Catheter Radiofrequency Ablation of Recurrent Para-Hisian Accessary Pathways with Near Zero X-ray Exposure

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Abstract

Introduction Radiofrequency (RF) ablation of parahisian accessory pathways (PHAPs) is a serious challenge, which is associated with high recurrence and fluoroscopy exposure. According to previous studies and case reports, catheter ablation of PHAPs is associated with a high post-ablation recurrence. The aim of this study is to assess the efficacy, safety and long-term outcome of radiofrequency ablation in patients with recurrent PHAPs after prior ablations with zero or extremely low fluoroscopy. Methods and Results A total of 58 patients (43 male, 75.4%) with PHAPs that had one or more previously unsuccessful RF ablations were enrolled. RF ablation procedures were performed under a three-dimensional guiding system (EnSite NavX, St. Jude Medical, MN) with extremely low exposure of fluoroscopy to femoral venous or arterial routes. The acute success rate was 96.6% (56/58). Two procedures were terminated during ablation because of high risk of complete AVB. In addition to a case of transient complete AVB during RF energy delivery, no minor or major complications were recorded during the procedure or long-term follow up. The mean fluoroscopy time was 98 seconds (0-129), and the mean radiation dose was 1.98 mGy (0-3.38) in all 58 cases. Fourteen patients underwent the EPS and RF ablation with zero X-ray exposure. The long-term success rate was 98.2% with a median follow-up period of 30 (12-45) months. Conclusions With a near zero X-ray exposure, RF ablation of recurrent PHAPs can be performed with a high acute success rate and convincing safety during long-term follow-up.

Abbreviation:

SVT = supraventricular tachycardia; RF = radiofrequency; PHAP = parahisian accessory pathway; AVRT = atrioventricular reciprocating tachycardia

1. Introduction

Catheter ablation has been a revolutionary treatment of parahisian accessory pathways (PHAP), [1-4] which can be challenging due to the anatomical proximity to the normal atrioventricular conducting system. [5] In addition, radiofrequency ablation of PHAPs can induce complications such as coronary artery injury and complete atrioventricular block.[5-8] Low-power RF or cryotherapy ablation may lead to a lower incidence of atrioventricular conducting tissue injury and complete atrioventricular block but also a lower acute success rate and a higher rate of recurrence. There are no studies that have investigated RF ablation of recurrent PHAPs with one or more former failed ablations in a relatively large sample of patients and RF ablation of PHAPs with zero or near zero X-ray remains not well known. [9 -11] Using a three-dimensional guiding system (EnSite NavX, St. Jude Medical, MN), we performed RF ablation in patients with recurrent PHAPs with zero or extremely low fluoroscopy over more than 6 years with a high acute success rate. The aim of this study is to assess the efficacy, safety and long-term outcomes of radiofrequency ablation in patients with recurrent PHAPs with near-zero X ray exposure.

2. Methods

2.1. Study population

A total of 58 patients with recurrent atrioventricular reciprocating tachycardia (AVRT) or preexcitation due to PHAPs were continuously enrolled in Fuwai Hospital between February 2015 and January 2020. Every patient had participated in one or more previous electrophysiology studies and RF ablations at one of 25 different centers in China. The inclusion criteria were recurrent AVRT due to an manifest or concealed PHAP and asymptomatic WPW with high-risk criteria or inducible AVRT. The demographic and clinical data included the patient's age, gender, ethnicity, height, weight, and clinical manifestations. These were collected before the electrophysiological procedure.

This study was approved by the Institutional Ethics Committee for Biomedical Research of Fuwai Hospital. Written informed consent was obtained from all the patients. The data that support the findings of this study are available from the corresponding author on reasonable request.

2.2. Electrophysiological Study

Anti-arrhythmic medications were discontinued at least 5 half-lives before the electrophysiological study (EPS). All procedures were performed under conscious sedation (intravenous administration of midazolam). Under the guidance of the three-dimensional mapping system (EnSite NavX, St. Jude Medical, MN), a decapolar electrode catheter was positioned in the coronary sinus and a quadri-polar electrode catheter was placed in the right ventricular apex via the right femoral vein. Fluoroscopy was applied to guide electrode catheter positioning in the cases of vascular tortuosity and anatomic abnormalities. Intracardiac electrocardiograms were recorded simultaneously with electrocardiographic leads I, aVF, and V1 using a multichannel recording system at a paper speed of 100 mm/s (Bard Electrophysiology, Lowell, MA, USA). The three-dimensional electro-anatomical mapping was used to determine the anatomical and electrical landmarks and to reduce fluoroscopy time. All patients underwent EPS by two senior physicians (Dr. Feng Hu and Gang Chen). This included single, double and burst atrial or ventricular extra stimuli at standard variable drive-paced cycle lengths, both with and without an isoproterenol infusion, as was required for arrhythmia induction.

2.3. Definition

PHAPs were defined as being both anatomically located in the apical third of the triangle of Koch and having a His-bundle signal recording at the ablation site. If there was no His deflection during or at the end of the ablation, the APs were considered as antero-septal APs and were not included as PHAPs in this study. Procedure time was defined as the interval from the initiation of femoral puncture to extraction of the femoral venous sheaths at the end of the procedure. Fluoroscopy time was defined as the total duration of fluoroscopy during the whole interventional procedure. The radiation dose was the calculated dose of the catheter lab, which was measured in mGy.

2.4. Radiofrequency Ablation

Mapping and ablation of PHAPs were guided by the three-dimensional mapping system (EnSite NavX, St. Jude Medical, MN). A 4-mm-tip temperature controlled bidirectional ablation catheter (Safire, St. Jude Medical, MN) with with support of a Swartz sheathwith support of a Swartz sheathan upper power limit of 40 W and maximum temperature of 55°C was introduced into the right atrium via the femoral vein approach or noncoronary cusp via the femoral artery approach. To enhance the stability of catheter at parahisian site, we used a Swartz sheath (St. Jude Medical, MN)to support the bidirectional ablation catheter. Surface ECG and intracardial ECG were recorded by a multichannel recorder (Bard Electro-physiology, Lowell, MA, USA) throughout the whole procedure. Sites of AV fusion or early atrial/ventricular activation were identified as ideal targets. Initial radiofrequency application at the parahisian site was initiated at 10 W and titrated up to 20-40 W (depending on the anatomic location, the response of AP, atrioventricular nodal conduction, and the appearance of junctional rhythm). If the initial ablation at the parahisian site was unsuccessful, mapping and ablation of PHAPs at the site of the noncoronary sinus would be performed. If detrimental effects on AV conduction were observed or if the AP conduction was not blocked after 10-30 seconds at 30 W, the RF ablation was terminated and the catheter was repositioned. The end points of ablation were loss of preexcitation after a bolus injection of adenosine and/or atrioventricular dissociation under RVA burst stimulation. After ablation, if ventriculoatrial conduction was still present, parahisian pacing was used to exclude retrograde conduction over an AP. After a successful ablation, patients were observed in the catheter lab for 30 min. Various atrial and ventricular programmed stimulations were performed to check for the completeness of the procedure after 30 min of observation.

2.5. Clinical Follow-up

The follow-up consisted of a clinical visit every 3-6 months in the first year after RF ablation, followed by outpatient clinical visits every 12 months starting from the second year. Spontaneous recurrence of documented SVT and pre-excitation on electrocardiogram were carefully recorded.

2.6. Statistics

Statistical analysis was performed using the IBM SPSS version 22.0. All data were reported as median and quartile range or mean ± standard deviation for continuous variables and frequency for categorical variables. Normality of the distribution was tested by the Kolmogorov–Smirnov test. Independent-samples T tests and the Mann–Whitney nonparametric test were used as needed for continuous variables. Comparisons of categorical data were performed using a chi-square test (Fisher's exact test for cell counts <5). Recurrence event proportions were calculated by using the Kaplan-Meier method. Multivariate Cox proportional hazards models were used to evaluate the associations between age, gender, number and duration of RF ablations, number of prior ablations and manifest/concealed APs and the recurrence rate. P value <0.05 was considered significant.

3. Results

Baseline and electrophysiological data

All 58 patients (43 male,75.4%) with PHAPs underwent EPS and RF ablation via the right femoral venous approach, while six underwent additional ablation at the noncoronary cusp (NCC) via the right femoral arterial approach. All but two patients had a structurally normal heart: two were affected by congenital heart disease (one Ebstein's anomaly and the other transposition of great arteries) previously surgically corrected. The median age was 27 (17-40) years, and the median time since the most recent ablations was 33 (5-46) months. Normal antegrade conduction of the atrioventrtricular node (AVN) was confirmed in all 58 patients before RF ablation to exclude overlooked AVN injury from the previous ablation. Nine patients had two accessory pathways (5 right lateral manifest APs at 7-9 o, clock of tricuspid annulus, 2 right posteroseptal manifest APs, 2 left posteroseptal concealed APs). Among all 58 patients, 46 (79.3%) had documented orthodromic AVRT, and 26 had preexcitation at epicopreal ECG. Concomitant atrial fibrillation was documented in 3 patients. No antidromic AVRT or atrioventricular nodal reentry tachycardia were induced during EP tests. The mean antegrade effective refractory period of 26 manifest APs was 245±13 msec. For previous ablations, patients <14 years of age showed a lower acute success rate compared with those [?]14years (57.1% versus 90.2%,P=0.017). All of patients received RF ablation more than 3 months after the previous procedures. The EPS and ablation data of previous ablation were listed in table 1.

Acute results

Fifty-six (96.6%) of the 58 patients underwent successful RF ablation. Two procedures were terminated after the first failed therapy without perfect targets at either the parahisian regions or NCC. Among the 56 successful procedures, 54 were performed at the parahisian regions, and the other 2 procedures were performed at the NCC regions. The mean procedure time was 36 (20 to 120) min. The median maximal RF power was 20 (17-30) W, and the median time of energy delivery was 40 (30-60) seconds. Transient mechanically induced AV prolongations were recorded in 5 patients, and ablation-induced transient AVB was noted in 4 patients(3 cases of 1st degree and 1 case of complete AVB). During RF ablation, junctional rhythms were noted in 10 patients, and one case of post-procedure complete right bundle block was recorded. Except for one case of transient complete atrioventricular block during energy delivery, no minor or major complications were noted during the peri-procedure period.

According to concealed or manifest PHAPs, we divided the 58 patients into 2groups. The baseline characteristics and RF ablation data of patients were listed in Table 1.

Fluoroscopy time

The mean fluoroscopy time of the 58 patients was 98 (0-129) seconds, while the mean radiation dose was 1.98 (0-3.38) mGy. Moreover, 14 patients underwent the EPS and RF ablation with zero X-ray exposure; in these patients, the placement of electrode catheters in the coronary sinus and right ventricular apex, as well as the position of ablation catheters, was guided completely under the three-dimensional mapping system. Fluoroscopy was necessary in 44 patients (75.9%) because of difficult venous access (n=16), difficult CS electrode introduction (n=12), need to check ablation catheter stability during radiofrequency delivery (n=8), need for Swartz sheath introduction to enhance catheter stability (n=8), and need to check guide wires (n=2). The fluoroscopy time was significantly different between group A and group B(P=0.04).

Long-time follow up

One patient presented SVT recurrence of concealed PHAP at a 5-month follow-up, while the other 55 patients with acute ablation success remained asymptomatic without SVT attack, pre-excitation on ECG or documented arrhythmias with a mean follow-up period of 30 (12-45) months. The outcome of the 58 patients is summarized in Figure 4. Kaplan-Meier curves comparing the outcomes of the different subgroups are shown in Figure 5 and 6. According to Cox regression analysis, the long-term success rate was not statistically as sociated with age (P=0.889) , gender (P=0.386) , manifest/concealed APs (P=0.183) , procedure time (P=0.928) , or maximal ablation power (P=0.827) .

Discussion

In this study, we report our experience with radiofrequency ablation of recurrent PHAPs with zero or near-zero fluorocopy.

Our major findings include:

1. The majority of recurrent PHAPs can be successfully treated with a bidirectional ablation catheter via a femoral venous or arterial approach.

2. RF ablation of recurrent PHAPs showed a high acute success rate of 96.6% and low recurrence over long-term follow-up with a mean of 30 (12-45) months.

3. Complete 3-dimensional system-guided EPS and RF ablation minimized the fluoroscopy to a near-zero level.

4. Three-dimensional system-guided RF ablation of recurrent PHAPs was safe and effective in patients with prior failures.

Accessory pathways located at parahisian regions, accounting for 1.4% of all APs, are quite rare. Catheter ablation of PHAPs has an acute success rate of 85.1%-94%, [9-10] which may explain the limited data about recurrent PHAPs from previous ablation therapies. Mandapati et al [13] reported that RF ablation could not be performed in 17% of patients with anteroseptal APs and in 15% of patients with mid-septal APs due to the high risk of AV block. Frederic Sacher et al [16] reported that one-third of the failures of ablation of APs were due to AP location (parahisian, epicardial region), multiple pathways, multiple insertions or structural heart disease (e.g., congenital heart disease); therefore, RF ablation remains a greater challenge in recurrent APs than in other modalities of APs. A large case series reported by Sacher F et al. [9] showed that previous failure of parahisian and mid-septal accessory pathways (n = 11), with a low acute success rate of 27.3% (3/11) in their study, was due to a lack of catheter stability, concern about the anatomical proximity of the APs to the atrioventricular (AV) node and the risk of subsequent conduction block. The major challenges during the ablation of PHAP are its proximity to AV conducting tissue and the catheter instability. [14,16] Without good catheter stability, precise localization, or minimal mechanical movement during RF ablation, the chance of damaging the His bundle is high. [13-16] In a previous study, Jackman et al. [1] reported that via the femoral venous approach, the catheter may not be stable; therefore, coaxial and contact force may not be good. Nevertheless, better catheter stability and higher acute success rate can be achieved via a superior or jugular approach with certain safety and efficacy. [17-18] In this study, we found that a bidirectional ablation catheter (Safire, St. Jude Medical, MN) with support of a Swartz sheath can ensure excellent catheter stability and precise localization at the RF ablation targets of PHAPs via a femoral venous or arterial approach in all patients with no minor or major complications. Liang M et al. [18] reported 55 consecutive patients with PHAPs, most of whom (52/54, 94%) underwent successful RF ablations via femoral venous (inferior vena cava) or arterial (NCC) approaches. In the present study, we reported an acute success rate of 96.6% (56/58) for recurrent PHAPs ablation via femoral route with no sustained AV block or other complications. However, we did not complete ablations in 2 patients due to the high risk of AV block. For long-term follow-up of PHAP ablation, Josep Brugada et al. [15] reported four recurrent APs from 88 initially successful ablations of in anteroseptal, parahisian and midseptal APs, with a mean follow-up of 27+-14 months. Swissa M et al.[19] reported that 55 children with cryoablation of PHAPs presented with a recurrence rate of 14.9% and a long-term success rate of 94% at a mean follow-up of 51.1+-25.9 months. Drago F et al. reported a 25.7% (9/35) chance of recurrence in cryoablation of anteroseptal and PHAPs with a mean follow-up of 18.6+-6.6 (3–111) months and emphasized that if recurrence does not occur during the earlier follow-ups, then the risk of recurrence in the long-term follow-up is very low [20]. In our series, we reported one early recurrence with SVT attack 5 months after the procedure but a long-term success rate of 94.8% with a mean follow-up of 30 (12-45) months. According to a previous study [19], increasing physician's experience is the main contributor to reducing the recurrence rate, rather than the number or duration of cryoablations. Moreover, in our series, the high acute success rate (96.6%) and low recurrence (1/56,1.8%) could be attributed to the RF ablation procedures being performed by the same experienced physician throughout the study.

Fluoroscopically guided radiofrequency catheter ablation (RFCA) provides a definitive treatment of supraventricular and ventricular tachycardias and is widely performed in clinical practice. However, a significant disadvantage of fluoroscopy is the risk of radiation damage, which can be described in terms of stochastic and deterministic effects. [22,23] Even low doses appear to be potentially harmful, particularly in women, children, and young adults. Different studies have confirmed the safety, feasibility, and efficacy of the non-fluoroscopic 3-dimensional mapping system as an exclusive or partially exclusive guide in ablation procedures of a broad spectrum of tachyarrhythmias. [25-30] In 2002, Drago F et al. [25]reported the first 9 cases of zero-fluoroscopy ablation completely guided by a Carto mapping system and a mean fluoroscopy time of 9.2+-7.7 (0.3-20) minutes in another 12 patients with right-sided APs. In 2017, Giaccardi M et al. [28]reported 297 consecutive RF ablations, including 26 cases of non-fluoroscopic ablation, with a mean fluoroscopy time of 14+-6 seconds. The study indicated noninferiority of the near-zero fluoroscopic approach versus the traditional fluoroscopy-guided procedures in terms of clinical outcomes, as well as superiority in terms of the dramatic reduction in fluoroscopy exposure. Nevertheless, studies or case reports of RF ablation for PHAPs with zero/near zero fluoroscopy are extremely rare due to the complexity of mapping at the parahisian region and the risk of atrioventricular block.[25,28] A mean fluoroscopy time of 23-28.5 minutes was reported in previous studies of RF or cryoablation of PHAPs guided under the traditional fluoroscopy technique. [9,19-21] In 2016, the NO-PARTY study [29] reported 134 SVT patients who underwent RF ablation with near zero fluoroscopy including 10 cases of right APs, while we cannot assure if PHAPs were enrolled or not. Using Carto 3 mapping system, Scaglione M. et al. [30] reported successful RF or cryoablations in 44 cases of accessory pathways with zero X-ray exposure, including 5 cases of PHAPs. To the best of our knowledge, this is the largest series of PHAPs ablation performed with near zero X-ray exposure.

The EnSite NavX mapping system used in this study is able to navigate the electrodes at any time from the moment that it is inserted in the sheath and allows an accurate reconstruction of the geometry of both vessels and heart chambers. As a result, after defining the anatomic contours, the mapping is facilitated even in complexity and risk of procedures at parahisian region or coronary cusps. In our study, a mean fluoroscopy time of 98 (0-129) seconds and mean radiation dose of 1.98 (0-3.38) mGy were recorded, with 14 (14/58, 24.1%) cases of zero-fluoroscopy procedures. A high acute success rate of 96.6% and low recurrence of 1.8% at long-term follow-up were achieved with this zero/near zero X-ray procedure.

Study limitations

The procedure data of prior EPS and ablation procedure of most patients could not be gathered or accessed. All of the patients underwent EPS and ablation via femoral venous or arterial approach, and jugular or subclavian approach were not attempted in 2 cases of unsuccessful procedure. In addition, no traditional fluoroscopy-guided ablations were included as a control group to compare with the zero/near-zero fluoroscopy group in this study.

Conclusions

In conclusion, our results show that RF ablation is an effective and safe procedure for recurrent PHAPs. Moreover, the 3-dimensional mapping system-guided EPS and RF ablation can minimize the fluoroscopy time and X-ray exposure to a near-zero level.

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Figure Legend

Figure 1 Approach of electrode catheter positioning in coronary sinus and right ventricle with no X-ray

Figure 2 Antegrade block of a manifest PHAP with a power application of 40 watts

Figure 3 Retrograde block of a concealed PHAP with a power application of 28 watts

Figure 4 Transient complete atrioventricular block during ablation in noncoronary cusp

Figure 5 Kaplan-Meier of the probability of postablation recurrence of PHAPs. Comparison of the manifest PHAPs with the concealed PHAPs

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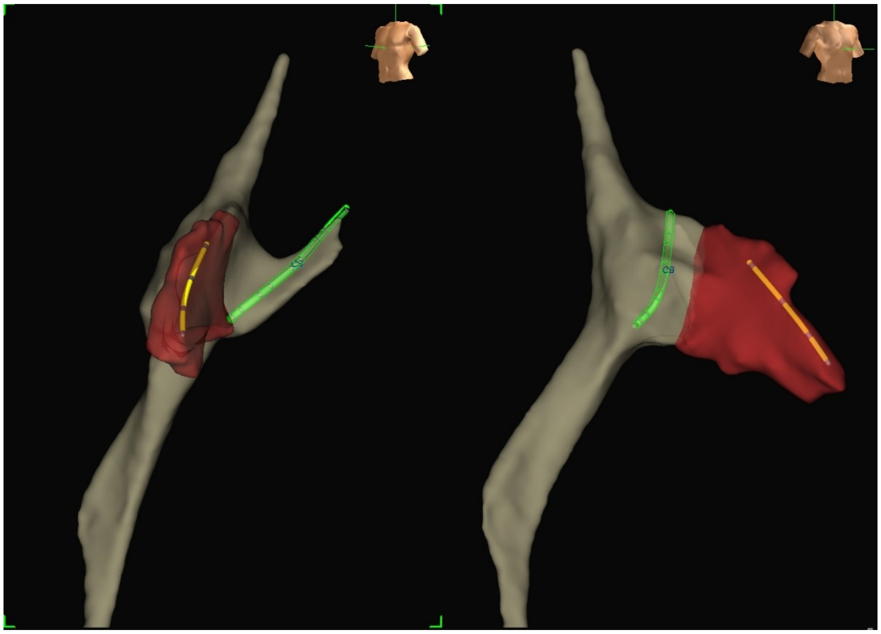
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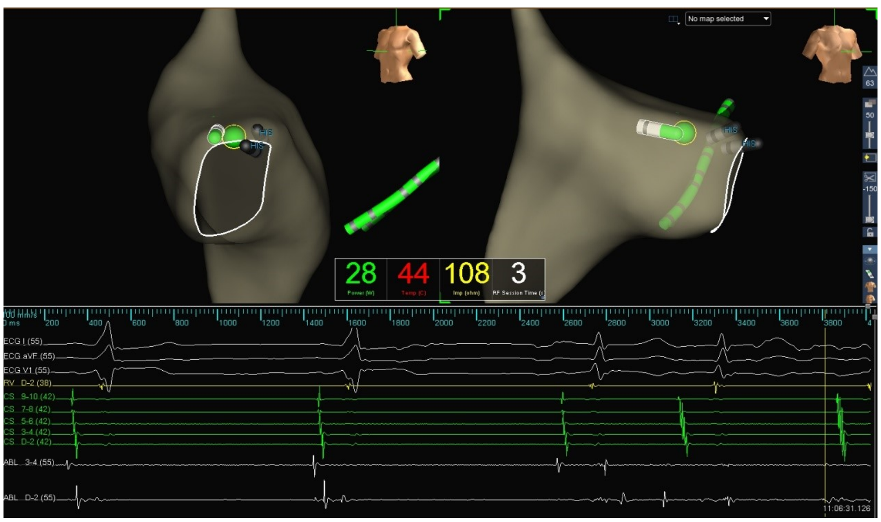
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