Papillary Muscle Arrhythmias
To Freeze or to Burn, That Is the Question

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Technological advances during the past decade have significantly enhanced our ability to successfully map and ablate ventricular arrhythmias in patients with a structurally normal heart, as well as various forms of underlying cardiac disease. Increased recognition of the deleterious effects of ventricular arrhythmias, such as the potential of frequent premature ventricular complexes (PVCs) to induce cardiomyopathy, has increased indications for ablation. Successful outcomes of catheter ablation of ventricular arrhythmias are subject to many potential challenges and reported with variable rates of success.

See Article by Rivera et al

Patient selection for ablation of ventricular arrhythmias should reflect symptom severity, effect of the ventricular arrhythmia on underlying cardiac substrate, effectiveness and side effects of medical therapy, and expected safety and efficacy of ablation. Challenges to a successful ablation include lack of inducibility of the arrhythmia, inability to effectively access the ablation target (ie, intramural or epicardial location), and risk of collateral damage with ablation (ie, the coronary arteries or the conduction system). The papillary muscles create a unique challenge by presenting a target on a mobile and intracavitary structure.

In a recent large-scale multicenter outcomes analysis of ablation of idiopathic PVCs, the significant predictors of procedure failure included number of PVC morphologies and PVC location. Epicardial and papillary muscle sites of origin represented the locations with lowest acute procedural success (67% and 80%, respectively). At follow-up, patients with papillary muscle PVCs had among the highest recurrence rate with only 60% of patients maintaining a successful outcome of 80% reduction in PVC burden without the use of antiarrhythmic drugs.

Obstacles for both acute and long-term results for ablation of ventricular arrhythmias originating from the papillary muscles likely include the intracavitary location of the papillary muscles presenting challenges for both mapping and ablation, the constant motion of a contracting muscular structure in an already contracting chamber, and the variability of papillary muscle anatomy. The use of intracardiac echocardiography can be helpful by providing real-time visualization of the papillary muscles during mapping and ablation procedures. Yet, maintaining catheter contact during ablation at an identified site of origin can remain challenging using irrigated radiofrequency energy, given the constant motion of the muscular papillary apparatus. Furthermore, the thermal and mechanical effects during radiofrequency application often trigger ventricular arrhythmias that can lead to further catheter instability and dislodgement from the target tissue.

In this edition of Circulation: Arrhythmia and Electrophysiology, Rivera et al describe a retrospective case series of 21 patients in whom papillary muscle ventricular arrhythmias were targeted with either cryoablation using an 8-mm cryocatheter or radiofrequency energy using a 4-mm open-irrigated catheter. Anatomic mapping was performed integrating prior multidetector computed tomographic images with real-time intracardiac echocardiographic images onto the St. Jude Medical NavX system. A decapolar catheter was used for activation and pace-mapping to identify the ventricular arrhythmia site of origin. Access for mapping and ablating in the left ventricle was through a transseptal approach for all cryocatheter procedures and either a transseptal or a transaortic approach for radiofrequency procedures.

Acute procedural success was reported in all 12 patients who underwent cryoablation and in 7 of the 9 patients undergoing radiofrequency ablation (100% versus 78%; P=0.08). Catheter stability was significantly greater in patients undergoing cryoablation. Ventricular ectopy with multiple morphologies was seen in 7 of the 9 patients undergoing radiofrequency ablation and in none among those undergoing cryoablation. The lack of ventricular ectopy during cryotherapy was attributed to adherence of the ablation catheter to the target tissue resulting in a lack of catheter motion relative to the contacted surface. Recurrence of ventricular arrhythmias at clinical follow-up was seen in 0% and 33% of patients undergoing cryoablation versus radiofrequency ablation, respectively (P=0.03).

This study presents valuable information as to the potential benefit of cryotherapy in combination with adequate imaging to produce effective results for ablation of papillary muscle–associated ventricular arrhythmias. The study’s claim of superiority of cryoablation to radiofrequency energy, however, must be interpreted with some caution. Among the limitations and confounders of this study are that cases were not prospective or randomized, the sample size was small, patients were sequentially treated with each technology, and each technology was used by separate operators. Furthermore, contact force sensing technology was not used in the radiofrequency group, which undoubtedly affected the ability to ascertain...
consistent contact with the papillary muscle during ablation. Patients in this study also universally presented with a single morphology of ventricular arrhythmia. Often patients with papillary muscle arrhythmias have pleomorphic PVC morphologies with subtle differences from one PVC to another, making activation mapping and pace-mapping challenging and often requiring ablation at multiple sites. This case series presents an ideal patient population where both ablation modalities should perform well. The 100% procedural success rate during ablation with cryotherapy and the lack of any recurrence at a mean follow-up of 360 days, however, warrants recognition for the potential benefits of this technology applied to ablation of papillary muscle arrhythmias.

It needs to be pointed out, however, that the data are limited to patients with idiopathic ventricular arrhythmias. Furthermore, a reduction of the PVC burden of <50% of the original PVC burden was used to define success in the study by Rivera et al, whereas the standard definition of successful PVC ablation is a reduction of ≥80%.5

The primary advantage of cryoablation in this setting would seem to be its ability to ensure constant contact with the mobile papillary muscle facilitated by the adherence of the catheter to the target tissue during ablation. The lack of catheter motion and avoidance of radiofrequency also limits mechanical and thermally induced ectopy, which can impede catheter stability. However, there is concern that cryoablation may not result in permanent lesions, and although there were no recurrences described in the current study, this will need to be assessed using larger patient populations.

A prior publication analyzed factors that resulted in successful outcomes targeting ventricular arrhythmias originating from the papillary muscles.6 Identification of Purkinje potentials at the site of origin correlated with improved outcomes arguing for a more localized and superficial location of the site of origin. This finding is confirmed by the current authors’ earlier publication in JACCCEP, where in the majority of successful ablation sites Purkinje potentials were present. Furthermore, the observation that matching pace-maps were found at successful ablation sites supports the notion that papillary muscle arrhythmias most often originate from the surface of the papillary muscle and not from deeper within the muscle. Another factor previously studied is that papillary muscle mass in patients with successful ablation was smaller than that in patients with failed ablations, suggesting that in some patients deeper seated foci may result in failed ablation procedures.6 Whether deeper sites of origin can be reached with cryoablation as opposed to radiofrequency ablation is debatable.

Overall, the results of this study reveal the benefit of harnessing technological advances to improve efficacy in a specific patient subset where outcomes are less than optimal. Most initial success rates published on ablation of PVCs and nonsustained ventricular tachycardia focused on more readily accessible locations, such as the right ventricular outflow tract. Increasingly, we are recognizing the presence of alternate and often more challenging locations, such as the papillary muscles or epicardium. The 100% success rate with no recurrences reported in this study, albeit in such a small sample and with the caveats mentioned above, merits recognition of the potential of using cryotherapy in conjunction with advanced imaging for ablation of papillary muscle PVCs and should be verified prospectively in a larger patient population.

Disclosures

None.

References


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