Texas Heart Institute Journal

Techniques

Continuous Thoracic Paravertebral Block to Treat Electrical Storm

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Continuous ganglion block is increasingly being used to help manage ventricular tachyarrhythmias. We present the cases of 2 patients in whom we used continuous left thoracic paravertebral block to achieve sympathetic denervation and improvement in drug-refractory ventricular tachyarrhythmias. Whether as destination therapy or bridging therapy, we conclude that the block is safe, improves patients' comfort, and is superior in several ways to stellate ganglion block and other single-injection techniques. ***(Tex Heart Inst J 2022;49(2):e176433)***

Citation:
Smith DI, Kralovic SA, Hegazy RA, Tran H. Continuous thoracic paravertebral block to treat electrical storm. Tex Heart Inst J 2022;49(2):e176433. doi: 10.14503/THIJ-17-6433

Key words:
Anesthetics, local/therapeutic use; anti-arrhythmia agents/therapeutic use; arrhythmias, cardiac/therapy; nerve block/methods; recurrence; stellate ganglion/physiopathology; sympathetic nervous system/surgery; tachycardia, ventricular/prevention & control/therapy; thoracic vertebrae; treatment outcome

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Controlling nonischemic ventricular tachyarrhythmias by interrupting sympathetic cardiac innervation has been achieved through single interventions (Table I).[1-4] Earlier, we[5] reported a modified approach to definitive left cardiac sympathetic denervation (LCSD) in a patient who had electrical storm (ES). After we administered a continuous sympathetic neural block to rule out intermittent, spontaneous ectopic quiescence in ceasing ventricular irritability during the block, our observations led us to consider a different approach: continuous left thoracic paravertebral block (TPVB).

We describe what we think is a previously unreported technical application of left sympathetic gangliolysis to treat recurrent ventricular tachyarrhythmias, illustrated by 2 cases that caused us to shift our practice.

Case Reports

Patient 1

A 71-year-old man presented with ES. He had a medical history of hypertension, hyperlipidemia, type 2 diabetes, nonischemic cardiomyopathy, biventricular implantable cardioverter-defibrillator (ICD) placement, and recurrent ventricular tachycardia (VT) refractory to radiofrequency ablation and to carvedilol and amiodarone therapy. He was first referred for electrophysiologic evaluation, but no intervention was indicated. Repeat echocardiograms showed no substantial worsening of cardiac function. He was then referred to our Acute Pain Service for possible left cardiac sympathetic block. Through a left thoracic paravertebral catheter, 0.1% bupivacaine was infused at a rate of 5 mL/hr. Because only 2 episodes of VT necessitating cardioversion occurred during the 7-day infusion, it was considered successful management of the patient's VT (Fig. 1). The patient agreed to undergo chemolytic (permanent) sympathectomy, and he was given a lytic, 6% phenol block of the thoracic vertebral level 1 through 5 (T1–T5) sympathetic ganglia through the neural blockade catheter. Only 3 episodes of VT necessitating cardioversion occurred within 7 days after lytic ganglionectomy, and the patient was discharged from the hospital. At his 6-month follow-up examination, no additional shockable episodes had occurred.

Patient 2

A 73-year-old man was admitted to our cardiovascular intensive care unit (ICU) because of recurrent asymptomatic VT (heart rates, ≥140 beats/min). He reported

TABLE I. Reports of Ventricular Tachyarrhythmias and Interrupted Sympathetic Cardiac Innervation

Reference	Pts. (n)	Age (yr), Sex	Presentation	Technique	Outcome	Comment
Mahajan A, et al.[1] (2005)	1	75, M	ES, LVEF, and antiarrhythmic therapy failure	Thoracic epidural injection	Sustained VT ceased	VAD insertion (left atrial–femoral artery bypass)
Collura CA, et al.[2] (2009)*	20	2 mo–42 yr (12 M, 8 F)	LQTS and CPVT	Surgical ganglionectomy (18 VATS, 2 open)	No perioperative ectopy or hemorrhage; no VATS; open conversion determined procedural safety	Markedly fewer cardiac events after LCSD as secondary prevention
Loyalka P, et al.[3] (2011)	1	58, M	Anterior MI, unstable VT, repeated external countershocks, and amiodarone	Single SGB	1 postprocedural defibrillation; no further events	Ablation of developed ectopic atrial tachycardic focus, and AICD placement
Malik AA, et al.[4] (2014)	1	70, M	Ischemic cardiomyopathy, AICD, intractable VT, failed RF ablation, and ES	Single SGB	VT reverted to sinus rhythm 2.5 hr after block; lasted through 1-mo follow-up	—
Smith DI, et al.[5] (2015)	1	65, M	ES, AICD, and LVAD	Continuous SGB	Open surgical ganglionectomy performed on day 7 of block	—
Current report	1	71, M	Refractory VT, ES, biventricular AICD, and failed RF ablation	Continuous TPVB and lytic ganglionectomy	Three cardioverted VT episodes after ganglionectomy; no further events at 6 mo	—
	1	73, M	Refractory VT, ES, AICD, LVAD, and failed RF ablation	Continuous TPVB for LCSD	Repeat catheter therapy for refractory VT; warfarin resumed	Repeat ablation planned if VT were to recur

AICD = automatic implantable cardioverter-defibrillator; CPVT = catecholaminergic polymorphic ventricular tachycardia; ES = electrical storm; F = female; LCSD = left cardiac sympathetic denervation; LQTS = long QT syndrome; LVAD = left ventricular assist device; LVEF = left ventricular ejection fraction; M = male; MI = myocardial infarction; Pts = patients; RF = radiofrequency; SGB = stellate ganglion block; TPVB = thoracic paravertebral block; VAD = ventricular assist device; VATS = video-assisted thoracic surgery; VT = ventricular tachycardia

*Retrospective electronic chart analysis

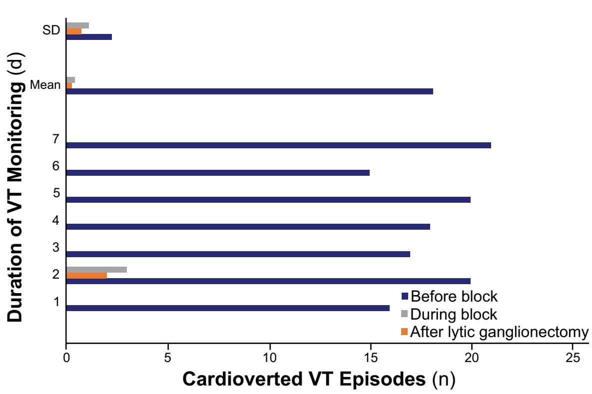

Fig. 1 *Patient 1. Graph shows the number of ventricular tachyarrhythmias during 3 phases: 7 days before continuous paravertebral block treatment, 7 days during block treatment, and 7 days after lytic ganglionectomy. The mean (± SD) number of events necessitating cardioversion was 18.14 ± 2.1 before block treatment; during continuous block it was 0.29 ± 0.7; and after lytic ganglionectomy, 0.43 ± 1.*

dyspnea, palpitations, and difficulty breathing during minimal exercise. He had chronic kidney disease, hypertension, and a history of ischemic cardiomyopathy (left ventricular ejection fraction [LVEF], 10%). Nine years earlier, a Medtronic single-lead automatic ICD had been placed to treat refractory VT. Four years after that, a HeartMate II left ventricular assist device (LVAD) (Thoratec, an Abbott company) was placed, and warfarin was prescribed. He had undergone unsuccessful VT ablation twice.

Before the current admission, the patient had been hospitalized after ICD interrogation showed asymptomatic VT for longer than a month (heart rate, 120–130 beats/min). His prescribed amiodarone and metoprolol were maximized to treat the recurrent VT, but to no effect.

At our hospital, direct-current ICD cardioversion converted the patient's monomorphic VT to a ventricular-paced rhythm. However, his asymptomatic VT intermittently recurred, so our Acute Pain Service was consulted.

The patient had an LVAD, so we decided that the best interventional approach would be through a left-sided paravertebral tunneled catheter; unlike continuous left stellate ganglion block (SGB), the paravertebral approach would enable better catheter stability and patient positioning. Meanwhile, the patient's international normalized ratio (INR) was 1.9 on 3 mg/d of oral warfarin. We planned to discontinue warfarin, bridge with a heparin drip, and attain an INR <1.3 before the procedure. If the catheter procedure failed, we planned surgical ganglionectomy to control the VT.

During 5 days of bridging, asymptomatic VT episodes occurred despite maximal medical therapy. On the 6th day, the heparin drip was held for 2 hours before catheter placement (activated partial thromboplastin time, 69.2 sec). In the operating room, the patient was mildly sedated and placed in a sitting position. A cardiac perfusionist monitored LVAD function throughout. Ultrasonography revealed the left paravertebral space at the first thoracic vertebral level, and an 18G Tuohy needle was advanced into it. After negative aspiration, 30 mL of 0.5% bupivacaine with epinephrine (ratio, 1:200,000) was injected into the space. A 20G polyethylene open-tip catheter was threaded into the space to a depth of 5 cm, tunneled subcutaneously, brought out, and secured at the skin. A continuous infusion of 0.1% bupivacaine was initiated at a rate of 2 mL/hr. The patient tolerated the approximately 40-minute procedure well.

After the procedure, left-sided ptosis (Horner syndrome) was noted. Two hours later in the ICU, the patient's heparin drip was restarted. No VT occurred for 4 days. On the 5th day, the VT recurred with possibly associated syncope. A 15-mL bolus of 0.25% bupivacaine with epinephrine (ratio, 1:200,000) was injected through the catheter; the infusion concentration was increased to 0.125% bupivacaine at a rate of 6 mL/hr, all without positive effect. The patient's hemodynamic values remained stable before and after the bolus (mean arterial pressures, ~60 mmHg).

The patient had persistent left-sided ptosis without other overt signs of ipsilateral Horner syndrome. We assumed that the catheter tip had reached the cervical vertebrae, leading to cephalad spread of the local anesthetic solution and a blockade of the cranial nerves. However, we also suspected inadequate caudal spread to the cardioaccelerator fibers (Fig. 2).

Our cardiologists decided to hold the heparin drip and to discontinue the catheter 2 hours later. The patient's previous warfarin therapy was slowly increased to initial therapeutic levels, because refractory VT had recurred despite the catheter therapy. Two weeks postprocedurally and after adjustments to the ICD, the patient was discharged from the hospital. Plans were made for repeat ablation if the VT recurred with associated hemodynamic instability.

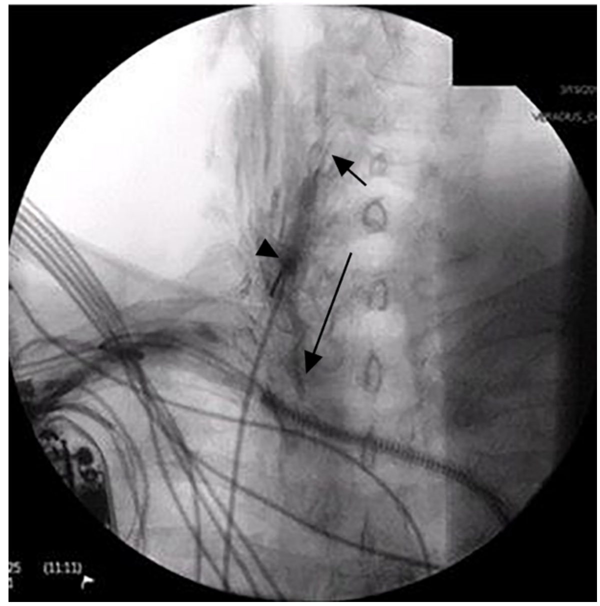

Fig. 2 *Patient 2. Fluoroscopic view. Arrows show the extent of radiopaque dye spread cephalad from the 6th cervical vertebral level caudad to the 3rd thoracic vertebral level. Arrowhead shows the needle's entry site at the first thoracic vertebral level.*

Discussion

We previously reported the successful use of continuous SGB as bridging therapy to surgical ganglionectomy for a patient with an LVAD and ES. Our practice has evolved to provide more options based on patients' needs and available therapies. In Patient 1, who had ES and a biventricular ICD, we used continuous TPVB as a bridge to chemolytic ganglionectomy.[5] In Patient 2, who had an ICD and LVAD, we used continuous TPVB to treat sympathetically mediated, refractory monomorphic VT. The TPVB aided his comfort and would have guided definitive surgery, had TPVB failed.

Electrical storm has been defined as 3 or more sustained VT or ventricular fibrillation episodes or appropriate ICD countershocks.[6-13] The tachyarrhythmias are often self-limiting; however, they may threaten life or occur frequently enough to necessitate therapy. Authors have described using LCSD, usually left SGB, to treat ventricular tachyarrhythmias and ES.[3-5,14] Mahajan and colleagues used a continuous thoracic epidural injection to treat tachyarrhythmia.[1]

Technique

We modified our approach to LCSD after determining what creates a successful blockade. In Patient 1, we needed a statistically meaningful reduction in daily shockable events (Fig. 1). We had to establish that the actual mechanism of ES is at least partly influenced by increased sympathetic tone and therefore amenable to LCSD, that the effect could be maintained over time, and that proceeding to definitive treatment was warranted. At our institution, this last is surgical or chemolytic (permanent) LCSD. After our clinical experience with Patient 1, we adopted continuous neural blockade for LCSD through the thoracic paravertebral route.

Advantages of the Paravertebral Approach

We prefer left TPVB to the single-injection LCSD approach. The anatomic location enables catheter stability, more cervical mobility than in SGB,[5] more direct delivery of local anesthetic to the cardiac sympathetic ganglia in the paravertebral region, and easier documentation of injectate spread with the use of radiopaque dye (Fig. 2). In addition, catheter positioning can be verified for subsequent injection of lytic agents through the same device (if appropriate after the continuous-block trial), there is less physical disfigurement, and potentially catastrophic cervical events can be avoided, especially if a prolonged catheter trial is indicated.

Ultrasonography and fluoroscopy enable good views of target regions. The infusion catheter is tunneled through and out of the paraspinous muscles, subcutaneous tissue layers, and skin. Active and bedridden patients are usually able to move their neck and shoulders with a TPVB catheter in place; in contrast, indwelling cervical catheters and the need for dressings may inhibit such movement. The mass and relatively fixed position of the paraspinous muscles minimize accidental dislodgment and enable mobility during observation. The tunneling also enables protracted use of the continuous technique (>1–2 wk) and reduces risks of catheter-related infection.

Chemical Ganglion Blockade

We prefer alcohol lytic blockade over phenol blockade. Undesirable effects of phenol include central nervous system stimulation, cardiovascular depression, nausea and vomiting, and possibly incomplete destruction of neuronal cell bodies. A 95% alcohol solution destroys neuronal cells more efficiently than phenol does, and, when mixed with local anesthetic, the blockade established by the infusion itself increases patients' comfort. Whereas phenol can be mixed with dye to determine directions of regional spread, thoracic paravertebral space enables the same when first dye and then alcohol are injected. Finally, alcohol is metabolized rapidly in the liver.

The ongoing shockable tachyarrhythmias in Patient 2 ceased immediately after the paravertebral space was injected with 30 mL of local anesthetic. Dye was clearly spreading cephalad and caudad, encouraging us to insert the 20G catheter and inject some dye to confirm paravertebral positioning. However, in the ICU, the patient's tachyarrhythmia recurred, probably because of inadequate injection volume.

Of note, ptosis was the only sign of Horner syndrome observed after injection. We had assumed 2 things: first (probably correctly), that the ptosis indicated catheter position in the paravertebral space because the oculomotor nerve was blocked; and second (probably incorrectly), that the ptosis indicated adequate spread to the cardiac fibers (T1–T4/5) of the sympathetic ganglion. Ultimately, the 15-mL bolus of anesthetic was not enough for caudal spread that would block the cardioaccelerator fibers. Although the classic markers of an effective sympathetic block ensure blockade of the lower fibers of the stellate ganglion, the cardioaccelerator fibers are not also automatically blocked. Others have shown that 15 mL of injectate at the thoracic paravertebral space spreads to 4 or more paravertebral levels (range, 1–9 levels).[15,16] Assuming that Patient 2's oculomotor nerve was the highest level covered, the farthest caudal level reached was approximately T4, which excluded the cardioaccelerator fibers. This technical failure was part of the steep learning curve associated with our new approach to treating ES. In future procedures, we will place the catheter in the 3rd or 4th thoracic paravertebral space to ensure caudal spread adequate to cover the cardioaccelerator fibers.

Conclusion

The continuous left paravertebral approach for delivering local anesthetic to directly block cardioaccelerator fibers appears adequate to achieve sympathetic denervation and improvement in drug-refractory ventricular tachyarrhythmias. Our technique is straightforward to perform, risks fewer severe complications than do other methods, enables catheter stability, and is comfortable for patients.

Published: 8 April 2022

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