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Original Article

The use of adenosine to identify dormant conduction after accessory pathway ablation: a single center experience and literature review

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Abstract: Introduction: Atrio-ventricular reentrant tachycardias (AVRT) represent around 40 percent of supraventricular tachycardias. After ablation, recurrence rates are around 10 percent. Adenosine has been described as a useful tool to assess presence of dormant conduction and predict recurrence after apparently successful ablation. We reviewed the patients of our service and assessed the role of adenosine in predicting dormant conduction and factors that could influence recurrence rates. Methods: We retrospectively reviewed electrophysiologic studies and medical charts of 65 patients who had AVRT ablation and had adenosine used to assess dormant conduction at a single quaternary center between 2011 and 2015. Dormant conduction was defined as transient recovery of the preexcitation (for pathways with antegrade conduction) or return of the retrograde conduction through an apparently successfully ablated concealed accessory pathway (AP). Results: One patient was found to have dormant conduction (1.5%) with early recurrence that was not further ablated due to the difficult location of the AP. The overall recurrence rate was 4.6%. General features like location of AP's, their properties, ablation times and technique were assessed. Conclusion: Similar to its use in identifying other arrhythmias, adenosine may be useful in identifying dormant conduction for further ablation during initial ablation of an accessory pathway; however, the absence of dormant conduction on adenosine testing does not reliably predict non-recurrence. The low recurrence rates in our service may be related to the frequent use of irrigated tip catheters, 3D mapping and long average ablation time over the successful site of ablation.

Keywords: Ablation, accessory pathway, adenosine, arrhythmia, dormant conduction

Introduction

Atrio-ventricular reentrant tachycardia (AVRT) is a common form of supraventricular tachycardia (SVT) with a reported incidence of around 35 cases per 100,000 per year [1]. The most common variant of AVRT uses the atrioventricular node as one of the limbs for the reentrant circuit and an accessory pathway (AP) as the other limb although variants using accessory pathways as antegrade and retrograde limbs have been described [2]. Given that success rates of more than 90% can be achieved with catheter ablation [3-5], it has become the treatment of choice for elimination of APs. Arrhythmia recurrence rates after ablation varies between 5 and 10% in different studies [3-7]. To decrease the rate of recurrence, several strategies have been attempted, including the use of irrigated tip catheters and contact force sensing. Another proposed approach is the use of adenosine after ablation to detect the presence of dormant conduction. This approach has been described in a case report and case series [8, 9]. Here we describe our experience in using adenosine to identify dormant conduction after AP ablation and present a review of the literature.

Adenosine depresses sinoatrial node activity, AV nodal conduction, atrial contractility and ventricular automaticity [10]. It is used as first line therapy for treatment of acute SVTs using the atrioventricular node as part of the circuit with near 100% of termination of these arrhythmias with doses of up to 12 mg. Adenosine's main mechanism of action to stop SVTs is by slowing the conduction in and eventually blocking the AV node [10-12]. Block in the AP is rare and is more commonly seen in decremental APs [13-15]. Adenosine may, in some cases, restore conduction through APs after successful ablation. This strategy of assessing the return of the conduction in areas that had just received an ablation has already been tested in a randomized trial and proven to be very effective after pulmonary veins isolation for atrial fibrillation [16]. The hypothesis is that adenosine injection after a short observation time [17] may identify patients who are likely to develop long-term recurrence of accessory pathway conduction. In turn, lack of dormant conduction after adenosine injection is an adequate surrogate marker for identification of patients unlikely to have recurrence, it may obviate the need for extended periods of observation after apparently successful ablation.

Materials and methods

We retrospectively reviewed electrophysiological studies (EPS) and medical charts of all patients who underwent AVRT ablations and received adenosine to test dormant conduction between 2011 and 2015 at the McGill University Health Centre - Canada. The study was approved by the MUHC Research Ethics Board. Demographic data were collected as well as technical data relating to the intervention. Follow-up information was obtained from medical chart when possible. When data was not available, patients were contacted.

Review of electrophysiology tracings was performed for all patients and information was collected regarding the type of catheter used, approach, use of 3D mapping, duration of ablation, mean duration of observation before administration of adenosine, presence or absence of AV block after adenosine administration, presence of dormant conduction, application of additional ablation lesions and total time of observation. To assess the additional ablation lesions, we determined which one was the successful one during the study review and all following ablations were considered as "extra ablations" over the same site.

Patients with concealed APs were ablated during ventricular pacing or during orthodromic AVRT at the atrial insertion site. When antegrade conduction was present, the site of ablation (atrial *vs* ventricular insertion) was decided based on the safest place (the longest site from the mid septum area in cases of slanted APs) or according to the electrophysiologist preference and convenience. The initial dose of adenosine was 12 mg in the majority of the cases, and it was progressively increased until we had AV block or development of recurrent preexcitation in cases of manifest Wolf-Parkinson-White (WPW). In cases in which AV nodal block could not be achieved even with high doses of adenosine, 2 other parameters were considered as an indication of adenosine effect: 1) prolongation of the cycle length (CL) greater than 10 percent - as also used by Spotnitz *et al.* [18]; 2) AH prolongation - not previously used in other studies but logical if considered that this is one of the effects of adenosine on the conduction system. For all patients we included with prolongation of the AH or CL after adenosine (total of 10 patients), the prolongation was between 50-100% of the prior measurements. After AV block or prolongation of the CL or AH, ventricular pacing was started to assess retrograde conduction through the AV node and possible recurrence of conduction through the AP.

In cases in which the conduction through the APs was restored "only transiently", patients were considered to have dormant conduction. Patients with and without dormant conduction were assessed for recurrence of the AVRT during the first 24 hours of admission and 4 months follow up visit. Patients were usually admitted for 24 hours after the intervention for monitoring. Data was obtained from the notes and ECGs in the medical charts and the electronic medical record. Patients were considered to have recurrence of conduction through the AP if one of the following occurred: reappearance of pre-excitation in any ECGs during admission or follow up visits; SVT was recorded on an ECG or rhythm strip during the 24 h monitoring or hospital visits for palpitations; or the presence of symptoms believed to be related to SVT confirmed by a new EPS.

Results

A total of 65 patients had their EPSs and medical charts retrospectively reviewed for the study. One patient was excluded because adenosine caused no effect in the CL, AH interval or AV or VA block. Characteristics of the APs,

Table 1. Baseline patient characteristics

Age, years	41.3
Male, n (%)	41 (63)
AP localization, n (%)	
Left Lateral	49 (74.2)
Left Posterior	7 (10.6)
Right Posterior	4 (6)
Right Lateral	1 (1.5)
Antero Septal	1 (1.5)
Mid-septal	4 (6)
Antegrade ERP, sec*	300
Retrograde ERP, sec	297
Dual AV nodal physiology, n (%)	12 (18.4)
Decremental AP, n (%)	4 (6.1)
Retrograde aortic Approach (left APs), n (%)	54 (96.4)
Radiofrequency, n (%)	64 (96.9)
Cryo Ablation, n (%)	2 (3)
Irrigated-tip Ablation catheters, n (%)	
Left sided APs	47 (85.4)**
Right sided APs	5 (50)
3D mapping, n (%)	
Left sided APs	17 (30.9)
Right sided APs	5 (50)
Time of extra ablation - mean (SD) in the successful site, sec	137.48 (88.26)
Time until AP blocked during ablation, sec	8.7
Occurrence of AV block with adenosine, n (%)	55 (84.6)
CL or AH prolongation, n (%)	10 (15.3)
Adenosine given during sinus rhythm, n (%)	53 (81.5)
Time of adenosine after successful ablation, min	17
Total observation time, min	31

Obs.: 1 patient had 2 Accessory pathways (2 Left sided AP). *For Antegrade and retrograde ERPs we took the shortest interval between S1-S2 and decremental pacing (with or without isoproterenol). **For 3 patients with left sided APs we could not find if an irrigated catheter was used or not. sec = seconds. n = number, min = minutes.

type of ablation, access, accessory pathway location and other features related to the ablation and adenosine administration are presented in **Table 1**. Only one patient exhibited dormant conduction. This patient had very early recurrence of conduction through the AP but did not undergo further ablation due to the sensitive location of the AP. In patients without dormant conduction, the recurrence rate was very low at three percent. Both cases of recurrence occurred late and were due to a concealed AP.

Catheters with 3.5 mm and irrigated tips were used in the majority (80%) of both left and right-sided APs (total of 51 patients). The non-irrigated catheters had 4 mm-tips and were used in the minority of cases. The ablations were performed in temperature control mode (maximum temperature 41.8°C and average temperature 38.8°C) and with power programmed to 30-35 W (average 31.4 W and max energy 39 W) in most of the cases. Three-dimensional mapping was used in 34% of the procedures. The access for the left sided APs was retrograde through the aortic valve in almost all the cases (54 of 55), with the trans-septal approach reserved for one case of recurrence. The average time spent at the successful site of ablation was 52.8 seconds, with average time until the abolition of the AP during ablation of 8.7 seconds. The total in seconds of extra ablations after successful ablation was 188 seconds; mean (SD) was 137.48 (88.26) seconds.

In our review of 65 patients we found only one case of dormant conduction, in which adenosine use predicted recurrence. The patient had a mid-septal AP with only antegrade conduction. He was ablated with Cryo energy, and with administration of adenosine he had recurrence of the pre-excitation for 14 beats (**Figure 1**). It was decided not to perform more ablations due to high-risk location of the AP. He had recurrence of AVRT in the first 24 hours after ablation. In another case adenosine was given 1 minute and 30 seconds after the successful ablation and failed to predict dormant conduction given that the AVRT recurred 16 minutes after. In this case, adenosine may have given too early.

Discussion

The current study demonstrated a very low rate of recurrence after accessory pathway abla-

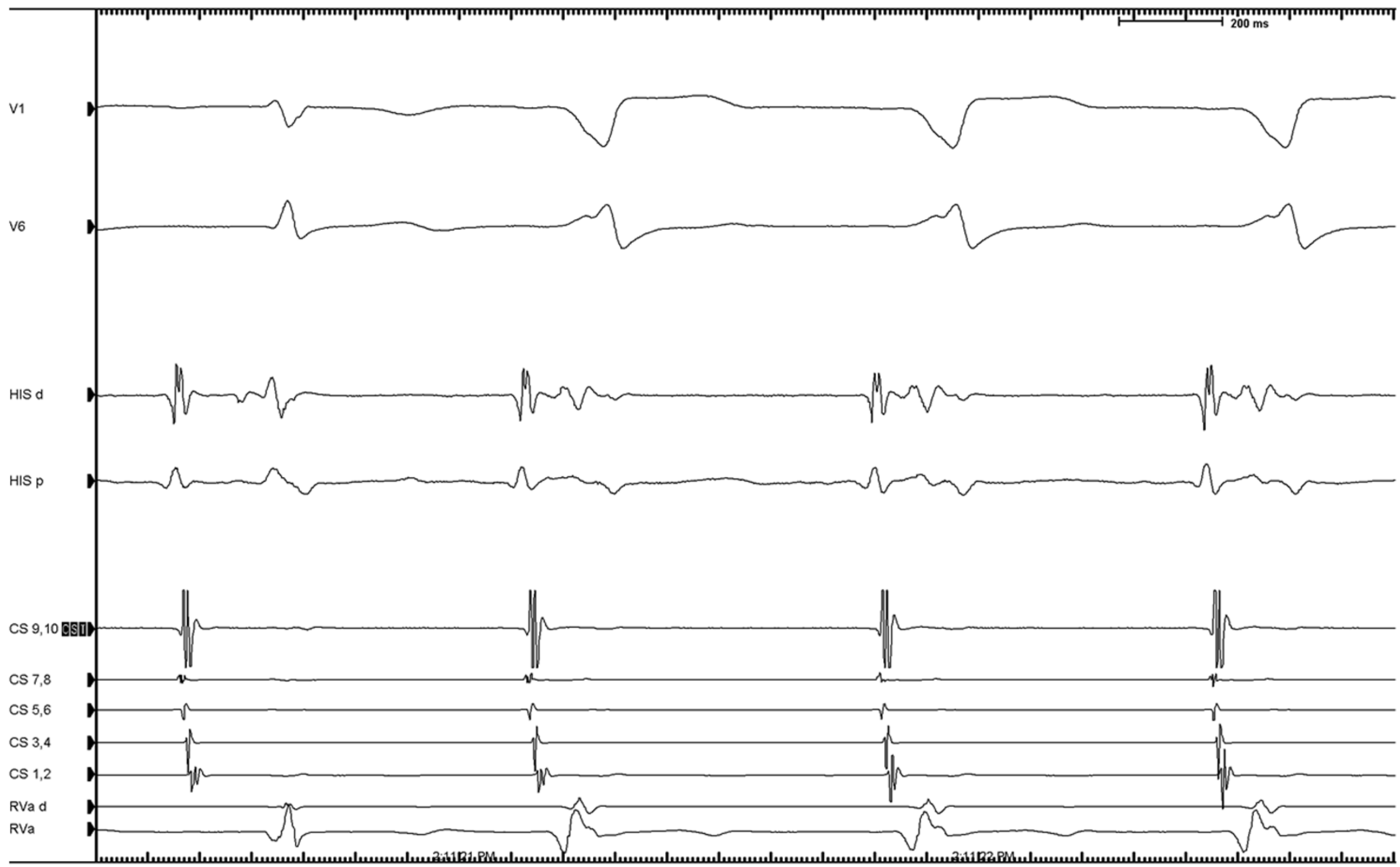

Figure 1. Effect of adenosine restoring transiently the antegrade conduction after ablation (recovery of pre-excitation after the second beat) in a patient with mid-septal AP.

tion. Therefore, the utility of adenosine to assess dormant conduction was limited. The role of adenosine may be better appreciated in patients with higher risk pathways in which a typical ablation approach could not be performed or centers with that observe a higher risk of recurrence. Recurrence of conduction through APs after ablation occurs in 5% to 12% of the cases [5, 7, 19, 20]. Adenosine has been used to assess dormant conduction for at least 28 years. Dormant conduction has been found after successful ablation in 8% to 12% of the cases. The same studies suggested that extra ablations in the same site after dormant conduction could reduce the recurrence rates of AVRT [17, 18, 21]. Adenosine use leads to a significant increase in open acetyl choline-sensitive potassium channels in the atrium which shortens the refractory period which results in an improvement of conduction [22].

Irrigated tip ablation catheters allow delivery of higher power when there is temperature limitation due to areas of low blood flow and also decrease the chance of clot formations at the catheter tip. We used irrigated tip catheters for 80% of all the right and left-sided ablations. The use of 3D mapping in a third of the cases in our study allowed the recording of the successful site of ablation and with that the delivery of further ablations at that precise location. Therefore, we cannot exclude that the frequent use of an irrigated tip catheter and 3D mapping led to a low recurrence rate.

The administration of radiofrequency for long periods at the successful site in our study - with an average of 188 seconds - mean (SD) of 137.48 (88.26) seconds - may also have contributed to this result. Other studies in general presented information such as: how long was the total ablation time during the procedure; for how long an ablation should be kept over the same site if no elimination of the AP occurred; and how long the ablation that resulted in elimination of the AP conduction lasted. They do not mention, however, if extra ablations were performed at the successful site after the AP was eliminated to assure that the conduction would not recur. And in case they had been performed, how long these ablations lasted [23-25]. For the "extra ablations", we performed a maximum of "1-minute ablations" each time in order to avoid occurrence of "pops" or other complications (no complications were observed).

Limitations

Several limitations were present due to the retrospective design of our study. This study may have been underpowered to detect a difference with the use of adenosine. After the successful ablation, further ablation was presumably performed at the same site, however we cannot exclude that the catheter may have moved, and the following ablations were only "near" the successful site. The small percentage of recurrence found in our review makes the comparison between cases with and without dormant conduction not statistically significant. As we had only one patient with dormant conduction , who did not receive extra ablations after dormant conduction was found, we cannot affirm that these ablations could reduce further recurrence as already suggested by *Spotnitz et al.* [18]. In our study, adenosine was not administered prior to ablation, therefore adenosine-sensitive APs could not be identified. This increases the chance of false negative dormant conduction. The low recurrence rates after ablation suggest that the chance that an AP that could contribute to AVRT was missed is low. In contrast to the findings of *Miyata et al.* [11], the presence of dual AV nodal physiology did not prevent occurrence of AV block with adenosine; we had 12 patients (18%) with both dual AV nodal physiology and AP, among those, 75% had AV block with the initial dose of adenosine and 100% with two doses.

Conclusion

Adenosine predicted recurrence of conduction through an ablated AP in the one case in which dormant conduction was found. However, the absence of dormant conduction does not reliably exclude recurrence. The low recurrence rates after AP ablation in our service could be explained by the frequent use of 3D mapping, irrigated-tip ablation catheters and prolonged ablation time (extra ablations) over the successful site.

Acknowledgements

The study was approved by the Medical Research Ethics Committee of the McGill University Health Center Ethics Board. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or nation-

al research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Data was obtained from electronic medical records retrospectively after ethics committee approval. No direct patient contact including consent took place.

Disclosure of conflict of interest

None.

Abbreviations

AVRT, Atrio-ventricular reentrant tachycardia; SVT, supraventricular tachycardia; AP, accessory pathway; EPS, electrophysiological studies; WPW, Wolf-Parkinson-White; CL, cycle length.

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