



## Case Report

# Cryoneurolysis and Quadriplegia: A Case Report on Pain and Severe Spasticity Management



Laura Schatz, BSc <sup>a</sup>, Samuel Herzog <sup>a,b</sup>,  
Mahdis Hashemi, MD <sup>a</sup>, Paul Winston, MD <sup>a,c,d</sup>

<sup>a</sup> Vancouver Island Health Authority, Victoria, BC, Canada.

<sup>b</sup> Faculty of Science, University of British Columbia, Vancouver, BC, Canada.

<sup>c</sup> Division of Physical Medicine and Rehabilitation, Faculty of Medicine, University of British Columbia, Vancouver, BC, Canada.

<sup>d</sup> Canadian Advances in Neuro-Orthopedics for Spasticity Consortium, Kingston, ON, Canada.

## KEYWORDS

Case report;  
Denervation;  
Muscle spasticity;  
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Rehabilitation;  
Spinal cord injuries

**Abstract** Spasticity, a common symptom after spinal cord injury, often leads to pain, muscle contracture, and compromised daily activities. Cryoneurolysis, a minimally invasive, drug-free procedure for the treatment of pain, is now gaining recognition for treating spasticity. It involves using an ultrasound-guided probe to freeze and destroy overactive target nerves. The objective of this case study was to assess the effect of cryoneurolysis on joint range of motion (ROM) by reducing spasticity and pain in a person with quadriplegia spinal cord injury. A 52-year-old male with C4 incomplete quadriplegia presented with severe right hip osteoarthritis, causing a severe hip flexion deformity with hip flexor spasms, as well as spasticity in the upper limbs. Previous attempts with exceeding maximum-dose botulinum toxin injections for the lower limb proved insufficient to improve ROM. Percutaneous cryoneurolysis was performed on multiple nerves, contributing to spasticity in the upper and lower limbs. Immediately after each procedure, the patient experienced an increased ROM in the upper and lower limb targeted regions. During the patient's follow-up, he also reported improvements in performing daily activities, such as independent showering, no falls, and a significant decrease in muscle tone. Results were primarily maintained up to 9 months postprocedure when cryoneurolysis was repeated for the lower limbs only. On repeat cryoneurolysis, results were re-established. Cryoneurolysis is a nonsurgical, percutaneous procedure that could be considered for pain and spasticity management in patients

*List of abbreviations:* AROM, active range of motion; BoNT, botulinum toxin; DNB, diagnostic nerve block; MAS, modified Ashworth scale; ROM, range of motion; SCI, spinal cord injury.

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with quadriplegia. It can provide an option for improved quality of life and independence for patients.

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Spasticity, a velocity-dependent increase in tonic stretch reflexes, is a common complication in patients with upper motor neuron lesions, including patients with spinal cord injuries (SCIs).<sup>1,2</sup> Spasticity directly causes pain and distorted joint positioning, leading to difficulties with hygiene and pressure ulcers. It can also lead to further complications, such as musculotendinous retractions and joint contractures.<sup>3</sup> Spasticity is a ubiquitous complication for SCI patients.<sup>2</sup> It may affect many muscle groups and lead to decreases in independence. Cryoneurolysis is a novel, percutaneous procedure consisting of targeted destruction of the axons of motor neurons via a freezing cold cryoprobe.

## Case Report

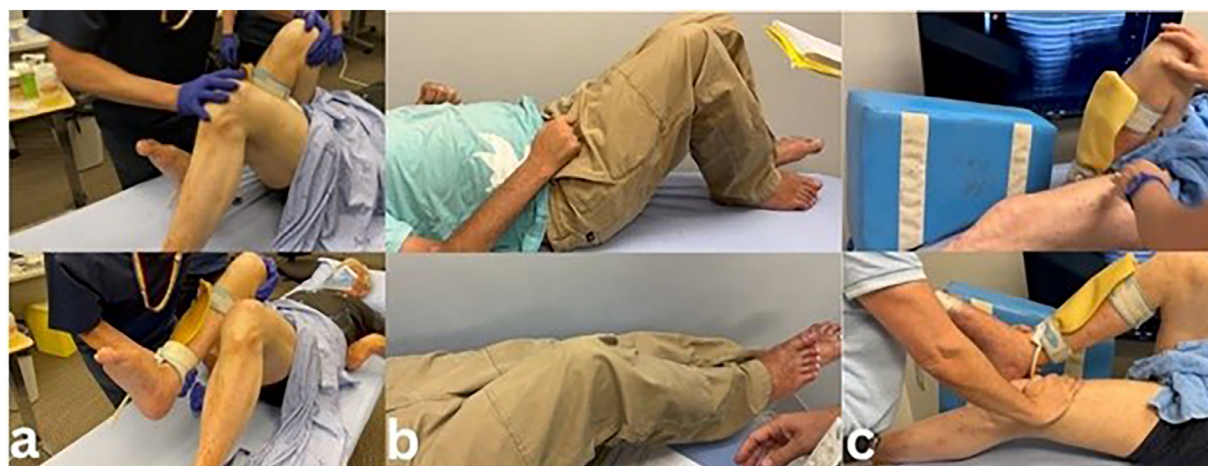
A 52-year-old man presented with severe lower limb spasticity, as well as spasticity affecting the wrist and hands, as a complication of C4 incomplete quadriplegia acquired in a motor vehicle collision in 1991. There was severe osteoarthritis in his right hip (fig 1). The hip joint was functionally fixed in place, in severe hip adduction and flexion. The associated pain was an exacerbating factor in his spasticity

which contributed to disruptive hip flexion spasms (fig 2A). His wrist and finger spasticity affected functional usage.

He had a 15-year history of repeat botulinum toxin (BoNT) injections at high (600 units every 3mo) doses, exceeding on-label recommendations. These were all on the right leg, labeled as (1) Hamstrings 250 units; (2) adductors 200 units; and (3) hip flexors 150 units (all of which are considered off-label muscle groups in the lower extremities). Treatment included 80 mg of oral baclofen, administered daily, as well as diazepam and zopiclone for sleep disruptions caused by hip flexion spasms. Physiotherapy was ineffective in altering the range of motion (ROM). He experienced recurrent pressure ulcers in the lower extremities because of shearing and flexion caused by his spasticity and had been recommended for a right Girdlestone excision arthroplasty as a treatment. There were many disruptions to his independence caused by the combination of these factors, including issues with transferring, wheelchair positioning, sleep disturbance, and reduced ability to perform activities of daily living. He had plateaued in his response to treatment for several years. This case report aims to determine the efficacy of cryoneurolysis as a treatment for pain and spasticity in an SCI patient with severe orthopedic deformity and impaired hand function. The anatomy of novel muscles not previously published



Fig 1 Hip radiograph.



**Fig 2** Lower limb ROM. Top at resting position, bottom active extension. (a) Leg extension at baseline. (b) Leg position at three months follow up. (c) Leg position at nine months follow up.

for cryoneurolysis will be demonstrated. Accompanying videos demonstrate the patient's progress and cryoneurolysis technique ([Supplemental Video S1 and S2](#)).

## Methods

As per the case report (CARE) guidelines, informed consent was obtained for the procedures, and measures were taken to ensure patient confidentiality throughout the study. Institutional Research Ethics Board approval was not required. In publications on cryoneurolysis, changes in ROM are reported using the modified Ashworth scale (MAS) and the Modified Tardieu Scale, which includes the angles ( $X$ ) of maximum passive ROM  $X_{(v1)}$  about the joint and the angle of catch with quick movement  $X_{(v3)}$ .<sup>2</sup>

## Cryoneurolysis

To prepare for cryoneurolysis, the skin at the injection sites was swabbed with chlorhexidine to reduce infection risk. Local injections of 1% lidocaine were performed to anesthetize the entry points. A 16-gauge angiocatheter was inserted to guide the cryoprobe, enhance the echogenicity of the ultrasound, and shield the skin from the cold cryoprobe. The probe was inserted through the catheter, and target nerves were located using ultrasound guidance and electrical stimulation (less than 1mA at 1Hz). Each lesion consisted of a freezing and thawing cycle lasting 106 seconds. No adverse events were reported during or directly after the treatment.

## First lower extremity procedure

The severe deformity of the right hip suggested that multiple muscles were co-contracting simultaneously in addition to the orthopedic deformity. Potential side effects were communicated, and consent was given to perform cryoneurolysis using the Iovera Handheld System<sup>a</sup>, a free-standing unit that uses liquid nitrous oxide capsules. The severe hip adduction was addressed by targeting the bilateral anterior and posterior divisions of the obturator

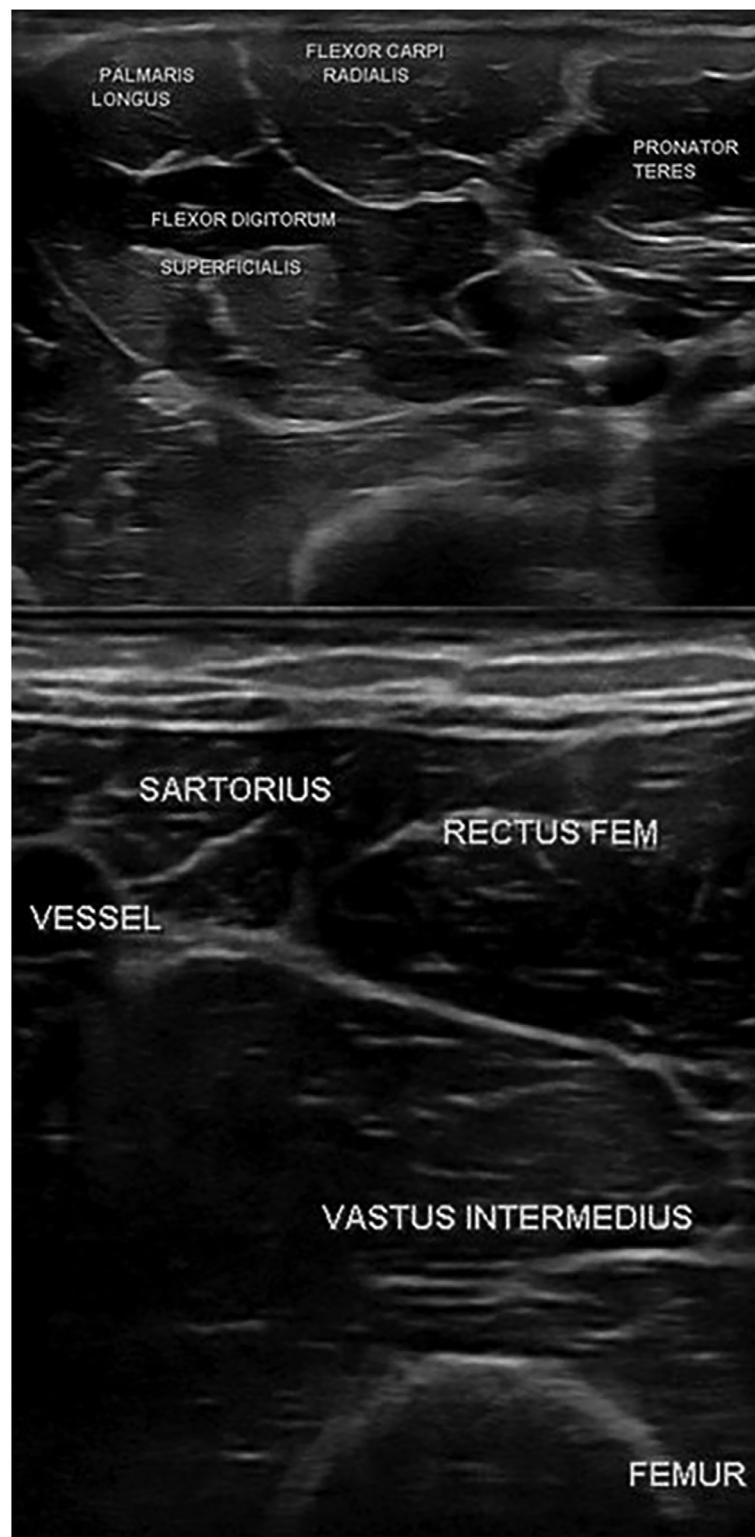
nerve as described by MacRae et al.<sup>4</sup> Hip flexion may be caused by multiple muscles.<sup>5</sup> The rectus femoris anatomy for cryoneurolysis was described by Boissonnault et al,<sup>6</sup> and the addition of the underlying vastus intermedius is shown in [figure 3](#). The iliacus portion of the iliopsoas was only seen after treatment of the rectus femoris, which allowed for hip extension and visualization of this muscle under ultrasound and was treated intramuscularly. The right sartorius muscle was later added during a repeat cryoneurolysis to help reduce the hip flexion contracture, as it is a hip flexor. The sartorius was located on ultrasound above the rectus femoris, adjacent to the femoral vessels ([fig 3](#)). The knee flexion was addressed by treating the hamstring muscle groups intramuscularly as they flex the knee adding to the flexion movement about the hips.<sup>7</sup> The intramuscular sciatic nerve branches of the semimembranosus and semitendinosus were localized 5–10 cm below the subgluteal fold. The treated muscles are listed in [table 1](#).

## Results for lower extremities

After the cryoneurolysis procedure, immediate improvements in ROM were demonstrated and the patient reported being “happy with the extra movement” for bilateral knee extension ([fig 2](#), [table 2](#)) and hip extension and abduction. Improvements were also seen at 3-, 6-, and 9-month follow-ups, sustained in the left leg ([tables 2 and 3](#)). For hip abduction, improvements were sustained up to 9 months, with a peak for the left and right sides at 6 and 2 months, respectively. Between the 3- and 9-month follow-up, the abduction of the osteoarthritic right hip gradually lessened but remained improved from baseline. The patient's tone as measured on the MAS did not decrease significantly, possibly because of the severe joint restrictions as well as joint pain and pressure ulcers.

## Repeat lower extremity cryoneurolysis

At 9 months, spasms driven by the hip pain returned as the nerve regrew; therefore, repeat cryoneurolysis was



**Fig 3** Ultrasound anatomy of implicated muscles.

deemed necessary ([table 1](#)). Immediately after the repeat procedure, increases in right hip and knee ROM were re-established ([tables 3 and 4](#)). Two months after the repeat procedure, there were improvements seen in ROM in left and right hip abduction of 5° each, left and

right knee extension of 5° and 40°, respectively, and interknee distance of 2 cm ([table 3](#)). A decrease in left hip abduction tone was also noted. The presentation and technique for the lower extremity are found in [Supplemental Video S1](#).



**Table 1** Targeted sites for cryoneurolysis

	Upper Limb Cryoneurolysis	Lower Limb Cryoneurolysis	Repeat Cryoneurolysis (Lower Limb)
Sites targeted	<ul style="list-style-type: none"> <li>• Intramuscular branches of FDS (bilateral)</li> <li>• FCR &amp; palmaris longus (left)</li> </ul>	<ul style="list-style-type: none"> <li>• Peripheral nerves to rectus femoris (bilateral)</li> <li>• Anterior and posterior divisions of obturator nerve (bilateral)</li> <li>• Intramuscular branches of medial and lateral hamstrings (bilateral)<sup>†</sup></li> <li>• Vastus intermedius (right)<sup>†</sup></li> <li>• Iliopsoas at the hip (right)</li> </ul>	<ul style="list-style-type: none"> <li>• Rectus femoris (right)</li> <li>• Anterior and posterior divisions of obturator nerve (bilateral)</li> <li>• Vastus intermedius (right)</li> <li>• Sartorius (right)<sup>*</sup></li> </ul>

<sup>\*</sup> This muscle was added onto the protocol upon repeat cryoneurolysis of the lower limb.

<sup>†</sup> These muscles were added onto the protocol on 3-month follow-up.

**Table 2** Follow-up results for the lower limb

Follow-Up	Lower Limb
3 mo	<ul style="list-style-type: none"> <li>• Results sustained for interknee distance, left hip abduction, and bilateral knee extension (<a href="#">table 4</a>).</li> <li>• The patient reported tightness in the rectus femoris was significantly reduced.</li> </ul>
6 mo	<ul style="list-style-type: none"> <li>• Improvements in ROM for bilateral hip abduction.</li> <li>• The patient reported gains in lower limb positioning, and a cessation of hip flexor spasms (<a href="#">table 4</a>).</li> </ul>
9 mo	<ul style="list-style-type: none"> <li>• Results largely maintained, left leg still able to reach full extension.</li> <li>• Tone reappearing bilaterally in the hips, particularly on the right.</li> </ul>

## Cryoneurolysis for upper extremities

After the success of the lower extremities, focus was placed on the upper extremities. He had received 1 remote injection in his hands to the flexor digitorum superficialis (FDS) and profundus (FDP) with botulinum toxin (BoNT), which did not improve function. On physical examination, several targets were identified as potential contributors to the patient's spasticity ([table 1](#)). The FDS, flexor carpi radialis (FCR), and palmaris longus are innervated by the median nerve and are involved in finger and wrist flexion—actions important in grip and fine motor control.<sup>5</sup>

As it was crucial not to weaken the patient to avoid losing function and to evaluate muscle contribution to spasticity, a diagnostic nerve block (DNB) using 2 cc of (1%) lidocaine was performed intramuscularly to the bilateral FDS muscles and the left flexor pollicis longus.<sup>8</sup> After the DNB, the patient reported immediate improvement in ROM, ease of movement, and relaxation of the fingers and hand, with no

sensory disruptions. There were still restrictions in movement at the left wrist, suggesting that these muscles were an additional target. Cryoneurolysis was then performed at a later date to allow the DNB to wear off ([table 1](#)). It was noted that the left thumb relaxed after the proximal muscles were treated and did not require treatment of the flexor pollicis longus, suggesting a possible synergistic movement.

## Results for the upper extremities

After cryoneurolysis for the upper limb, at 3 months follow-up ([table 3](#)), there were increases of 25° and 5° for right and left passive wrist extension, respectively, and a bilateral increase in active wrist extension of 35°. The right hand opened up significantly enough to have a cylinder grip. There was a bilateral decrease in tone for wrist extension, and all fingers demonstrated improved motor control. The left fingers were able to extend fully, and significant improvements were seen in the left wrist function ([fig 4](#)). Improvements were maintained at 9 months post-procedure ([tables 3 and 5](#)). Measures showed a mild decrease in wrist extension at 9 months; however, in comparison to baseline, a significant increase was still notable. An improvement in hygiene score was also observed after the procedure and was found sustained at 9 months follow-up ([table 3](#)).<sup>9</sup> A video of the presentation and cryoneurolysis is found in [Supplemental Video S2](#).

## Discussion

Spasticity is present in over 80% of SCI patients and is often a major contributor to disability, leading to restrictions in many daily activities.<sup>10</sup> It develops gradually in the months after injury and is often most pronounced in lower extremity flexors.<sup>2</sup> The first line of treatment for spasticity in SCI patients includes both widespread and focal antispasmodic agents (such as Baclofen and BoNT) and stretching with physiotherapy. Therapy outcomes are inconsistent because of the presence of spasms, clonus, contracture, and osteoarthritis seen in SCI. Surgery is also used to treat associated nonreducible deformities. Because of the widespread nature

**Table 3** Quantitative measurements for upper and lower extremities

		Baseline	2-mo Follow-Up	3-mo Follow-Up	6-mo Follow-Up	9-mo Follow-Up <sup>§</sup>	11-mo Follow-Up <sup>  </sup>
Left hip abduction	X <sub>(v1)</sub> <sup>*</sup>	10°	25°	25°	35°	25°	30°
	X <sub>(v3)</sub> <sup>*</sup>	0°	5°	5°	10°	10°	0°
	AROM <sup>†</sup>	None	None	None	None	None	None
	MAS <sup>‡</sup>	3	2	3	3	3	2
Right hip abduction	X <sub>(v1)</sub>	5°	20°	5°	10°	15°	20°
	X <sub>(v3)</sub>	0°	10°	−5°	0°	—	0°
	AROM	None	None	None	None	None	None
	MAS	3	3	3	3	2	3
Left knee extension (with hip at 90°)	X <sub>(v1)</sub>	−40°	-	−40°	−35	−35°	−30°
	X <sub>(v3)</sub>	−105°	-	−105	−60	−75°	−65°
	AROM	None	-	None	None	None	None
	MAS	3	-	3	3	2	2
Right knee extension (with hip at 90°)	X <sub>(v1)</sub>	−100°	-	−100°	−65	−70°	−30
	X <sub>(v3)</sub>	−105°	-	−105°	−90	−90°	−80
	AROM	None	-	None	None	None	None
	MAS	3	-	3	3	3	3
Interknee distance		15.5 cm	29 cm	32 cm	29 cm	28 cm	30 cm
		-	-	22 cm	22 cm	23 cm	23 cm
Left wrist extension	X <sub>(v1)</sub>	65°	-	90°	-	85°	-
	X <sub>(v3)</sub>	30°	-	65°	-	65°	-
	AROM	15°	-	50°	-	50°	-
	MAS	2	-	1+	-	1+	-
Right wrist extension	X <sub>(v1)</sub>	85°	-	90°	-	90°	-
	X <sub>(v3)</sub>	35°	-	No catch	-	65°	-
	AROM	None	-	35°	-	20°	-
	MAS	2	-	0	-	1+	-
Box and block test	Left	9 blocks	-	15 blocks	-	-	-
	Right	2 blocks (test limited due to shoulder)	-	Not repeated	-	-	-
Hygiene score	-	3	2	-	-	2	-

\* X denotes the angle. X<sub>(v1)</sub> denotes the maximal range of passive range of motion. X<sub>(v3)</sub> denotes the angle of catch or clonus.

† AROM, Active range of movement.

‡ MAS, Modified Ashworth Scale. Measured within the patient's available ROM.

§ This was also used as the baseline measure for repeat cryoneurolysis to the lower limb.

|| This was also the 2-month follow-up from repeat cryoneurolysis.

of spasticity in SCI patients, the maximum dose of BoNT is often reached before patient goals are met. In Canada and the USA, the maximum on-label dose of BoNT is 400 and 360 units per injection, respectively, which is significantly less than this patient's 600 units. Furthermore, the product monograph of the Onabotulinum toxin A used does not

include any lower extremity muscles above the knee, as they are considered off-label.<sup>11</sup> Oral baclofen is an insufficient treatment for some patients, and there are numerous challenges associated with treatment through intrathecal baclofen, such as pump malfunction or catheter-related complications.<sup>12</sup>

**Table 4** Repeat cryoneurolysis results

Follow-Up	Lower Limb – Repeat Cryoneurolysis
Immediate results	Decreased tone and increased ROM for the right leg re-established.
2 mo	<ul style="list-style-type: none"> <li>• Bilateral improvements in ROM for hip abduction, knee extension, and interknee distance (table 4).</li> <li>• No difference in tone upon follow-up.</li> <li>• Pronounced improvement in right knee extension.</li> </ul>



**Fig 4** Wrist and handfigure ROM.

Cryoneurolysis disrupts the conduction of motor neurons through the targeted application of freezing temperatures. The immediate improvements in ROM and muscle relaxation observed postprocedure can be attributed to the precise targeting of these key muscles and their neural innervations. The sustained effects at 3- and 9-month follow-ups suggest that cryoneurolysis provides immediate relief and offers a lasting reduction in spasticity. This long-term benefit is likely because of the length of the regenerative process of the nerves, as well as the possibility of developing a more normalized pattern of neural activity during nerve regrowth. Cryoneurolysis may also be administered to the intramuscular motor branches, allowing for better treatment of hand and wrist spasticity, with immediate results and patient feedback.<sup>13</sup> For this patient, percutaneous cryoneurolysis was used to treat nerves or muscles that were non or minimally responsive to off-label BoNT. Immediate relaxation

achieved through cryoneurolysis allowed sequential access to muscles inaccessible caused by severe hip deformity.

Additionally, many persons with SCI are medically frail or have issues with positioning which infringe on their ability to receive more invasive treatments.<sup>14</sup> SCI patients with spasticity are more prone to hip osteoarthritis and are also poorer candidates for hip arthroplasty because of increased risks of dislocation, component loosening, and heterotrophic ossification.<sup>15</sup> Cryoneurolysis could provide an additional treatment option for patients who are not candidates for hip arthroplasty or other invasive surgeries. The reductions in spasticity through the cryoneurolysis treatment may also alleviate some of the spasticity-associated risks of hip arthroplasty. Thus, cryoneurolysis differs from BoNT and surgical neurectomy because of the immediate effect on an awake patient, and the minimally invasive nature of the procedure.

**Table 5** Follow-up results for the upper limb

Follow-Up	Upper Limb
3 mo	<ul style="list-style-type: none"> <li>• Results sustained for bilateral wrist extension.</li> <li>• The patient reported feeling “delighted” with the improvements in hand function, specifically with wheelchair maneuvering, teeth brushing, face cleaning, and grasping.</li> <li>• MAS scores represented decreases in wrist flexor tone bilaterally (table 3).</li> <li>• Box and Block test results demonstrated an improvement in left hand function (table 5).</li> <li>• The patient reported many improvements in Activities of daily living as a result of the procedure, such as being able to shower independently.</li> </ul>
6 mo	<ul style="list-style-type: none"> <li>• Examining physician reported that the patient’s hands felt “dramatically better.”</li> </ul>
9 mo	<ul style="list-style-type: none"> <li>• Patient noted functional improvements in hand/wrist function for both hands.</li> </ul>

## Study limitations

The case study research design puts an inherent limit on the generalizability of findings. Quadriplegia is a diverse condition with varying levels of severity, patterns of muscle involvement, and individual patient factors. This heterogeneity means that results rely on the individualized assessment and response to the DNB for each patient. Future studies involving larger, more diverse cohorts as well as randomized controlled trials are necessary to validate these results and ensure they are applicable to a broader population.

## Conclusions

Percutaneous cryoneurolysis in SCI resulted in many months of improvements in bilateral hip abduction and knee extension ROM. Retreatment at 9 months to the legs returned the gains. Bilateral wrist extension ROM and MAS scores were maintained for 9 months. There was a significant increase in independence and ease for several daily activities, including tooth brushing, showering, and wheelchair transfers. Cryoneurolysis could be an effective, long-lasting method for managing severe spasticity in patients with SCI with minimal side effects.

## Suppliers

<sup>a</sup>lovera System 190 Smart Tip; lovera, Pacira.

## Disclosures

Paul Winston has received grants, and educational funding, and has served on Ad boards of Abbvie, Ipsen, Merz, and Pacira. The other authors have nothing to disclose.

## Corresponding author

Paul Winston, MD, 1 Hospital Way, Victoria, BC V8Z 6R5, Canada. E-mail address: [Paul.Winston@islandhealth.ca](mailto:Paul.Winston@islandhealth.ca).

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