Bilateral pain relief after unilateral thoracic percutaneous sympathectomy

[Contrôle bilatéral de la douleur après une sympathectomie thoracique percutanée]

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Purpose: To present a case of unexpected bilateral pain relief following unilateral thoracic percutaneous sympathectomy.

Clinical findings: We present a case report where severe ischemic pain due to paraneoplastic Raynaud's syndrome with distal gangrene was successfully treated by means of percutaneous thoracic sympathectomy. A unilateral T2, T3 radiofrequency sympathectomy combined with small volume phenol injection resulted in unexpected bilateral pain relief.

Conclusion: Our observations from this case report suggest a possible crossover of sympathetic innervation at the cervical and thoracic levels. Percutanenous thoracic radiofrequency sympathectomy is a feasible option for the treatment of refractory ischemic upper limb pain.

***Objectif** : Présenter un cas de contrôle bilatéral inattendu de la douleur à la suite d'une sympathectomie thoracique percutanée.*

***Constatations cliniques** : Nous présentons un cas où une douleur ischémique sévère causée par un syndrome paranéoplasique de Raynaud, accompagnée de gangrène distale, a été traitée avec succès par une sympathectomie thoracique percutanée. La sympathectomie unilatérale à radiofréquence en T2, T3 combinée à une injection de phénol de faible volume a produit un contrôle bilatéral inattendu de la douleur.*

***Conclusion** : Nos observations suggèrent une innervation sympathique croisée possible aux niveaux cervical et thoracique. La sympathectomie thoracique percutanée peut traiter la douleur ischémique réfractaire aux membres supérieurs.*

PERCUTANEOUS chemical and radiofrequency thoracic sympathectomy has been used for years as a treatment modality for palmar hyperhidrosis and for various painful conditions. Though it appears to be useful and relatively simple to perform, it is not widely accepted and utilized. In contrast to the abdominal and sacral sympathetic plexuses, thoracic and cervical sympathetic innervation is thought to be strictly unilateral.[1] There is no anatomic evidence showing cross connections at the level of upper thoracic and cervical sympathetic chain. However, several clinical reports suggest that such links might exist, since unilateral interventions resulted in bilateral changes of sympathetic activity and/or pain relief.[2–5] The question of whether this phenomenon relates to a hypothetical cross innervation at the level of thoracocervical plexuses or at the spinal or supraspinal levels has yet to be answered.

Acute vascular occlusive events, such as Raynaud's syndrome, are often accompanied by excruciating pain refractory to systemic analgesics. Sympathetic block and sympathectomy can have major roles for both nutritional blood flow restoration and pain control.[6] Aggressive treatment of impending gangrene is of utmost importance. Percutaneous chemical and radiofrequency thoracic sympathectomy is a relatively simple, minimally invasive procedure, which might provide sustained pain relief.[7] We report a case where unilateral radiofrequency sympathectomy was applied in the Acute Pain Service setting and lead to dramatic and lasting bilateral pain relief. Consent for anonymous publication of personal health information was obtained for publication in this document, in accordance with local institutional guidelines.

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Case report

A 74-yr-old, Caucasian male was admitted to hospital, complaining of excruciating pain as a result of dry gangrene of the second and third fingertips of both hands. He reported that the pain started abruptly three weeks prior to admission when his hands turned pale and cold. The patient had no recall of previous similar events. A family physician had prescribed nifedipine but the patient discontinued it due to ankle edema. His past medical history was remarkable for basal cell carcinoma of scalp, which had been treated with surgery and radiotherapy. He had surgical and radiation therapy for a neck cancer 12 yr previously, and two years prior to admission he had surgery for a "benign neck mass". A temporary tracheotomy was performed as part of his care at that time. His only significant medical comorbidity was essential hypertension.

The patient had lost 20 pounds of weight and complained of "low energy" during the previous year. His regular medications consisted of clopidogrel, acetylsalicylic acid, omeprazole, quinapril, amlodipine, simvastatin and vitamin E. He had no known drug allergies.

Physical examination at the time of admission was remarkable for cyanotic and cold hands from metacarpal joints to fingertips. The second and the third fingertips were necrotic. Radial and ulnar pulses were bounding bilaterally. Emergent angiography was performed, which revealed arterial vascular occlusion in both hands, immediately distal to ulnar and radial arteries at the wrist. A working diagnosis of paraneoplastic vasculitis, Raynaud's syndrome with distal necrosis was made.

A five-day course of epoprostenol *iv* infusions at a rate of 2 $ng \cdot kg^{-1} \cdot min^{-1}$, with a subsequent increase of 2 $ng \cdot kg^{-1} \cdot min^{-1}$ every 30 min to the maximal dose of 8 $ng \cdot kg^{-1} \cdot min^{-1}$ for four hours daily was initiated, with nitroglycerin ointment application over the forearm vessels. During the first three days, pain was poorly controlled despite oral dosing of hydromorphone up to 18 $mg \cdot day^{-1}$ and acetaminophen 4 $g \cdot day^{-1}$. His visual analogue scores for pain were 8/10. On day four, necrotic changes in several other distal phalanges appeared. The patient was exhausted, sleep deprived and in continuous pain. The Acute Pain Service was consulted and multimodal pain management initiated. The dose of hydromorphone was increased, while gabapentin 600 mg *po* daily, and nortriptyline 10 mg *po* at bedtime were added to the analgesic regimen. During the next five days, the pain was moderately controlled (visual analogue scores 5/10), but hydromorphone doses of 38 to 42 $mg \cdot day^{-1}$ plus adjuvants caused excessive sedation.

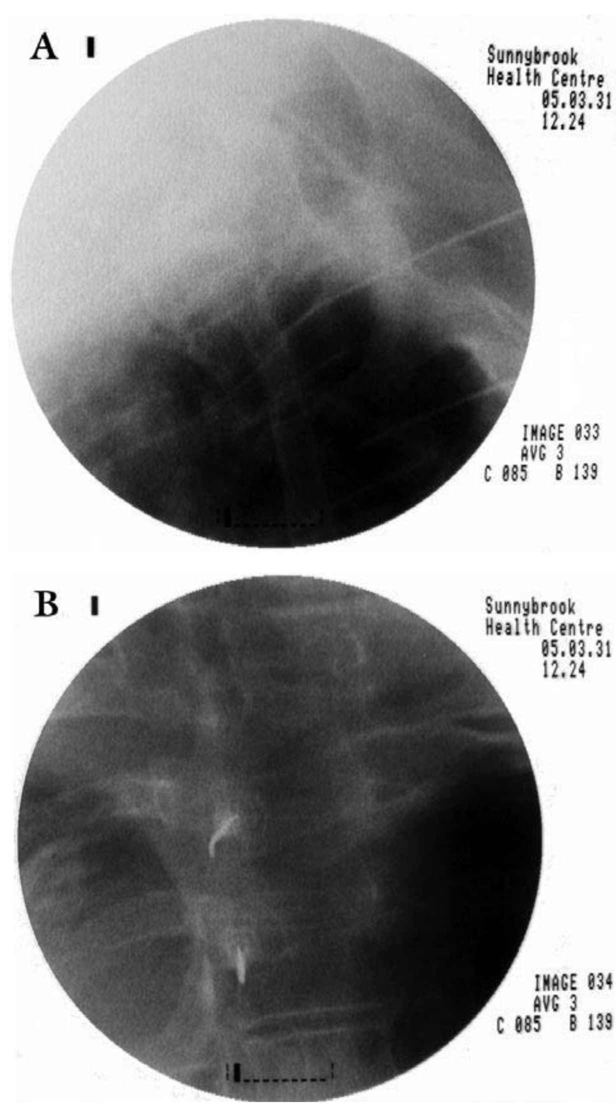

FIGURE 1 A) Lateral view. Two electrodes are at the junction of the posterior and middle third of the T2, T2 vertebral bodies; B) Oblique view. The curved electrodes are shown in a "tunnel" view.

Ten days after admission the patient was seen by the author (M.G.). A left-sided fluoroscopically guided stellate ganglion block at C7 was performed with bupivacaine 0.25% 5 mL. The patient preferred a left-sided procedure first, since he perceived slightly more severe pain on the left. Prior to a local anesthetic injection, 5 mL ionexol 300 $mgI \cdot mL^{-1}$ was injected for radiological confirmation. Spread occurred in the typical anterolateral pattern over the C6 and C7 vertebrae without any

FIGURE 2 Three days after the procedure. Well-demarked necrotic areas and decreased edema.

caudal extension. Signs of Horner's syndrome lasted approximately two hours, and greater than 50% pain reduction was noted for six hours. It was assumed that the pain relief would only occur on the ipsilateral side of the block, and so he was not questioned at this time about contralateral pain relief. Daily hydromorphone consumption decreased to 26 mg.

Subsequently, a T2 and T3 radiofrequency sympathectomy was performed. A chemical stellate ganglion neurolysis was thought to be unsafe due to the history of a previous surgery and a high probability of unpredictable spread of phenol. Two days later, a left-sided T2 and T3 radiofrequency sympathectomy was performed. Two RFK (20 G, 100/10 mm) curved blunt-tipped electrodes (Baylis Medical, Montreal, QC, Canada) were inserted as described elsewhere[8] (Figure 1). A radiofrequency generator (Baylis Medical PMG-115, Montreal, Canada) was used. Sensory stimulation at 50 Hz, 1.2 V elicited a vague sensation over the left arm and forearm. Motor stimulation at 2 Hz, up to 2.5 V, evoked no intercostal contractions, thus the active tip was positioned properly, far enough from the exiting ventral nerve root. Following verification of the electrode tip position by injection of 2 mL ionexol 300 mgI·mL^{-1}, two sets of radiofrequency lesions with electrode rotation cephalad and caudad at 80°C, 75 sec each, were performed. No sedation was needed. Next, 1 mL aqueous phenol 10% was injected slowly through each electrode. The electrodes were then flushed with isotonic saline and removed.

The patient tolerated the procedure well without complications. Hydromorphone consumption decreased dramatically to 6 to 8 mg daily. Gabapentin and nortriptyline were gradually discontinued. Interestingly, the pain disappeared bilaterally, although hand swelling appeared on the left side only the next day and then subsided. On the third day post-treatment, well-demarcated necrotic areas with less edema, and signs of improved capillary perfusion of both hands, were observed (Figure 2). Unfortunately, no preoperative photographs had been taken for comparison. The patient was discharged home ten days following the procedure. At the five-month follow-up he was practically pain free without any analgesic medication. Several fingertips had self-amputated. His primary malignancy remained undiagnosed.

Discussion

This case highlights dramatic bilateral pain relief after unilateral percutaneous radiofrequency thoracic sympathectomy. A placebo effect was highly unlikely, as we observed definite signs of a successful left-sided sympathectomy. Although we could not rely upon signs of local temperature changes, the initial swelling, accelerated demarcation, and beneficial skin colour changes indicated microcirculatory improvement. This unexpected and favourable result may imply the existence of bilateral sympathetic innervation somewhere distal to the thoracic sympathetic ganglion. In a study where measurement of palmar skin temperature was performed during T2 sympathectomy for palmar hyperhidrosis, bilateral temporary temperature elevation was observed after a unilateral lesion in 62% of cases.[2] Hogan *et al.* observed similar findings following stellate ganglion block.[3] Allen *et al.* documented a contralateral Horner's syndrome following unilateral stellate ganglion block.[4] However, these reports could be explained by the contralateral spread of a high volume injectate.[9] Valley *et al.* observed complete contralateral analgesia after stellate ganglion block for intractable sympathetically maintained pain. A previous ipsilateral procedure had failed to produce any analgesia. Subsequent surgical T2–T4 sympathectomy was performed with 50% pain reduction and moderate functional improvement during a six-month follow-up period.[5] Although bilateral sympathetic innervation exists in the lumbosacral spine, it has never been described at the thoracic or cervical levels.[1] It is possible that interconnections exist at the level of stellate ganglion.

Another reason for pain relief unrelated to sympathetic regulation of the vascular tone may be hypothesized. Sympathetic nerve terminals in peripheral tissues may serve as mediator elements in hyperalgesia.[10] Some of the postganglionic sympathetic fibres return to the dorsal horn via gray rami communicants, while others travel up and down along the sympathetic trunk to terminate in remote ganglia. These fibres may play a role in an afferent conduction much similar to the afferent conduction of visceral pain through a sympathetic pathway. One may speculate that interconnections exist between these fibres and dorsal horn neurons, with subsequent pain projection through ipsilateral and contralateral tracts. There is evidence that such a pathway exists in animals.[11] Afferent sympathetic fibre conduction block and subsequent pain propagation cross-inhibition at the spinal or supraspinal level might be responsible for analgesia. Further neuroanatomical studies would be required to confirm such a hypothesis.

Thoracic sympathetic blockade has been used for the past 80 years to manage painful conditions and vascular insufficiency of the upper extremities. Proximity of the thoracic sympathetic ganglia to the intercostal nerves and neuroforamina have resulted in a high rate of neurological complications.[8] Large volume injectate and utilization of a "blind" technique likely contributed to many of these complications. Eventually, chemical sympathectomy was abandoned. More recently, the technique has been reintroduced. Phenol injections using low volumes under fluoroscopic guidance have been reported to be successful, with only minor side effects.[12]

There are a number of potential indications for thoracic sympathetic blockade and sympathectomy including: complex regional pain syndrome, ischemic and vasospastic painful conditions, frostbite, hyperhidrosis and malignant and non-malignant thoracic visceral pain.

Despite a high rate of recurrence, when implemented in Raynaud's syndrome, thoracic sympathectomy clearly produced a high success rate and showed potential for reducing the severity of refractory symptoms.[7] Although total flow is not significantly increased, peripheral sympathectomy increases the nutritional flow and appears to improve abnormal arteriovenous shunting and microcirculation in ischemic areas.[6]

Wilkinson first described the technique of percutaneous thoracic radiofrequency sympathectomy in 1984. In 1996, the first large prospective study of this technique was published. Although the trial was an open label study, the results were encouraging and favourably compared with thoracic endoscopic sympathectomy.[13] However, the technique was criticized as time-consuming, and questionable with respect to long-term results.[14] The procedure has since been modified using blunt-tipped curved radiofrequency electrodes.[15] This modification permits better "steering", increases the lesion area, and reduces the complications of intercostal nerve injury and pneumothorax. In a recent series of 1,742 cases of hyperhidrosis, the authors concluded that the modified technique is associated with good long-term results and a low complication rate. Similar outcomes were obtained when the sympathectomy was performed at the T2 and T3 levels, or at the T2 level only.[16]

The basic principle for radiofrequency ablation of a sympathetic lesion involves accuracy and precision. Sensory electrical stimulation occasionally elicits either a vague sensation or pain at the target area. Motor stimulation usually serves as an indicator of sufficient distance from the ventral root. Absence of motor stimulation at a current setting twice that of sensory stimulation is thought to be appropriate to avoid a nerve root heat injury. To maximize the probability of success, the radiofrequency electrode must be located as close to the sympathetic ganglion as possible. According to the anatomical study of Wilkinson, the T2 ganglion is situated roughly in the middle of the vertebrae rostro-caudally and 1/3 dorso-ventrally.[17] Others have indicated that approximately 90% of the T2 or T3 sympathetic trunks are located on the head of the corresponding rib.[18] A recent study found that the second thoracic ganglion is usually located (in 92.5% of patients) in the second intercostal space at the level of the intervertebral disc, between the second and the third thoracic vertebrae.[19] Although a variation of 1–1.5 cm is not of great importance during a surgical sympathectomy, it is critical during radiofrequency electrode placement. Therefore, we usually combine the radiofrequency lesion with a small volume of phenol.

In conclusion, percutaneous thoracic radiofrequency sympathectomy is feasible for the treatment of refractory ischemic upper limb pain, and our observations from this case suggest a possible crossover of sympathetic innervation at the cervical and thoracic levels.

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