Peripheral Nerve Blockade for Patients With Raynaud Phenomenon and Other Causes of Digital Ischemia: A Case Report and Practice Implications

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Raynaud phenomenon can be an idiopathic benign disease, or it can be associated with vascular insufficiency due to arterial disease caused by other processes. Medical management of Raynaud phenomenon can be difficult, and digital ischemia, gangrene, and ulcers may occur secondary to vascular insufficiency. This case report describes the anesthetic management of a patient with a diagnosis of Raynaud phenomenon who presented to the perioperative area for débridement and distal amputation of the right third finger, which had become necrotic and gangrenous. An ultrasound-guided supraclavicular nerve block was performed preoperatively with 15 mL of 1.5% mepivacaine and 15 mL of 0.5% bupivacaine. The block was performed without complication, and the patient tolerated the procedure. A review of literature related to the use of peripheral nerve blockade for the treatment of digital ischemia is discussed. Ultrasound-guided technique is considered the gold standard for the performance of peripheral nerve blocks because this technique provides better efficacy and safety. These same ultrasonographic skills can expand anesthesia providers’ practice beyond nerve blockade for anesthesia and analgesia with the addition of treatment and management of digital ischemia.

Keywords: Anesthesiology, chemical sympathectomy, digital ischemia, peripheral nerve block, Raynaud phenomenon.

Digital ischemia is associated with several rheumatologic disorders, including Raynaud phenomenon (RP), and is often problematic to treat. If inadequately treated, pain, ulcers, and infection may develop in the affected digits. The need for amputation and poor quality of life may ensue. Regional anesthesia techniques, such as brachial plexus peripheral nerve blocks, result in a local anesthetic-induced blockade of sympathetic fibers, which has proved useful in the treatment and pain management of patients with digital ischemia caused by RP or other causes. The findings of this case report and a review of the literature related to the use of peripheral nerve blockade for patients with digital ischemia suggest that anesthesia providers have an active role in the management of these patients, as they are experts in providing regional anesthesia.

Raynaud phenomenon is categorized as a primary entity or secondary to other disorders. Primary RP has an incidence in the general population of 3% to 5% and most frequently affects young women. The course of the disease is usually benign, but chronic cases may result in atrophy of the skin, subcutaneous tissues, and muscles. Ulcers and ischemic gangrene may occur but are rare. Primary RP usually involves all fingers in a symmetrical pattern and is associated with minimal pain and a negative antinuclear antibody test result. Secondary RP is vascular insufficiency due to arterial disease caused by other processes such as rheumatologic disease or vascular occlusive disease. Secondary RP may also be caused by thyroid disorders, hematologic conditions, neurologic disorders, environmental conditions, and medications or toxins. Secondary RP is associated with asymmetric finger involvement, irreversible ischemic change, ulceration, pain, and a positive antinuclear antibody test result.

Raynaud phenomenon is caused by the vasoconstriction of arteries and arterioles in the extremities, typically in the fingers and toes, but can also occur in the nose, earlobes, or lips. It is characterized by cold hypersensitivity of the bilateral upper extremities and digital color change without vascular disease or digital trophic changes. Vasospasm is triggered by cold temperature or emotional stress. Vasoconstriction causes cyanosis in the most distal part of the affected area, whiteness more proximally, and redness in the most proximal area. The color change reflects proximal vasodilation, central vasoconstriction, and more distal cyanosis.

The pathophysiological mechanism for RP is poorly understood, complex, and may involve multiple factors. Factors hypothesized as pathophysiological contributors of RP include abnormalities of the sympathetic
nervous system, digital blood vessels, altered sensitivities, numbers of α-adrenoceptors and β-adrenoceptors, and vasoactive peptides, including calcitonin gene-related peptide, and endothelin. A high female-to-male ratio of RP suggests that symptoms may be attributed to hormones, specifically estrogen’s upregulation of α-adrenergic receptors and noradrenergic release. Other modulators of vascular tone implicated in RP include nitric oxide, profibrotic vasoconstrictor endothelin-1, the cold-sensitive α2 adrenoceptor, the Rho/Rho kinase pathway, and the renin-angiotensin system.

Treatment of RP is aimed at increasing distal vasodilation and decreasing vasoconstriction and vasospasm. The overall goal of treatment is to decrease the potential for peripheral vascular ischemic injury by decreasing the number and severity of occurrences. Mild primary RP can be managed with the avoidance of cold, maintenance of a warm core temperature, warming of the affected digits, and the avoidance of vasoconstrictive drugs.

Severe symptoms of RP must be managed with pharmacologic therapy. Calcium channel blockers (CCBs), nifedipine and amiodipine, are first-line therapy for the treatment of RP when conservative measures are no longer sufficient. In cases resistant to CCBs, phosphodiesterase-5 inhibitors such as sildenafil, tadalafil, and vardenafil are prescribed. Evidence suggests that phosphodiesterase-5 inhibitors are also efficacious for healing of ulcers in secondary RP. Other drugs that have been studied for use in RP include angiotensin-converting enzyme inhibitors, angiotensin receptor blockers, selective serotonin reuptake inhibitors, endothelin-1 antagonists, prostacyclin analogues, and botulinum toxin A.

In addition to noninvasive management and pharmacologic therapy, peripheral nerve blockade can be used to induce a chemical sympathectomy, improving blood flow in patients with digital ischemia caused by RP. The following case report discusses the anesthetic management of digital ischemia with the use of a supraclavicular nerve block for a patient with a diagnosis of RP. Table 1 outlines the management and treatment of RP.

### Table 1. Treatment and Management of Raynaud Phenomenon

<table>
<thead>
<tr>
<th>Disease severity</th>
<th>Treatment and management</th>
</tr>
</thead>
</table>
| Mild primary RP  | • Avoid cold, keep core temperature warm  
|                  | • Warm affected digits  
|                  | • Avoid vasoconstrictive drugs  
| Pharmacologic management of severe RP | • First-line therapy: CCBs  
|                  | • Cases resistant to CCBs: PDE-5 inhibitors  
|                  | • Other drugs: ACE inhibitors, ARBs, SSRIs, endothelin-1 antagonists, prostacyclin analogues, and botulinum toxin A  
| RP refractory to pharmacologic therapy | • Surgical sympathectomy  
|                  | • Chemical sympathectomy with local anesthetics  

**Case Summary**

A 45-year-old woman was admitted to a large academic medical center with necrosis and gangrene of the right distal third finger. The patient’s angiogram revealed marked hyperemia in the right third digit and substantial lack of arterial flow in the remaining 4 digits. A major improvement in arterial flow in all 5 digits of the right hand was noted after nitric oxide was administered to the brachial artery. Hyperemia persisted in the third digit, which was consistent with known gangrene. These results were suggestive of a vasospastic process such as what is seen in RP.

The patient underwent antinuclear antibody testing, which is used to aid in the diagnosis of an underlying autoimmune disease. Approximately 40% of individuals with RP have a positive antinuclear antibody test result, indicating the presence of antinuclear antibodies. The patient’s antinuclear antibody titer was positive with a mildly positive RNA polymerase 3 antibody. All other laboratory results were unremarkable.

The patient was recently treated for triple negative breast cancer (negative for estrogen receptors, progesterone receptors, and excess HER2 protein) with 6 cycles of docetaxel-carboplatin-pembrolizumab. Docetaxel is known to cause nail toxicity and onycholysis (nail detachment from the skin). The patient’s rheumatologist determined that an underlying infection of the nailbed coupled with vasospasm from predisposing RP led to abscess formation, osteomyelitis, and necrosis of the right distal third finger.

The patient subsequently presented to the preoperative area to undergo a débridement and distal amputation of the right third finger and was evaluated by an anesthesia provider. The patient weighed 80 kg (body mass index, 30 kg/m²) and was assigned an ASA physical status score of 3. The patient’s airway examination revealed a Mallampati 2 classification, a thyromental distance of greater than 3 fingerbreadths, and full range of motion of the neck. Her medical history included breast cancer, asthma, well-controlled gastroesophageal reflux.
disease, anxiety, and anemia. The patient’s daily medications included pantoprazole and mirtazapine. She did not experience complications during her previous anesthetics. The patient complained of numbness and severe pain in the right arm and hand. She had right third finger erythema with distal cyanosis and foul-smelling drainage. There were no other abnormal findings on her preoperative physical assessment.

The patient was premedicated with 2 mg of intravenous midazolam and 50 μg of intravenous fentanyl in the preoperative bay. An ultrasound-guided supraclavicular nerve block was performed with 15 mL of 1.5% mepivacaine and 15 mL of 0.5% bupivacaine. The block was performed without complication, and the patient tolerated the procedure. The patient was taken to the operating room for a débridement and partial amputation of the right distal third finger.

On arrival to the operating room, the patient was given 4 L/min of oxygen via a nasal cannula. An intravenous propofol infusion was initiated at a dosage of 40 μg/kg/min and titrated for patient comfort. A total of 144 mg of propofol was administered. The patient was able to spontaneously ventilate and converse during the procedure. The patient received 700 mL of intravenous lactated Ringer’s solution, and the estimated blood loss was 30 mL. The total operative time was 51 minutes. No complications were encountered during the surgical procedure.

In the recovery room, an ultrasound-guided supraclavicular nerve catheter was inserted without complication. Although the regional anesthesia team at this facility placed the nerve catheter postoperatively, placement of nerve catheters during the initial procedure would be recommended to avoid a second procedure and additional infection risk. After an uneventful recovery period, the patient was transferred to her inpatient room. An infusion of 0.125% bupivacaine was initiated through the peripheral nerve catheter at 6 mL/h with a PCA dose of 3 mL every 30 minutes, and a 1-hour maximum limit of 12 mL. The infusion and use of the nerve catheter were discontinued 5 days later, before the patient’s discharge from the hospital. Two and one-half months following discharge, the patient denied pain and symptoms of RP. Table 2 outlines anesthetic considerations for patients with RP.

### Table 2. Anesthetic Considerations for Patients With Raynaud Phenomenon (RP)

<table>
<thead>
<tr>
<th>Consideration</th>
<th>Rationale</th>
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<tbody>
<tr>
<td>Maintain normothermia, increase ambient temperature of the operating room, use patient warming devices (forced air warmer), allow patient to wear gloves and socks when possible</td>
<td>Peripheral vasoconstriction occurs in response to decreased core temperature, exacerbating symptoms of RP</td>
</tr>
<tr>
<td>Create a calm environment, explain all procedures to the patient, consider premedication with midazolam</td>
<td>Many patients with RP report stress-induced vasospasms or RP attacks precipitated by emotional stress</td>
</tr>
<tr>
<td>Consider regional anesthesia</td>
<td>Local anesthetics used for regional anesthesia can enhance peripheral blood flow, provide analgesia, promote the healing of ischemic ulcers, and provide a treatment bridge before peripheral sympathectomy</td>
</tr>
<tr>
<td>Avoid epinephrine in peripheral nerve blocks</td>
<td>Vasoconstriction of affected extremities can exacerbate symptoms of RP</td>
</tr>
<tr>
<td>Continue patient’s home medications used to manage RP: calcium channel blockers, phosphodiesterase-5 inhibitors, angiotensin-converting enzyme inhibitors, angiotensin receptor blockers, selective serotonin reuptake inhibitors, endothelin-1 antagonists, prostacyclin analogues</td>
<td>Medications are used when conservative measures are insufficient in controlling symptoms of RP</td>
</tr>
<tr>
<td>Use noninvasive blood pressure measurement techniques</td>
<td>These techniques avoid any arterial compromise of potentially affected extremities</td>
</tr>
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### Discussion

Surgical sympathectomy and chemical sympathectomy with local anesthetics can be performed to improve blood flow in patients with RP. The principle supporting these procedures is based on the Poiseuille law, which states flow is proportional to the fourth power of the radius. Even a small increase in the radius of the affected blood vessels can significantly improve blood flow. Another advantage to a sympathectomy is it can be localized to the affected limb, avoiding the side effects of systemic vasodilators. Periarterial digital sympathectomy was first described in 1980 and is currently a surgical treatment option for RP that is refractory to pharmacologic therapy. During this procedure, the adventitial layer is stripped away from the affected arteries, interrupting sympathetically mediated vasoconstriction. The benefit of this procedure may be due to mechanical decompression in addition to the sympathectomy. Clinical improvement in ischemic pain and healing ulcers with few complications has been documented in several case reports.

Most local anesthetics produce vasodilation and a subsequent increase in blood flow to the tissues near injection occurs directly by relaxation of vascular smooth muscle and indirectly by blockade of sympathetic efferent fibers. Chemical sympathectomy with local anesthetics can be a temporary treatment for patients.
with RP or patients with transient symptoms of RP, like the patient described in this case report. Brachial plexus peripheral nerve blockade has been used successfully in the treatment of patients with digital ischemia secondary to RP and in patients undergoing vascular surgical procedures, patients with vaso-occlusive disease, or patients who have experienced trauma.\textsuperscript{5,12,13} If a more permanent solution for RP is required, such as surgical sympathectomy, peripheral nerve blockade can be beneficial for initiating wound healing and providing pain relief before surgical treatment.\textsuperscript{6}

Continuous peripheral nerve block catheters offer additional benefits for patients with digital ischemia. The primary indication for the use of continuous nerve catheters began with a focus on postoperative analgesia.\textsuperscript{12} A continuous nerve catheter provides analgesia without opioid-induced side effects such as nausea, vomiting, constipation, and sedation. Results of a meta-analysis found that continuous peripheral nerve blockade, regardless of catheter location, provided superior postoperative analgesia with fewer opioid-related side effects compared with opioid analgesia.\textsuperscript{14} Compared with a single-shot peripheral nerve block, continuous nerve catheters allow anesthesia providers to adjust the concentration of the local anesthetic as well as the basal and bolus doses to meet the analgesic goals of the patient.\textsuperscript{12} As the practice of continuous catheter placement has increased, the indication for their use has evolved to include induction of chemical sympathectomy in RP, induction of sympathectomy and vasodilation after vascular surgical procedures or trauma; replantation or limb salvage; treatment of peripheral embolism; analgesia for fractures; and treatment of chronic pain syndrome, complex regional pain syndrome, terminal cancer pain, and phantom limb pain.

The vasodilatory effect of a local anesthetic is important to consider when selecting a drug for a peripheral nerve block in a patient with digital ischemia. Most local anesthetics produce a biphasic effect on peripheral vascular smooth muscle.\textsuperscript{15} At low concentrations local anesthetics cause vasoconstriction, and at clinical concentrations local anesthetics produce dilation of vascular smooth muscle. The aminoamide local anesthetics levobupivacaine, ropivacaine, mepivacaine, and lidocaine have been shown to produce vasoconstriction at low doses both in vivo and in vitro.\textsuperscript{16} The effect of the local anesthetic on vasmotor tone is complex and is dependent on concentration, time, and the vasculature near the site of administration. Clinical concentrations of local anesthetics should be used for peripheral nerve blocks in patients with digital ischemia to promote vasodilation. Epinephrine is a common additive to local anesthetics because its vasoconstrictive property decreases the rate of vascular absorption of the local anesthetic. The result is a more profound block, lower systemic level of the local anesthetic, and longer duration of action of the local anesthetic. The addition of epinephrine should be avoided in peripheral nerve blocks for patients with digital ischemia because it may greatly exacerbate the condition through its vasoconstrictive properties.\textsuperscript{17}

Several studies and case reports have demonstrated that peripheral nerve blockade is successful in managing digital ischemia triggered by RP or other causes. As experts in regional anesthesia, anesthesia providers have a role in the management of these patients. Soberon et al\textsuperscript{1} studied patients with digital ischemia who were unresponsive to medical management. The participants' radial and ulnar artery diameter and blood flow velocities were measured before and 60 minutes after an axillary peripheral nerve block was performed with 20 mL of 1.3% liposomal bupivacaine. Pain scores, temperature of the hand, and capillary refill were also assessed. The results of the study showed clinically and statistically significant changes following the block procedure, including a decrease in pain scores, increase in hand temperature, and improvement in capillary refill time. Percentage increases of 21%, 132%, and 79% were found in radial artery diameter, peak systolic velocity, and mean diastolic velocity. The mean pain score (0-10) before the block was 6.0 and after the block was 0.4. The mean pre-block temperature of the hand was 26.3°C and 29.6°C after the block. Two patients in whom conservative measures and medical management had failed experienced complete resolution of their ischemic symptoms.

Greengrass et al\textsuperscript{6} described a patient with digital necrosis secondary to RP. The patient's symptoms progressed despite treatment with nifedipine and a bilateral thoracoscopic sympathectomy. The patient was referred for a continuous axillary peripheral nerve block. Eighty minutes after the local anesthetic infusion was initiated, the baseline diameter of the radial artery increased by 24%, the temperature of the right hand increased from 32.2°C to 34°C, and the velocity of the blood flow in the dorsal radial artery increased. The patient was discharged home with a continuous catheter infusion of ropivacaine for 5 days. During this time, the patient denied pain, reported pink warm fingers, and noted healing of digital ulcers. During the infusion, the patient was able to discontinue opioid use, and normal sleep habits were restored. Following catheter removal, the patient was able to undergo a successful digital sympathectomy.

A case report by Soberon et al\textsuperscript{15} described a patient who presented with cyanosis and discomfort of the fourth and fifth digits. It was determined that the patient's ulnar artery had been damaged during intravascular catheter placement during a recent hospital admission. The patient refused amputation and, in an effort to save her digits, an axillary peripheral nerve block was performed with 12 mL of 1.3% liposomal bupivacaine. The follow-
ing day, the vascular surgeon noted normal color in the fifth digit and up to the dorsal aspect of the distal one-third and plantar to the proximal one-third of the fourth digit. The patient’s grip strength and hand movement also improved. A photoplethysmographic study showed increased blood flow in her fourth and fifth digits 1 week after the block. The patient’s ischemic vasculopathy worsened over the subsequent 6 weeks, and a surgical sympathectomy and amputation of a gangrenous digit were performed. The patient had no further complications following the operation and reported better pain control and use of the hand.

Conclusion
A supraclavicular brachial plexus block with placement of a postoperative continuous nerve catheter was determined to be the best anesthetic plan for the patient described in this case report. Postoperative continuous blockade not only provided analgesia for the patient but also provided vasodilation to the affected limb, preventing further ischemia and promoting healing. Anesthesia providers are familiar with the use of peripheral nerve blockade and catheter placement for intraoperative anesthesia and postoperative analgesia. However, the use of regional anesthesia and the pharmacologic effects of local anesthetics to improve blood flow and preserve digits or limbs is a topic that is not as well researched or discussed among anesthesia providers. A review of the current literature surrounding the use of peripheral nerve blockade for patients with digital ischemia suggests anesthesia providers have an active role in the management of these patients, as they are experts in providing regional anesthesia.

REFERENCES

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