Pain Physician 2012; 15:E711-E718 • ISSN 2150-1149

Case Series

Utility of Intercostal Nerve Conventional Thermal Radiofrequency Ablations in the Injured Worker after Blunt Trauma

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Disclaimer: There was no external funding in the preparation of this manuscript.
Conflict of interest: None.

Manuscript received: 03/20/2012
Revised manuscript received: 04/24/2012
Accepted for publication: 07/09/2012

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Background: Intercostal nerve blocks offer short-term therapeutic relief and serve as a diagnostic test for intercostal neuralgia. This original case report demonstrates the efficacy of radiofrequency ablations for long-term pain relief of intercostal neuralgia. To date, there have been no studies that demonstrate the efficacy of thermal conventional intercostal nerve radiofrequency ablations for intercostal neuralgia.

Objective: Describe the use of conventional thermal radiofrequency ablations of the intercostal nerves to treat blunt chest wall trauma.

Study Design: Case report.

Setting: Clinical practice.

Methods: Six patients suffering from work-related injuries to the chest wall whose treatment focused on conventional thermal radiofrequency ablations of the intercostal nerves.

Results: Four of the 6 patients were pain free by their final visit. The remaining 2 patients experienced pain relief until one began wearing a brace after an L5-S1 fusion; the other required repeat treatment after 5.5 months.

Limitations: Case series. There was limited follow-up as patients were either discharged after receiving potentially curative care or were lost to follow-up.

Conclusions: Following conventional thermal radiofrequency ablations of the intercostal nerves, 5 of the 6 patients experienced either long-term pain relief or required no additional care. The treatment has potential efficacy for injuries, including rib fractures or intercostal neuralgia, stemming from blunt trauma to the chest wall. In addition, there may be a potential for this treatment to help patients suffering from postthoracotomy pain.

Key Words: Radiofrequency ablation, intercostal neuralgia, rib fracture, blunt trauma, workers' compensation.

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Since 1945, diagnostic intercostal nerve blocks have been used to decrease pain secondary to thoracic trauma (1). During World War II, blind intercostal nerve blocks treated the pain associated with fractured ribs, secondary to blunt and penetrating trauma, thereby increasing pulmonary toilet.

In 2008, a review (2) of regional anesthesia for postoperative thoracotomy pain relief demonstrated the utility of intercostal nerve blocks. Compared to saline, single and repeat therapeutic intercostal local

anesthetic nerve blocks reduced supplementary analgesics. The short duration of single shot intercostal nerve blocks made for limited benefit. Continuous intercostal nerve blocks, though theoretically appealing, did not show benefit because of the low number of published studies.

Since continuous intercostal nerve blocks did not demonstrate benefit, pulsed radiofrequency ablation of the intercostal nerves was attempted to decrease post-thoracotomy pain (3). This study's results demonstrated no improvement over medical management. However, the failure to alleviate pain with pulsed radiofrequency ablation of the intercostal nerve may be secondary to the lack of efficacy of pulsed radiofrequency ablation (4,5). Radiofrequency ablation of the intercostal nerve could still be curative, but thermal conventional radiofrequency may need to be used.

There is strong data to support the efficacy of thermal conventional radiofrequency ablations. By extrapolating the data from medial branch conventional thermal radiofrequency ablations (6,7), a physician could potentially use this technique on any sensory nerve. Conventional thermal radiofrequency ablation could be used in place of pulsed radiofrequency ablation.

Starting in October 2009, 6 patients underwent intercostal nerve conventional thermal radiofrequency ablations. All 6 patients had injuries from blunt trauma to the chest wall at work and were therefore treated with worker's compensation insurance. Four of the 6 had rib fractures, and the remaining 2 had abdomen or chest wall pain consistent with intercostal neuralgia. Intercostal neuralgia was diagnosed with intercostal nerve blocks using local anesthetic only. Following the diagnostic blocks, confirmatory local anesthetic nerve blocks were completed (8). Following the confirmatory blocks, conventional thermal radiofrequency ablation of the intercostal nerves was intended to be a curative treatment for the intercostal neuralgia.

Conventional thermal radiofrequency ablation of the intercostal nerves attempts to reduce the disability associated with traumatic rib fractures. Secondarily, this technique offers pain relief. Traumatic rib fractures prevent patients from completing work-related responsibilities or usual activities for an average of 70 days (9). Therefore, there is the potential for substantial disability associated with blunt trauma to the chest wall. As a result, conventional thermal radiofrequency ablations of the intercostal nerves have the potential to not only decease pain, but increase function.

Methods

Conventional thermal radiofrequency ablation of the intercostal nerves was used to treat 6 patients during 2009, 2010 and 2011. A chart review of all 6 patients is presented below.

Patient 1

Patient #1 was a 54-year-old man who was hit in the abdomen with a hopper motor while at work. There was an immediate onset of low back, right rib cage, and right upper quadrant abdominal pain. The patient was sent to the company clinic and immediately transferred to the hospital. Following a one-week stay, he presented for an initial consultation about 3 weeks after his injury.

At the initial consultation he was experiencing a 9/10 NRS low back, right rib cage, and right upper quadrant abdominal pain. An abdominal computed tomography (CT) scan a few days after his initial presentation demonstrated a right rectus muscle contusion. No rib fractures were noted.

On follow-up, he had point tenderness over the right 8th, 9th, and 10th ribs. Diagnostic right 8th, 9th, and 10th intercostal nerve blocks were completed a month after the CT scan. He had no abdominal pain in the recovery room.

Confirmatory right 8th, 9th, and 10th intercostal nerve blocks were completed about 2 weeks later and he was pain-free in the recovery room. At the follow-up visit his pain was a 5/10.

He underwent right 8th, 9th, and 10th intercostal nerve conventional thermal radiofrequency ablations after another 2 weeks. His pain decreased to a 1/10 the following week and he was pain-free in the chest wall and abdomen 3 weeks after his procedure. Three months later, reporting zero pain in his chest wall or abdomen, he was discharged.

Patient 2

Patient #2 was a 34-year-old man at the time of his accident. While at work, he was accidentally pushed off a truck bed while helping to carry a heavy wood and metal door. He fell from the truck, landed on a cement floor, and lost consciousness for approximately 15 minutes. An ambulance arrived and transported him to the hospital. He reported left shoulder, left elbow, and left chest wall pain. At the hospital a fractured clavicle was diagnosed.

At the initial consultation 2 weeks after the acci-

dent, he complained of left shoulder, left elbow, and left chest wall pain. His chest CT scan a few days later was negative for rib fractures. About 2 weeks after the CT scan, he had point tenderness over his left 11th and 12th ribs.

He underwent diagnostic left 11th and 12th intercostal nerve blocks 4 months later. He had no chest pain in the recovery room and no point tenderness in his left chest wall.

Confirmatory left 11th and 12th intercostal nerve blocks were completed about 3 weeks after the diagnostic injections. He again had no pain in his left chest wall in the recovery room. At follow-up, his left chest wall pain was a 6/10.

Left 11th and 12th intercostal nerve conventional thermal radiofrequency ablations were completed about 2 weeks later. He described left chest wall numbness at his initial follow-up that was resolved by one month. Nine months later, he still had no left chest wall pain.

Patient 3

Patient #3 was a 38-year-old man who was climbing into his truck when he fell backwards onto the left side of his body. He was taken by ambulance to the emergency room. No rib fractures were found.

At his initial evaluation one month later, he complained of left chest wall pain, left knee pain, and bilateral low back pain that radiated down his right leg to his toes. He had point tenderness at approximately his left 6th rib. A chest CT scan was prescribed that was nondiagnostic. A bone scan was ordered demonstrating left 6th and 7th rib fractures or posttraumatic bone bruising.

Diagnostic left 6th and 7th intercostal nerve blocks were performed 7 weeks after the initial consultation. He was pain free in the recovery room.

After a discussion of the risks and benefits associated with intercostal nerve blocks and the increased risk due to his weight, he refused confirmatory blocks. He appreciated the increased risk of false positive diagnostic intercostal nerve blocks. In this setting, conventional thermal radiofrequency ablations were recommended.

Left 6th and 7th intercostal nerve conventional thermal radiofrequency ablations were completed about 2 weeks later.

After an additional 2 weeks, he had no chest wall pain. He still suffered from left knee and low back pain. At his final follow-up about 7 months later, his chest was still pain-free.

Patient 4

Patient #4 was a 43-year-old man who was injured at work. He was standing on a rack 12 feet above the ground when he fell. He hit a rack that was 6 feet above the ground. He ultimately landed, hitting his left side on a table. He was taken by ambulance to the emergency room where 2 fractured ribs were diagnosed.

At the initial visit 4 months later, he complained of greater left-sided than right-sided low back pain, right-sided neck pain that radiated into his right shoulder, left wrist pain, left chest wall pain, and left pectoralis pain. He had point tenderness in his left chest.

His chest CT scan 3 weeks after his initial consultation demonstrated nondisplaced posterior left 10th, 11th, and 12th rib fractures.

Diagnostic left 10th, 11th, and 12th intercostals nerve blocks were completed almost one year after the CT scan. He was pain-free in the recovery room and had no point tenderness in his left chest wall.

He refused confirmatory intercostal nerve blocks. Left 10th, 11th, and 12th intercostal nerve conventional thermal radiofrequency ablations were completed 3 weeks after the diagnostic injections.

At the initial follow-up, he reported a 2/10 chest wall pain. The patient was pain-free 3 months after the initial follow-up. Chest wall pain was not reported at his last visit, approximately 7 months after the conventional thermal radiofrequency ablations.

Patient 5

Patient #5 was a 47-year-old man who was dumping trash at work. He fell approximately 5 to 7 feet off of a pallet. There was an immediate onset of left-sided low back pain that radiated to the left ankle, left chest wall pain, left hip pain, left shoulder pain, and left neck pain. He was taken by ambulance to the emergency department where he was diagnosed with a pelvic fracture and a left L4 transverse process fracture.

At his initial consultation one month after the injury, after undergoing pelvic surgery, he had the aforementioned complaints. He was transitioned from hydrocodone to tramadol.

Diagnostic testing for a possible rib fracture was started at the second visit since he had point tenderness along his left chest wall consistent with rib fractures. The chest CT scan 14 weeks after the accident demonstrated left 4th through 8th rib fractures.

Diagnostic left 4th through 8th intercostal nerve blocks were completed 14 weeks after the chest CT scan. His chest was pain-free in the recovery room.

Confirmatory left 4th through 8th intercostal nerve blocks were completed 2 weeks later. In the recovery room his chest was again pain-free. At his follow-up visit, his chest wall pain was a 3/10.

Left 4th through 8th intercostal nerve conventional thermal radiofrequency ablations were completed 2 weeks later.

Another 2 weeks later he described numbness in his left chest wall. There were no repeat complaints of left chest wall pain or numbness until 8 months later when he was wearing a brace after an L5-S1 fusion.

From that point forward, he continued to describe minimal left chest wall pain when lying on his left side. He refused additional treatment for the chest wall pain since it was not severe.

Patient 6

Patient #6 was a 38-year-old man who was injured when pushing a bin of lettuce weighing between 300-400 pounds. The bin was hanging from tracks on the ceiling. He heard a click and the bin fell toward him. He lost consciousness and was transported to the hospital where he was diagnosed with rib fractures. About 2 weeks later he had a chest CT scan that demonstrated left 9th and 10th rib fractures.

At his initial presentation about 4 months after the injury, he complained of low back pain, neck pain, foot pain, and chest wall pain. He had point tenderness over his left 9th, 10th, and 11th ribs.

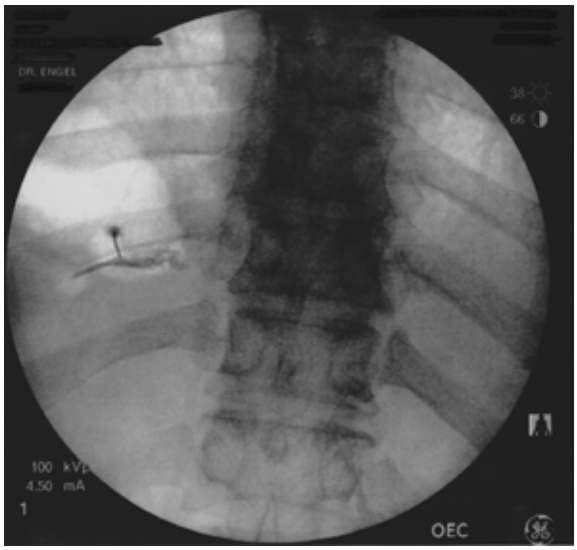

Fig. 1. *Diagnostic intercostal nerve block. Contrast spread along the intercostal nerve.*

Diagnostic left 9th and 10th intercostal nerve blocks were completed about 22 weeks after presentation. His chest was pain-free in the recovery room.

Confirmatory left 9th and 10th intercostal nerve blocks were completed 2 weeks later. His chest was again pain-free in the recovery room. He had no point tenderness in his left chest wall.

He underwent left 9th and 10th intercostal nerve conventional thermal radiofrequency ablations 2 months after the confirmatory blocks.

At the initial follow-up, he described continued chest wall pain, but on physical examination there was no point tenderness in his left chest. Three weeks later, he only had chest pain with deep inspiration. In another 2 weeks, the chest pain had resolved.

The pain returned about 22 weeks later. Repeat left 9th and 10th intercostal nerve blocks were discussed 66 weeks after the conventional thermal radiofrequency ablations since the patient had point tenderness on physical examination.

Procedure

The following protocol was adapted from the International Spine Intervention Society's standard for medial branch blocks. This protocol is important because it decreases the chance for false positive responses.

The intercostal nerve blocks were completed under fluoroscopic guidance with the patient in the prone position. No pain medications were used. Each patient was offered an anesthetic consisting of midazolam and propofol. After the correct ribs were identified under fluoroscopy, the skin and subcutaneous tissue were anesthetized. Using hand-curved 25-guage 3.5 inch spinal needles the ribs were contacted under fluoroscopic vision. The needle tips were walked off of the ribs and repositioned in the intercostal groove. Iopamidol one mL was injected at each level to demonstrate dye spread along the intercostal groove (Fig. 1). Aspiration was negative for blood and air. At each level, one mL of preservative-free lidocaine 1% was injected. Postprocedure, each patient was seen in the recovery room to determine the efficacy of the block. In the recovery room, select patients were given a physical examination.

A postprocedural office visit focused on the results of the diagnostic intercostal nerve blocks. The risks and benefits of confirmatory injections were discussed.

The confirmatory blocks were completed with the

identical protocol.

A postprocedural office visit focused on the results of the confirmatory intercostal nerve blocks. The risks and benefits of conventional thermal intercostal nerve radiofrequency ablations were discussed.

Conventional thermal radiofrequency ablation of the intercostal nerves was also completed under fluoroscopic vision with the patient in the prone position. The patient was offered an anesthetic consisting of midazolam and propofol. No pain medications were administered until after the conventional thermal radiofrequency ablations. Under fluoroscopic vision, the correct ribs were identified. The skin and subcutaneous tissue were anesthetized. Using curved 5 mm active tip radiofrequency ablation needles, the needle tips were placed on the ribs. The needle tips were walked off of the ribs and repositioned into the intercostal groove (Fig. 2). After needle placement, the patient was awake and conversant for sensory testing. At each level sensory testing was undertaken at 50 Hz with the goal of re-creating pain in the anterior chest with a stimulation of less than one volt; ideally the concordant pain was recreated at less than 0.5 volts. The needle tips were repositioned until the appropriate pain distribution was identified. Using stimulation at 2 Hz, motor testing was completed up to 2 volts. Only local muscle spasms were identified. Conventional thermal radiofrequency ablation was then completed at 80°C for 90 seconds. At each level, two 90 second cycles were completed. Intravenous pain medications were then administered.

Iopamidol was then injected to demonstrate spread along the nerve. If there was no spread along the nerve, the needles were repositioned until there was dye spread along the nerve. An additional 2 cycles of conventional radiofrequency ablation at 80°C for 90 seconds were completed. Following negative aspiration for blood and air, a total dose of 80 mg methylprednisolone with preservative-free lidocaine 1% was injected. The stylets were replaced prior to removing the needles.

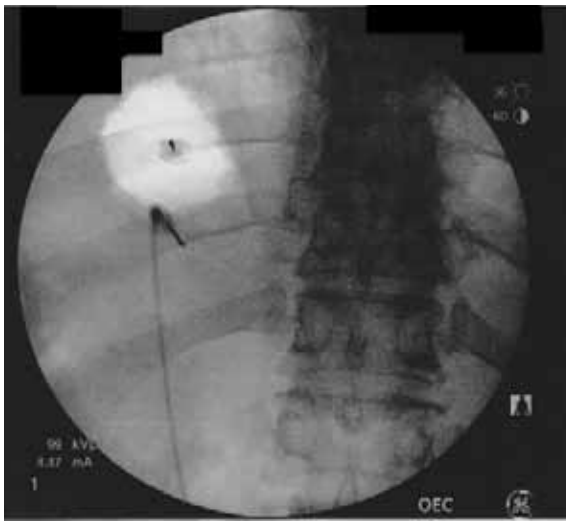

Fig. 2. *Intercostal nerve radiofrequency ablations. One curved radiofrequency ablation needle on the rib and the other needle in the intercostal groove.*

Results

After receiving conventional thermal radiofrequency ablations, all 6 patients were pain-free (Fig. 3). Five of the 6 patients reported immediate postprocedure pain relief . The single patient who did not experience immediate pain relief did, however, have no point tenderness in his chest wall.

Of the 5 patients who had immediate pain relief, 4 remained pain-free while continuing treatment in the clinic; one patient was discharged pain-free.

Patient #1 reported no chest wall or abdominal pain when discharged. This patient could not be reached after discharge for an update on his pain score. The fact that he has not returned for care implies that his pain has not returned. Therefore, the documented pain relief lasted from 4 to 10 months and will likely continue.

There are 2 patients, patients #5 and #6, who reported that their pain eventually returned. Patient #5 was pain-free for 10 months. The pain only returned when he started wearing a brace after an L5-S1 fusion. His pain has not increased to the point that he has wanted to undergo treatment, since the pain has remained manageable. He has not required treatment for 16 months.

Patient #6 also identified a reappearance of pain postprocedure. He was pain-free for an initial 5.5 months. Unfortunately, his pain has become so severe that another round of intercostal nerve blocks was recommended to determine if he would be a candidate for repeat conventional thermal radiofrequency ablations.

No complications from the intercostal nerve blocks or conventional thermal radiofrequency ablations were observed.

Discussion

As demonstrated by the above results, conven-

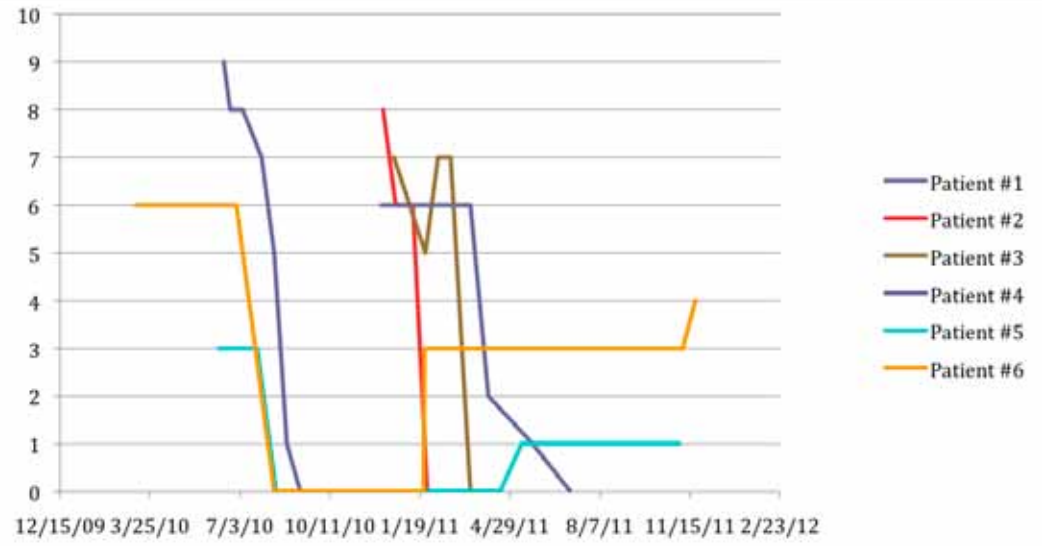

Fig. 3. *Graph of pain score versus time.*

tional thermal radiofrequency ablation of the intercostal nerves is a potentially curative treatment for pain caused by blunt chest trauma. In addition, other pain syndromes secondary to intercostal nerve trauma, including chronic postthoracotomy pain, could benefit from this treatment.

Beyond being an efficacious treatment, conventional thermal radiofrequency ablation of the intercostal nerves appears to be a safe treatment. There were no complications during the treatment for intercostal neuralgia. Prior to undergoing treatment, the patients were informed that there is a less than 1% risk of infection, bleeding, unintended nerve damage, headache, and lung puncture. Lung puncture was avoided by placing the skin wheal caudal to the rib. The curved needle contacts the rib under fluoroscopic vision and is walked off the rib. The needle tip is turned back toward the intercostal groove without advancing the needle. Theoretically, the needle does not pass more ventrally than the intercostal groove, thereby minimizing the risks of lung puncture. In cases where the needle tip is not steady, attaching a clamp to the needle at the level of the skin can help avoid advancing the needle tip ventrally.

Another risk associated with conventional thermal radiofrequency ablations is neuroma formation or deafferentation syndrome (10). Because the occurrence of this complication is very low, it was unlikely to occur in a case study of only 6 patients. If this treatment were to become a standard after randomized controlled trials, this complication could be seen. The incidence of neuroma formation could be reduced by injecting steroid through the radiofrequency ablation needle, as described above. The needle then would need to be flushed or the stylet replaced to prevent a steroid track.

Since this treatment is efficacious and safe, it may be appropriate for other patient populations. For example, an elderly patient with a therapeutic level of anticoagulation, could be a candidate for this regional anesthetic approach to painful rib fractures. Using ultrasound, an interventionalist could place the diagnostic injections in the sitting position at the bedside. The radiofrequency ablations could be performed the next day in the prone position. This patient with rib fractures could have long-term pain relief and the associated benefits of increased pulmonary toilet.

While the treatment is efficacious and has greater potential applications, it is important to acknowledge and discuss currently unanswered questions. At this point, some of the questions are the direct result of a limited case study. This paper focuses on 6 heterogeneous patients without a control group. It is possible that the patients observed had decreased pain because of the individuals' self-motivation. Placebo-controlled studies have already been completed demonstrating the benefits of single shot local anesthetic intercostal nerve blocks, but intercostal nerve conventional thermal radiofrequency ablations have not been compared to placebo. If an

institutional review board prohibits the use of placebo testing, conventional intercostal nerve thermal radiofrequency ablations could be compared to pulsed radiofrequency ablations. The comparison is warranted because pulsed radiofrequency ablations have the same efficacy as medication management. Since placing the needles for pulsed and conventional thermal radiofrequency ablations is the same, blinding would be simple. In addition, pulsed radiofrequency ablation has the same efficacy as no interventional treatment (3); therefore, it could be considered a placebo.

Without placebo controlled trials, it is nearly impossible to determine if the patients improved because of the natural history of rib fractures and intercostal neuralgia, or because of conventional thermal radiofrequency ablations. Typically, patients experience disability for an average of 70 days (9). In this case series, patients reported continued pain for many months after the initial injury. For these patients, the natural history of the disease would have been continuous pain unless treatment was offered. Conventional thermal intercostal nerve radiofrequency ablations were completed on average 225 days after the initial injury. Without treatment it is unlikely that the patients would have improved. However, a placebo-controlled study is needed to confirm this finding.

Another important question raised by the case study is the role of the anesthetic in diagnostic injections (11). Some in the medical community oppose the use of anesthetics during diagnostic injections. The 6 patients received an amnestic and an anesthetic. None of the 6 received any intraveneous pain medications during the diagnostic or confirmatory injections. If the anesthetic caused false positive diagnostic or confirmatory blocks, the conventional thermal radiofrequency ablations would not have produced pain relief. As stated earlier, while all of the patients did not report complete pain relief at the initial follow-up visit, over the course of care all 6 patients eventually were pain-free. The pain noted during the initial follow-up consultation could have been caused by muscle pain or by nerve irritation. Undoubtedly, the anesthetic, which did not contain pain medication, did not cause any false positive results. As such, the issue of anesthetics lacking pain medication should not affect the findings from this case report.

This study took place within the realm of a busy clinical practice. As a result, the time devoted to following the patients was limited. Patients were discharged or left the practice because they were pain-free. It is reasonable to expect that patients would have returned to the clinic if their pain had reappeared.

As with any clinical practice, patients exhibit different mechanisms of injury. The heterogeneity of the patient population treated in this case series is an issue. However, this heterogeneity importantly demonstrates that the case study has not relied upon selection bias. Because all patients who presented with rib injuries were treated with conventional thermal intercostal nerve radiofrequency ablations, the issue of heterogeneity could not be avoided.

These 6 patients have had work-related injuries beyond rib fractures. An ideal case study would contain patients who only have rib fractures or patients with postthoracotomy pain. Multiple pain generators can cloud the clinical presentation. However, the study importantly draws attention to a misconception. Historically, physicians have believed that patients with litigated worker's compensation claims are less likely to improve than patients without litigated claims. Patients pursuing litigation should be given the same opportunities as nonlitigating patients to be cured. The 6 patients discussed in this paper have litigated claims. Litigation is not a determinate of clinical outcomes in the correct environment (12).

The 6 patients were opioid-free at the time of treatment. Only patient #5 was taking opioids at the time of the initial consultation. This patient was successfully transitioned to tramadol from hydrocodone. The absence of opioids is significant. Patients taking opioids potentially have central pain that will not respond to interventional treatment. The interventionalist needs to remove that confounding factor before embarking on potentially curative treatment. Interventional treatments will only work if directed at the underlying pathology.

Conclusion

In conclusion, the 6 case reports demonstrate that conventional thermal radiofrequency ablation of the intercostal nerves may be a potentially viable treatment for intercostal neuralgia secondary to blunt trauma. This technique could be used to treat all pain secondary to the intercostal nerve, such as postthoracotomy pain, but before this treatment can be widely applied, either larger observational studies or placebo-controlled studies must be conducted.

Acknowledgments

I sincerely thank David Salk for data collection, Jenna Feldman for outstanding editing, and Wade King, MMed (Pain) and Devi Nampiaparampil, MD for invaluable feedback. In addition, I thank Derrick Wallery, DC and the staff at Medicos Pain and Surgical Specialists for their continued support.

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