The Sisyphean task of ventricular tachycardia mapping and ablation in structural heart disease

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Homer's Sisyphus was punished by Zeus for cheating death by being forced to repeatedly roll a heavy stone uphill only to have it rolled down again just as he reached the top. The implantable defibrillator, especially in those with ischemic cardiomyopathy, has clearly shown to save lives in the setting of an otherwise fatal ventricular tachycardia (VT) or fibrillation — effectively "cheating arrhythmic death". However, after recurrent implantable cardioverter-defibrillator (ICD) shocks and failed medication trials, clinicians are often faced with having to reduce or eliminate VT by catheter ablation, which has emerged as the best current therapy for many forms of this aftermath [1–4]. Many electrophysiologists who have spent hours ablating one VT only to have several others emerge would agree that this task can be punishing for both the patient and physician. How can we do better?

In the present issue, Karkowski and colleagues [5] describe their retrospective observations on a cohort of 54 VT ablation procedures in 47 patients. In their cohort, 85% of the procedures were index ablations, 89% of patients had systolic heart failure, and the large majority (44 of 47) had an ischemic etiology for their heart disease. They analyzed several variables in a univariate fashion with respect to length of VT-free survival and found three factors associated with success: (1) the absence of diabetes; (2) fewer inducible VT morphologies; and (3) the type of mapping strategy used during the procedure. Mapping strategies have vastly improved electrophysiologists' ability to tackle VT ablation, and those used in the article by Karkowski et al. [5], along with others, are described in Table 1. This study included a stepwise approach to 3 VT mapping techniques, namely substrate-based mapping (SbM), activation mapping (AM), and pace mapping (PM) implemented in a sequence wherein they first performed SbM followed by PM and AM (if hemodynamically tolerated). They dichotomized the group to "dual technique" if only SbM + PM were performed and "triple technique" if SbM + PM + AM were performed.

The authors report a high acute procedural success rate (85%) and a complication rate of 7.4%, with one patient death secondary to cardiac arrest. After a median follow-up of almost two years, the VT-free survival rate was 68.5%. In the dual technique group, they report 24-month VT-free survival of approximately 64% compared to 85% for the triple technique group, which was statistically significant.

The work raises several important questions as well. Diabetes mellitus had an important effect on VT ablation outcomes with the highest impact on risk of recurrence of the three significant factors discovered (HR 7.7). The mechanism may lie in the presence of more advanced or microscopic substrate, but only the inclusion of this important clinical variable in prospective randomized trials will validate that finding. VT-free survival period was comparable in patients undergoing repeat ablation procedures as well (71% vs. 68.5%; $P = 0.37$), which at the very least is a signal that repeat VT ablation procedures are not futile.

The limitations of this analysis cannot be overlooked — the most important being the

Table 1. Selected list of available invasive mapping strategies for VT ablation

Mapping strategy	Basic concept	Published data validation +=minimal ++++= extensive	Special catheters needed (y/n)	Additional time spent += minimal ++++= extensive	VT required during method (y/n)
Entrainment	Pacing during VT and applying principles of reentry	++++	n	++	y
Activation[a]	Timing of electrograms relative to surface ECG	+++	n	+	y
Pacemap[a]	Paced QRS match to VT QRS morphology	++++	n	++	n
Noncontact wavefront activation	Floating catheter instantaneously collecting activation during VT	+	y	++	y
Substrate[a] Voltage	Generating map based on scar (i.e. <0.5 mV bipolar) transition (0.5–1.5 mV bipolar) and normal (>1.5 mV bipolar)	+++	n (certain catheters perform better)	+++	n
Substrate[a] Late potential annotation (LAVA)	Annotating points with local signals that occur late with respect to surface ECG	++	n (certain catheters perform better)	+++	n
Substrate Isochronal mapping	Generating map sorted by time zones of activation with focus on areas of slowing/crowding	+	n (certain catheters perform better)	+++	n
Substate Decrement evoked potential	Generating map based on the extent of decrement from extra stimulus	+	n (certain catheters perform better)	++++	n

[a] Mapping strategies used in the present study

Abbreviations: LAVA, local abnormal ventricular activities; VT, ventricular tachycardia; y, yes; n, no

selection bias of which patient receives triple versus dual techniques. Activation mapping, by its nature, requires a relatively hemodynamically stable arrhythmia which in turn is associated with higher success rates and better outcomes [6]. The univariate nature of the analysis does not account for confounding variables, which are particularly inherent in retrospective reports. The lack of epicardial procedures, the absence of a unified monitoring strategy, and the paucity of non-ischemic substrates restrict generalizability. Nonetheless, the authors should be commended for attempting to add to a body of work aimed at refining, and perhaps, defining, how to make the task of VT ablation less Sisyphean.

Article information

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