ESC European Society of Cardiology

Europace (2023) **25**, 1–3
https://doi.org/10.1093/europace/euad314

EDITORIAL

Neuronal sympathetic block for ventricular arrhythmias: one size may not fit all

Veronica Dusi [1]* and Marmar Vaseghi [2]

[1]Division of Cardiology, Department of Medical Sciences, University of Turin, Corso Bramante 88, 10126 Turin, Italy; and [2]Division of Cardiology, Department of Medicine, UCLA Cardiac Arrhythmia Center, Los Angeles, CA, USA

Online publish-ahead-of-print 27 October 2023

This editorial refers to 'Stellate Ganglion Ablation by Conventional Radiofrequency in patients with Electrical Storm' by B. Hygriv Rao *et al.*, https://doi.org/10.1093/europace/euad290.

Electrical storm (ES) is associated with increased morbidity and mortality and can be challenging to treat.[1] ES has often been defined as three episodes of sustained or treated ventricular arrhythmias (VAs) over a 24-h period, though recent data suggest that as few as two VAs episodes over 90 days can be associated with an increase in mortality.[2] Overall, a compelling body of evidence strengthens the pivotal importance of reducing the risk of clustered VAs. Hence, when VA proves refractory to ablation or anti-arrhythmic drugs, therapeutic interventions aimed at improving cardiac autonomic balance to reduce VA burden are now recommended by all the latest international guidelines.[3,4] The pathophysiological basis for many of these neuromodulatory approaches, but especially cardiac sympathetic denervation (CSD), has been extensively reviewed elsewhere.[5] Briefly, sympathoexcitation plays an important role in the genesis of VAs and CSD has shown beneficial effects not only in patients with polymorphic but also monomorphic VT in the setting of structural heart disease (SHD).[6]

From an anatomical point of view, most of the post-ganglionic cardiac sympathetic innervation in humans stems from the paravertebral thoracic ganglia C8/T1 (that corresponds to the stellate ganglion, SG, depending on anatomical variability) to T4. As a result, bilateral CSD (BCSD), which consists of the removal of the lower 1/3 to 1/2 of the SG to T4 thoracic ganglia, has been safely performed in multiple patients with refractory VAs.[7] However, even with the latest minimally invasive thoracoscopic approaches, this procedure requires general anaesthesia and the ability to tolerate single lung inflation,[8] which can, at times, be challenging in patients with advanced heart failure or those requiring mechanical circulatory support. Regardless, at many centres, BCSD is the standard approach for a permanent neuronal cardiac sympathetic blockade, allowing for clear histopathological confirmation of the removed ganglia. In the setting of SHD, data suggest that BCSD is more effective than left CSD.[7] Alternative ways to achieve transient cardiac sympathetic blockade at the bedside include thoracic epidural anaesthesia (TEA)[9] and percutaneous SG block (PSGB).[10] Notably, the efficacy of these procedures is likely, in part, related to the inferior spread of anaesthetics in both TEA and PSGB, allowing for the inhibition of ganglia beyond the SG. The table provides a comparison of the most studied neuronal sympathetic blockade strategies.

In the current issue of the journal, Rao and colleagues[11] present the first case series of six patients with ES treated with percutaneous bilateral SG radiofrequency ablation under fluoroscopic guidance targeted at the vertebral level of C7 and T1 (corresponding to the expected anatomical location of the SG and potentially T2 or part of T2 ganglion). A mixed anatomical approach was used in each patient: an anterior paratracheal approach was used to target C7 using a needle, and a stimulation was first performed to rule out phrenic and recurrent pharyngeal nerve capture before ablation at 50, 55, and 60°C for 90 s. Subsequently, a posterior approach (after the patient was turned prone to avoid pneumothorax) was used to target the first thoracic vertebra (low SG/T2 ganglion level). A temperature of 70°C was targeted for three additional lesions, 60 s per lesion. In this series, Horner's syndrome was considered an acute procedural endpoint, which per the authors, eventually resolved in all patients. SG ablation was performed bilaterally in all patients (mean procedural time 38 min) and in one case, was split into two separate sittings due to clinical instability. Three patients had an underlying non-ischemic cardiomyopathy, two patients were treated within a few days of coronary artery bypass graft surgery, and one patient suffered from idiopathic ventricular fibrillation with a likely Purkinje trigger. Notably, two patients received conventional ventricular tachycardia (VT)/premature ventricular complex ablation after SG ablation (in one case at 24 h, in the second after 7 months). At 22 ± 8 months of follow-up, half of the patients suffered from recurrent VAs, though none had ES. As previously reported with BCSD[12] and as expected based on pathophysiology, the cycle length of recurrent VT was increased from 256 ± 49 to 376 ± 12 msec ($P = 0.05$).

The authors should be congratulated for evaluating the feasibility of a less invasive procedure targeted at the SG, via a percutaneous approach. However, several important limitations should be acknowledged. In addition to the very small number of patients, there was no functional or pathological confirmation of permanent sympathetic neuronal damage, and given that Horner's syndrome resolved in all patients, it's possible that any damage to the lower half of the SG could also have been temporary. In absence of any functional (such as skin temperature or sweating pattern evaluation), imaging, or pathological data, it also remains unclear whether the lower half of the stellate or any other parts of the other ganglia (T2) were effectively ablated. None of the patients were reported to have a clear contraindication

The opinions expressed in this article are not necessarily those of the Editors of *Europace* or of the European Society of Cardiology.

* Corresponding author. Tel: +390116336022. *E-mail address*: veronica.dusi@unito.it

	TEA	Pharmacological PSGB	CSD
Targeted neuronal level	T1–T4 (epidural level, pre-ganglionic block), with the needle typically inserted at the T1–T2 level	C8 + T1 ganglia (based on anatomical landmarks)	T1–T4 thoracic ganglia
Side of the neuronal block	Bilateral	Often performed unilaterally as left PSGB, but can be performed bilaterally	Bilateral for SHD
Duration of block	Until the catheter is in place (days)	For bolus injection: 2–6 h depending on the local anaesthetic used. For the continuous infusion: until the catheter is in place)	Permanent
Confirmation of the neuronal block (other than the anti-arrhythmic effect)	Functional: cutaneous anaesthesia in the corresponding dermatomes. Additionally, skin temperature or sweating pattern evaluation can be performed.	Functional: Horner's syndrome proves C8 blockade only (mostly ocular fibres), but the anaesthetic is expected to spread inferiorly. Additionally, skin temperature or sweating pattern evaluation can be performed.	Direct visualization of the ganglia and subsequent anatomopathological confirmation.
Availability in the emergent/urgent setting	At the bedside, requires lateral decubitus/sitting position to be performed	At the bedside, performed in the supine position.	Unavailable (the patient often needs to be stabilized while waiting for the operating room availability)
Required skills	Trained anaesthesiologist	Trained cardiologist or anaesthesiologist	Trained thoracic, cardiothoracic, or vascular surgeon
Contraindications	*Absolute:* Active infection, ongoing dual antiplatelet therapy, requirement for uninterrupted anticoagulation therapy *Relative:* acute myocardial infarction/ischemia, active major noncardiac medical or surgical processes	Significant head/neck pathology	*Absolute:* severe pulmonary pathology/inability to tolerate single lung inflation *Relatives:* high operatory risk, significant thoracic adhesions, inability to interrupt anticoagulation,

CSD, cardiac sympathetic denervation; PSGB, percutaneous stellate ganglion block; SHD, structural heart disease; TEA, thoracic epidural anaesthesia.

to CSD (three even had preserved left ventricular ejection fraction). SG ablation was, therefore, performed due to financial constraints and to avoid a second thoracic procedure or general anaesthesia in some of the patients. One third of the patients had ablation, and lack of ES at follow-up could also be related to effective ablation. Finally, as some of the patients had recently undergone revascularization, it's possible that improvements in their condition/substrate may have resulted in improved VA burden at follow-up, confounding the clinical results.

In conclusion, we are entering an exciting new era where neuromodulation beyond beta-blocker therapy and with a clear anti-arrhythmic purpose has made its way from the pre-clinical to the clinical arena. Novel approaches to CSD and other neuromodulatory therapies that reduce complications, off-target effects, need for anaesthesia, and surgical procedure times are welcomed. Albeit representing a potentially appealing and less invasive option for the most fragile patients with a prohibitive operatory risk, it's important to note that percutaneous SG ablation needs clearer endpoints, confirmation of tissue damage/ablation, validation in larger studies, and notably, the understanding that, as currently performed, it is less likely to provide the same cardiac sympathetic blockade as CSD (as T2–T4 ganglia are not clearly targeted by this procedure). Modified forms of sympathetic blockade sparing the SG have also been tried, though based on clinical and pre-clinical data clearly showing the pivotal contribution of the SG to cardiac innervation,[5] procedures that completely spare the SG need additional data and justification. Overall, given the degree of pre-clinical and clinical data behind CSD, the possibility of a less invasive (but also less extensive) procedure should be used in the setting of a contraindication to CSD, until additional data on these procedures become available.

Funding

None declared.

Conflict of interest: V.D. has nothing do declare. M.V. has received educational consulting fees from Biosense Webster, Medtronic, Recor and has shares in NeuCures Inc.

Data availability

No new data were generated or analysed.

References

1. Dusi V, Angelini F, Gravinese C. Electrical storm management in structural heart disease. *Eur Heart J Suppl* 2023;**25**:C242–8.
2. Elsokkari I, Sapp JL. Electrical storm: prognosis and management. *Prog Cardiovasc Dis* 2021;**66**:70–9.

3. Al-Khatib SM, Stevenson WG, Ackerman MJ, Bryant WJ, Callans DJ, Curtis AB *et al.* 2017 AHA/ACC/HRS guideline for management of patients with ventricular arrhythmias and the prevention of sudden cardiac death: executive summary: A report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Rhythm Society. *Circulation* 2018;**138**: e210–71.
4. Zeppenfeld K, Tfelt-Hansen J, de Riva M, Winkel BG, Behr ER, Blom NA *et al.* 2022 ESC guidelines for the management of patients with ventricular arrhythmias and the prevention of sudden cardiac death. *Eur Heart J* 2022;**43**:3997–4126.
5. Van Weperen VYH, Ripplinger CM, Vaseghi M. Autonomic control of ventricular function in health and disease: current state of the art. *Clin Auton Res* 2023;**33**:491–517.
6. Dusi V, Gornbein J, Do DH, Sorg JM, Khakpour H, Krokhaleva Y *et al.* Arrhythmic risk profile and outcomes of patients undergoing cardiac sympathetic denervation for recurrent monomorphic ventricular tachycardia after ablation. *J Am Heart Assoc* 2021;**10**: e018371.
7. Vaseghi M, Barwad P, Malavassi Corrales FJ, Tandri H, Mathuria N, Shah R *et al.* Cardiac sympathetic denervation for refractory ventricular arrhythmias. *J Am Coll Cardiol* 2017; **69**:3070–80.
8. Elliott IA, DeJesus M, Dobaria V, Vaseghi M, Ajijola OA, Shivkumar K *et al.* Minimally invasive bilateral stellate ganglionectomy for refractory ventricular tachycardia. *JACC Clin Electrophysiol* 2021;**7**:533–5.
9. Do DH, Bradfield J, Ajijola OA, Vaseghi M, Le J, Rahman S *et al.* Thoracic epidural anesthesia can be effective for the short-term management of ventricular tachycardia storm. *J Am Heart Assoc* 2017;**6**:e007080.
10. Savastano S, Dusi V, Baldi E, Rordorf R, Sanzo A, Camporotondo R *et al.* Anatomical-based percutaneous left stellate ganglion block in patients with drug-refractory electrical storm and structural heart disease: a single-centre case series. *Europace* 2021;**23**:581–6.
11. Rao BH, Lokre A, Patnala N, Padmanabhan TNC. Stellate ganglion ablation by conventional radiofrequency in patients with electrical storm. *Europace* 2023;**25**: euad290.
12. Hayase J, Dusi V, Do D, Ajijola OA, Vaseghi M, Lee JM *et al.* Recurrent ventricular tachycardia after cardiac sympathetic denervation: prolonged cycle length with improved hemodynamic tolerance and ablation outcomes. *J Cardiovasc Electrophysiol* 2020;**31**: 2382–92.