Radiofrequency Catheter Ablation
Safety and Practicality

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Although still in its infancy, ablation of accessory pathways using radiofrequency energy delivered through a catheter already has an important history. The technique evolved from the demonstration that accessory pathway potentials could be recorded with standard multipolar electrode catheters. It was only a natural extension of the technique to learn ways to eliminate accessory pathway conduction using some form of controlled destructive energy.

Two forms of energy that have been most commonly used include direct current energy and radiofrequency energy. These two energy forms differ significantly in many respects. The waveform for direct current energy is a monophasic damped sinusoid whereas that for radiofrequency current is continuous as an unmodulated sine wave. The peak voltage achieved with the two techniques differs with 1,000–3,000 V being standard for direct current energy, whereas less than 100 V is the norm for radiofrequency energy. Advantages of radiofrequency energy include the absence of barotrauma or sparking, no need for general anesthesia, and (potentially) a lower risk of arrhythmogensis because of the homogeneous nature of the lesion. Catheter damage is frequent with direct current techniques, but it is very infrequent with radiofrequency techniques. Control of energy delivery is difficult with direct current ablation but more possible with radiofrequency energy. Last, the lesion size is potentially larger using direct current ablation than with radiofrequency ablation, possibly an advantage of the former technique. Limitations of radiofrequency energy delivery include the requirement for a large surface area electrode, impedance rises (due to coagulum formation on the catheter tip) that necessitates removing the catheter from the patient and carefully cleaning the tip, the critical nature of catheter-tissue contact, a smaller area of tissue damage, and limited penetration of scar tissue. The latter is particularly important in patients with coronary artery disease and endocardial scar.

Direct current energy has been shown to effectively eliminate accessory pathway conduction in patients with the Wolff-Parkinson-White syndrome. Fears of the use of direct current energy surround the potential risk of barotrauma or sparking. Therefore, radiofrequency energy has more recently been used as the energy of choice and has been shown to be highly effective in eliminating accessory pathway conduction, in several studies, with a high degree of efficacy and very low risk. However, as with other new techniques in cardiology (i.e., permanent pacemakers, cardiac catheterization, angioplasty), radiofrequency catheter ablation must not only be demonstrated to be practical in the hands of operators possessing different degrees of skill, but also it must be proved safe. This is particularly important in patients with the Wolff-Parkinson-White syndrome, considering that surgical ablative techniques have been perfected and enjoy an efficacy of almost 100% and very low risk. Therefore, the two papers appearing in this issue of Circulation are particularly germane in this regard. Now that we know that radiofrequency catheter ablation techniques can successfully eliminate accessory pathways, other questions emerge: Is it a safe method of ablation? Can we minimize patient risk? Can we make the technique more practical? The papers by Calkins et al. and Kuck et al. shed light on these issues. These papers come from two institutions highly experienced in the technique of radiofrequency catheter ablation.

Calkins et al. carefully evaluated the measured radiation exposure during radiofrequency catheter ablation in 31 patients with the Wolff-Parkinson-White syndrome who underwent radiofrequency catheter ablation procedures. Ablation of accessory pathway conduction was successful in 28 of the 31 patients (90% success rate). The mean duration of fluoroscopy was 44±40 minutes. Radiation exposure was measured using thermoluminescent sensors placed on the patient and physician. The site receiving the largest amount of radiation in the patients was the 9th vertebral body posteriorly. The mean radiation exposure at all other sensor locations was small. The largest radiation exposure to the physician...
was at the operator’s left hand. The amount of radiation detected by the sensors located under the lead apron or under the thyroid shield did not exceed the threshold level of the sensors. Furthermore, the authors make a difficult estimation of the patient radiation risks based on the biological effects of ionizing radiation (BEIR V) report24 based on estimates from studies of atomic bomb survivors and patients radiated for treatment of spondylitis. The estimated risk of a fatal malignancy for the patients measured in their study was 0.7 per 1,000 patients or one per 1,000 patients per hour of fluoroscopy. Their estimates were slightly higher than those estimated for patients undergoing cardiac catheterization or PTCA.25,26 The authors estimate that the number of predicted genetic disorders in their patients, based on absorbed radiation to the gonads, would be five or 20 per 1 million births for male or female patients, respectively. Based on current guidelines, the authors recommend that physicians should perform no more than 15 radiofrequency ablation procedures per month, that fluoroscopy time should be minimized, that coronary angiography should not be performed routinely in these patients, and that pulse fluoroscopy might help reduce radiation exposure.

This is an important study, considering that radiation exposure can be considerable when fluoroscopy time exceeds 1 hour in an individual patient. A few points should be noted. The authors are experienced in the technique of catheter ablation (greater than 75 procedures per physician). One would anticipate that as other physicians learn the technique, fluoroscopy times may initially be considerably longer. Also, a lead shield covered the fluoroscopy tube in their electrophysiology laboratory.22 This is not the case (although it should be) in all electrophysiology laboratories, and radiation exposure may be greater to some physicians. Further, the risk estimates to both the patients and physicians are subject to great error. When dealing with statistical probability, these estimates should not be taken as dogma. Nonetheless, this report should be of some reassurance to physicians performing catheter ablations, and it highlights the importance of minimizing fluoroscopy time and using careful lead protection. Considering the marked cost advantage of catheter ablation over surgical ablative techniques,27 the acceptable radiation risk of catheter ablation adds to its allure. One caveat should be noted: Although it is commonly believed that after 1 hour of fluoroscopy or 4 hours of procedure time the chance of successful ablation is low, this assumption has never been tested.

The report by Kuck et al23 describes a technique that may become more practical as operators gain experience in the technique of catheter ablation. Thirty-four patients with the Wolff-Parkinson-White syndrome and a delta wave pattern from a left free wall accessory pathway underwent radiofrequency catheter ablation. The authors achieved an 88% success rate using a single (ablation catheter only) catheter technique. In the remaining four patients, ablation of the pathway was achieved using a multiple catheter approach. The procedure duration for the single catheter technique was 2.0 ± 1.1 hours and radiation exposure time was 22.8 ± 20.4 minutes.

This study highlights the importance of the experience of the electrophysiologist(s) performing the ablation procedure. In fact, Kuck et al23 admit to a “learning curve” using a single catheter approach. However, even in skilled hands, there are some limitations to this approach. The single catheter technique is applicable for the target accessory pathway when it is clear that the presenting arrhythmia is mediated by an accessory pathway. Induction of reciprocating tachycardia and/or documentation of atrial fibrillation with rapid conduction over an accessory pathway cannot be easily attained with this technique.28 Additionally, there is some risk, as admitted by the authors, that if the accessory pathway cannot be eliminated with the single catheter approach, a multiple catheter approach that may require a central venous puncture in a heparinized patient carries some risk.29 Another limitation is the occasional difficulty in determining whether accessory pathway conduction is eliminated. It has been frequently observed that accessory pathway conduction may occasionally be eliminated in one direction (e.g., anterograde) and not the other direction (e.g., retrograde).2,6 Thus, the delta wave may disappear, for example, but retrograde conduction over the accessory pathway may persist. Careful documentation of the inability to initiate atrioventricular reciprocating tachycardia is important. This may be difficult with a single catheter, and may necessitate introduction of additional catheters, as was done by Kuck et al.33 Further, an increase in the ventriculooatrial interval with ventricular premature beats can be misleading in identifying the route of retrograde conduction (His Purkinje system/AV node versus injured accessory pathway).30 Use of adenosine during ventricular pacing to differentiate the two is also occasionally confusing, especially if the accessory pathway has been injured. Additionally, it is occasionally useful to validate accessory pathway potentials when looking for a good ablation target.1,31 It is often difficult to differentiate an accessory pathway potential from an early ventricular depolarization or fractionated atrial activation. PACing techniques can readily help separate these.1,31 However, there are also some strong arguments in favor of using the ablating catheter to find an accessory pathway insertion site. Slanting of left free wall accessory pathways occurs commonly31 (atrial insertion site more “septal” than the ventricular insertion site). This often makes exact identification of the ventricular insertion site of a left free wall accessory pathway using a coronary sinus catheter difficult. The ablation catheter tip can be more reliable in this regard. Also, accessory pathways located in a lateral, anterolateral, or anterior location on the left side can be difficult to localize with a coronary sinus catheter as recording of ventricular depolarization in these regions sometimes
observes the local atrial deflection. Considering the recognized importance of the ratio of atrial to ventricular deflections described previously\(^\text{32}\) and noted in this report,\(^\text{23}\) recordings from the ablation catheter tip itself are invaluable and often predictive of successful ablation sites.

One therefore wonders how much we might gain by avoiding the diagnostic portion of the study. As documented in the study by Calkins et al.,\(^\text{22}\) the catheter insertion time was 27 minutes and the diagnostic portion of the study took 12 minutes. Thus, the ablation procedure itself usually consumes most of the procedure and fluoroscopy time. This was also the case in the study by Kuck et al.\(^\text{23}\) Last, some patients with atrioventricular reentry may also have AV nodal reentry\(^\text{33}\) that may be eliminated with selective ablation of the “fast” or “slow” AV nodal pathway.\(^\text{34}\) However, in the hands of a highly skilled and experienced electrophysiologist, the single catheter technique shows promise in reducing fluoroscopy time as long as one is aware of its potential risks.

Radiofrequency catheter ablation appears to be here to stay, certainly for elimination of arrhythmias mediated by accessory pathways or those due to AV nodal reentry. Emerging applications for this technique include ablation of idiopathic ventricular tachycardia,\(^\text{35}\) atrial tachycardias, or atrial flutter.\(^\text{36}\) Currently established applications include “therapeutic” AV junction ablation in patients with intractable atrial arrhythmias or atrial fibrillation\(^\text{37}\) or right bundle branch ablation in patients with sustained bundle branch reentry tachycardia.\(^\text{38}\) Catheter ablation for sustained ventricular tachycardia in coronary artery disease patients using radiofrequency techniques has been frustrating and is probably inferior to direct current energy for reasons stated earlier. When one considers that radiofrequency catheter ablation is now growing in popularity and usage worldwide, studies examining its safety and ways to refine the technique, such as the two studies reported this month in Circulation, are timely and welcome.

References


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