy in 2 human cases. The results of a prospective observational proof-of-concept study are forthcoming.

Authors' Contributions

AMK- Drafted and edited the manuscript, collected and analyzed data, researched and conceptualized mechanism, and designed a supporting figure.

AMS- Drafted and edited the manuscript, collected and analyzed data, researched and conceptualized mechanism, and designed a supporting figure.

MAF- Drafted and edited the manuscript, collected and analyzed data, researched and conceptualized mechanism, and designed a supporting figure.

PSK- Drafted and edited the manuscript, collected and analyzed data, researched and conceptualized mechanism, and designed a supporting figure.

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