# Sequential Supra-to-subvalvular Approach for Ablation of Right Anterolateral Accessory Pathway

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## Abstract

*Background* Ablation of accessory pathway from the region of anterolateral tricuspid annulus remains the most challenging although multiple approaches have been introduced. *Objective* To evaluate the feasibility of a sequential supra-to-subvalvular approach for mapping and ablation of right anterolateral accessory pathway. *Methods* Cases of right anterolateral accessory pathway ablation were reviewed and divided into group A (conventional approach) and B (sequential approach) for comparison. In group B, mapping and initial radiofrequency delivery was performed in the right atrium along tricuspid annulus, with the target marked on the 3D map. Radiofrequency was subsequently applied at the target from the right ventricle with a reversed catheter curve. Procedural and follow-up data were collected from the patients. *Results* Overall success was achieved in all patients in group B and 13/15 cases in group A. Compared to conventional approach, cases completed with sequential approach had a significantly shorter procedure time (124.5±13.4min vs. 152.1±36.0min, p=0.030) and mapping and ablation time (57.2±16.3min vs. 92.1±40.1min, p=0.016). Radiofrequency time was also shorter in group B but without statistical difference (536.9±161.0 sec vs. 650.7±321.9 sec, p=0.313). *Conclusion* The sequential approach can be feasible in routine ablation of right anterolateral pathway by improving efficiency during mapping and catheter stability during radiofrequency application.

## Introduction

Radiofrequency (RF) has been the first-line therapy for supraventricular tachycardia mediated by atrioventricular accessory pathway (AP)[1,2]. Nonetheless, right anterolateral APs (RAL-APs) were among the most challenging cases for electrophysiologists, which are least successfully treated by ablation procedures[2-4]. Anatomical complexity increases difficulties in ablation of pathways from this region mainly by influencing catheter stability[2-5].

Several alternative strategies have been attempted in right-sided APs e.g., superior vena cava approach[5], epicardial ablation[6], mapping with right atrial multielectrode catheter placed in the right atrium[7] or right coronary artery[8] for better outcome. Subvalvular approach was recently described as an effective approach showing superiority in complex cases by increasing catheter stability during RF delivery[9,10]. However, the under-valve catheter manipulation is more complicated in the area of anterior tricuspid annulus (TA), with higher difficulty in interpretation of electrograms, which limited detailed target mapping. To improve the feasibility, we have employed a sequential supra-to-subvalvular approach for RAL-APs with 3-dimensional (3D) mapping system.

Methods

*Study Design and Population*

From 254 AP ablation procedures using 3D mapping system in our center between 2018 and 2022, 25 cases (9.8%) in 23 patients were RAL-APs (Figure 1). Conventional approach was used in 15 procedures (group

A). A sequential supra-to-subvalvular approach was employed in 10 consecutive patients since 2020, who were classified into group B. RAL-APs were defined as APs locating at anterior free wall of TA (between 9-12 o'clock site on a 3D map). Additionally, the AP should be responsible for tachycardia e.g., orthodromic atrioventricular reentrant tachycardia (AVRT), antidromic AVRT, or preexcited atrial fibrillation. The procedural outcome, total procedure (skin to skin) time, mapping and ablation time (counted from beginning of mapping with ablation catheter to the end of last RF), fluoroscopy time and overall radiofrequency time were compared. The study was approved by the institutional review board of Huashan Hospital Fudan University (Approval No. KY2019-552).

*EP Study*

After informed consent, the procedures was conducted under conscious sedation. Antiarrhythmic agents had been discontinued for at least 5 have-lives. A decapolar catheter was placed in coronary sinus via left femoral vein or right jugular vein. 2 quadripolar catheters were inserted from right femoral vein, one for His bundle recording while the other positioned at right ventricular (RV) apex or right atrium.

Intracardiac electrograms were recorded (filtered 30–500Hz for bipolar and 0.05-500Hz for unipolar signals) using LabSystem Pro electrophysiology system (Boston Scientific, Boston, MA, USA) or Lead EP system (Jinjiang Electronic, Chengdu, Sichuan province, China). Diagnostic pacing was performed to confirm the conduction property of the APs. Tachycardia induction was attempted in each case to ensure the APs as substrate for clinical tachycardia. Necessary differential diagnostic maneuvers including sensed extrastimulus, overdrive pacing etc., were attempted during tachycardia to help appreciate the mechanism.

*Mapping and Ablation*

3D mapping system (CARTO3, Biosense Webster Inc, Irvine, CA, USA) was used in all cases. In group A, mapping and ablation was performed in the right atrium with an 8-French, irrigated-tip ablation catheter (Smarttouch or Thermocool, Biosense Webster Inc, Irvine, CA, USA), supported by a long sheath with fixed curve (SR-0 or SL-1, St. Jude Medical, St. Paul, MN, USA) or steerable curve (Mobicath or Vizigo, Biosense Webster Inc, Irvine, CA, USA). The location of AP was confirmed by the earliest atrial activation, or ventricular activation site, or pathway potential according to the conduction property. After verification of the potential target, RF was applied with the initial power setting of 30 to 35 watts and irrigation rate of 17ml/min. The power was adjusted to achieve an impedance drop of 10 to15 ohms. Once AP conduction was blocked in 10 seconds, RF was continued for 60 to 90 seconds if the catheter remained stable. Otherwise, RF was cut off and better electrograms are searched. After the first successful RF, a minimum of 3 to 5 lesions were created at the region for consolidation. A post-ablation waiting period of 20 to 30 minutes was given in each case, pacing and the use of adenosine triphosphate were helpful to verify AP block. In group B, careful target mapping was also performed in the right atrium along the annulus, followed by initial RF as in group A. If AP conduction could be blocked within 10 seconds, the site was marked with a tag on the 3D map, and RF was also maintained for 60 to 90 seconds if possible. After the first effective RF, the catheter was directly advanced into RV and positioned under the anterior tricuspid valve using a reversed-S curve with the help of the long sheath, directed at the tag from the ventricle (see graphical abstract). 3 to 5 lesions were applied at this region with the power and time comparable to group A. The rhythm e.g., sinus or RV pacing should not be altered during subvalvular ablation. The impedance change was also carefully monitored. Thereafter, extra supravalvular lesion could be given at the operators' discretion. An observation period with adenosine challenge was also provided. Intracardiac echocardiography (ICE) can be used when necessary.

*Follow-up*

Patients were discharged on aspirin 100mg per day for 1 month after ablation and observed in outpatient clinical at the 3$^{rd}$ and 6$^{th}$ month, followed by yearly telephone visit. Electrocardiography was performed in each patient. Extra visits and Holter monitoring were required in symptomatic patients.

*Statistics*

Clinical variables were expressed as a mean with standard deviation for continuous variables, median with interquartile rate for discontinuous variables, and percentage (%) for categorical variables. Characteristics between groups were tested using the unpaired Student t-test for continuous variables and chi-square test or Fisher's exact for categorical variables. A two-tailed p-value of $<0.05$ indicated statistical significance. Statistical analysis was performed using STATA 17.0 software.

## Results

*Baseline Characteristics*

The baseline characteristics and procedural data of all patients are listed in Supplementary Table 1. Comparison of baseline data between the 2 groups were shown in Table 1. The age and gender did not differ significantly (P>0.05).

*EP findings*

8 cases in group A and 8 in group B had manifest preexcitation during sinus rhythm. 2 APs in group B were unidirectional anterograde AP, while all the others from both groups had ventriculo-atrial conduction. 1 patient in group B had another right posteroseptal AP with bidirectional conduction. All patients had inducible tachycardia, including 2 antidromic AVRT mediated by above mentioned unidirectional pathways. Orthodromic AVRT can be induced in all other cases, compatible with their clinical scenarios. Additionally, 1 patients in group A and 1 patients in group B experienced episodes of atrial fibrillation longer than 30 seconds during procedure, respectively.

*Mapping and Ablation*

In group A (n=15), mapping was performed during sinus rhythm in 6 procedures and during RV pacing in the rest. Deflectable sheath and CF-sensing catheter were used in 8 and 12 cases, respectively. Acute success was achieved in 14/15 cases. The patient in the failed case underwent repeated procedure 2 month later with conventional approach which was successful.

In group B (n=10), mapping was performed during RV pacing in 7 procedures and during sinus rhythm in the others. Deflectable sheath was used in 9 patients. 7 cases were completed with non-CF-sensing catheter for its better flexibility. ICE was used in 3 patients for identification of tricuspid apparatus (Supplementary video 1 and 2). Although the time of first effective RF to blocked AP was satisfactory (Group B: 3.8±1.6sec vs. Group A: 4.1±2.2sec, p=0.74), it was cut off in 6/10 patients during delivery before 60 seconds mostly due to catheter instability or impedance rise (Figure 2). Nonetheless, it was thereafter followed by subvalvular ablation, with catheter successfully reaching the target from the RV with a reversed-S curve in all patients. An atrial signal with lower amplitude could be recorded at ventricular compared to the atrial side. APs were successfully ablated after subvalvular ablation in all 10/10 patients (Figure 3).

As comparison, the total procedure time and mapping and ablation time were significantly shorter in group B than in group A (procedure time: 124.5±13.4min vs. 152.1±36.0min, p=0.030, mapping and ablation time: 57.2±16.3 min vs. 92.1±40.1 min, p=0.016). The total RF time was lower in group B (536.9±161.0 sec vs. 650.7±321.9 sec, p=0.313) without statistical difference. Fluoroscopic time was similar between the 2 groups (group B: 4.1±1.4 min vs. group A: 4.2±2.1 min, p=0.898). No major complication occurred in the periprocedural period.

*Follow-up*

After a median follow-up of 24 (12-33) months, 1 patient in group A suffered from tachycardia recurrence after 1 month, who had successful ablation in our center with sequential approach 2 months later. All the other patients have been free from symptoms associated with tachycardia after successful ablation. No preexcitation pattern was found during follow-up.

Discussion

APs in the vicinity of anterior tricuspid valve are the most challenging pathways mainly owing to several anatomic reasons[1-4]. From histological perspective, free wall aspect of TA has very little fibrous tissue or collagen along the segment, which is greatly different from the rest area[11], making it difficult to define "annulus" on surgical or anatomic inspection[12]. Second, TA is a dynamic structure, the size of which decreases by up to 20-30% during systole[13,14]. Most of the changes of the annular circumference were along the anterior annulus[13]. When TA dilation is present, it also occurs mainly at free wall instead of septal leaflet[15]. These features markedly contribute to the difficulties in keeping catheter stable in this specific region. Third, the anterior leaflet is the largest and the longest valve leaflet in the radial direction with the larger area and the greatest motion compared to the others[12], which may result in mechanical bumping against the catheter. Moreover, there can be ostia of small veins at the atrial side of the TA[16,17] causing potential risk during RF.

Since the anatomical issues may result in compromised outcome with conventional approach, multiple techniques have been adopted to deal with right-sided pathways[5-10], including subvalvular approach in complex cases, especially after failed attempts[9,10]. However, the method requires skillful operator to make reversed curve from right ventricular outflow tract to reach RAL-AP as described previously[9]. Fine adjustment of catheter position can be troublesome under the anterior valve due to its length and circumference[11-13,18]. Moreover, a lower A-V ratio in local electrograms is not favored in detailed mapping. Therefore, we designed a modified sequential approach specifically for RAL-AP. Mapping of the earliest atrial or ventricular, or pathway potential, was performed in the atrium around TA, followed by the initial RF delivery. Ablation was subsequently performed with a subvalvular catheter curve at the target site labeled on the mapping system. It demonstrated better outcome and shorter mapping and ablation time during procedures.

The accuracy of mapping and the stability during RF delivery are key factors for RAL-AP ablation. Supravalvular approach, although imperfect for RF delivery compared to subvalvular catheter placement, is more efficient in seeking satisfactory electrograms in the area of interest as initial ablation site. Interpretation of the electrograms at the potential target is vital to ensure the effectiveness of RF and its value to guide subvalvular ablation. A short AP block time can be an indicator to further confirm the location of pathway[19].

However, the first effective RF was discontinued in most patients because of inadvertent catheter shift or impedance rise. Since local tissue edema caused by repeated ablation can influence the thermal effect of following RFs, it is critical to provide durable consolidation[3]. In our cohort, group A showed longer time for mapping and ablation with much greater deviation among cases owing to time-consuming repeated RF applications in a few procedures. In contrast, subvalvular ablation improves catheter stability once it is placed beneath the long and wide anterior tricuspid valve. In our strategy, it has been simplified as an anatomic approach since the target had been marked on the 3D map after careful mapping in the atrium. The ablation catheter is advanced into RV inflow tract with support by deflectable sheath, curved back into the space under valve, which can be observed with ICE (Figure 4). The maneuvers can be safely and precisely accomplished especially when the sheath allows visualization on the mapping system. During subvalvular ablation, the rhythm, pacing site and cycle length need to be identical to supravalvular mapping to ensure the spatial accuracy of the marked target, while RF during AVRT should be possibly avoided.

## Limitations

This is a retrospective study with limited number of patients. A prospective study with larger sample size is necessary for validating the superiority of the approach.

## Conclusions

In patients with APs located at anterolateral TA, the sequential supra-to-subvalvular approach with 3D mapping system achieves satisfactory efficiency by taking advantage of local anatomy, which can be considered feasible in the routine ablation of RAL-APs.

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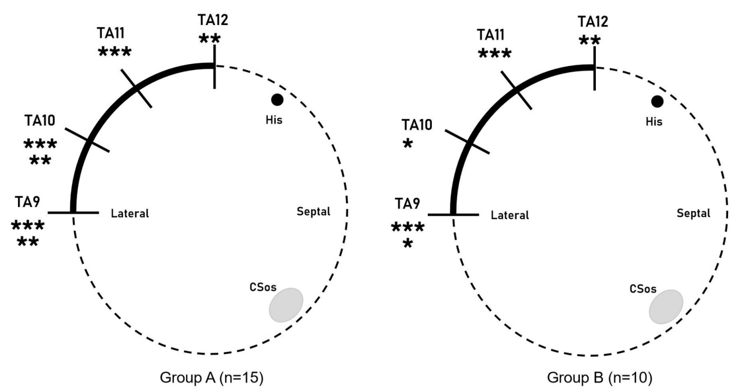
Figure legend

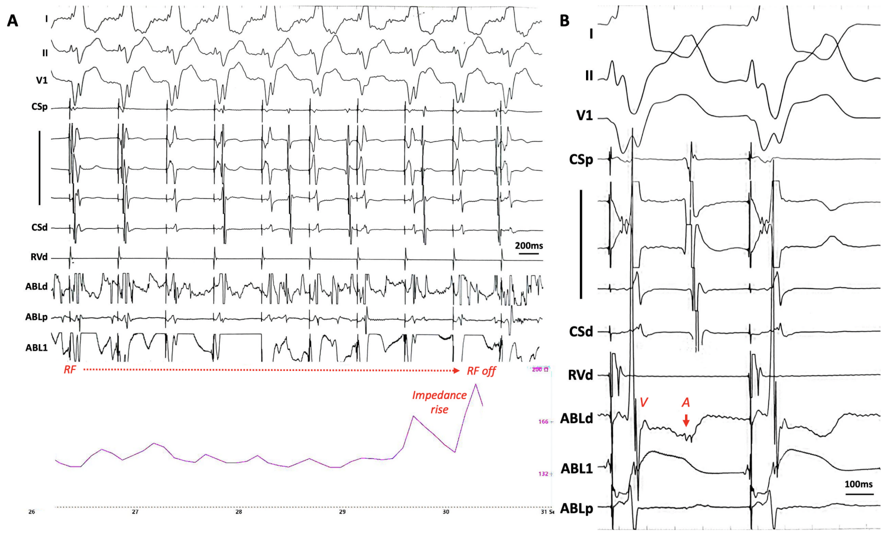
Figure 1: Distribution of right anterolateral accessory pathways (9-12 o'clock at TA) in 2 groups. TA=tricuspid annulus.

Figure 2: Catheter instability and abnormal impedance interrupted RF in a patient with RAL-AP. (A) Synchronous recording of electrograms and impedance during the first RF, which blocked a concealed pathway in 4 seconds. However, the RF was discontinued by the operator at the 30$^{\text{th}}$ second when abrupt impedance rise was observed, possibly due to shift of catheter into a venous ostium at the tricuspid annulus. (B) Subvalvular ablation was thereafter done for consolidation. Note the smaller A-V ratio when the catheter was under valve. ABL=ablation catheter; CS=coronary sinus; RAL-AP=right anterolateral accessory pathway; RF=radiofrequency; RV=right ventricle.

Figure 3: An example of sequential ablation in a concealed RAL-AP. (A-F) Supravalvular mapping during RV pacing showed the earliest atrial signal with V-A fusion present at 9 o'clock site on tricuspid annulus. RF here caused AP block after 3.1seconds. (G-L) After a 70-seconds RF delivery, the catheter was advanced into RV, positioned under tricuspid valve and directed at the target, after which RV pacing indicated reconnection of the AP. The electrograms were similar to supravalvular recording. RF immediately caused prolongation of AP conduction and subsequent pathway block. Dissociated large ventricular and small far-field atrial signal were demonstrated. AP conduction was then eliminated permanently after 4 additional lesions. ABL=ablation catheter; AP=accessory pathway; CS=coronary sinus; LAO=left anterior oblique; RAL-AP=right anterolateral accessory pathway; RAO=right anterior oblique; RF=radiofrequency; RV=right ventricle.

Figure 4: Intracardiac echocardiography images showed the catheter wedged into the space between the anterior tricuspid valve and annulus. (A) View from the TA septum; (B) View from the right atrium (home view). ABL=ablation catheter; ATV=anterior tricuspid valve; RA=right atrium; RV=right ventricle; TA=tricuspid annulus.

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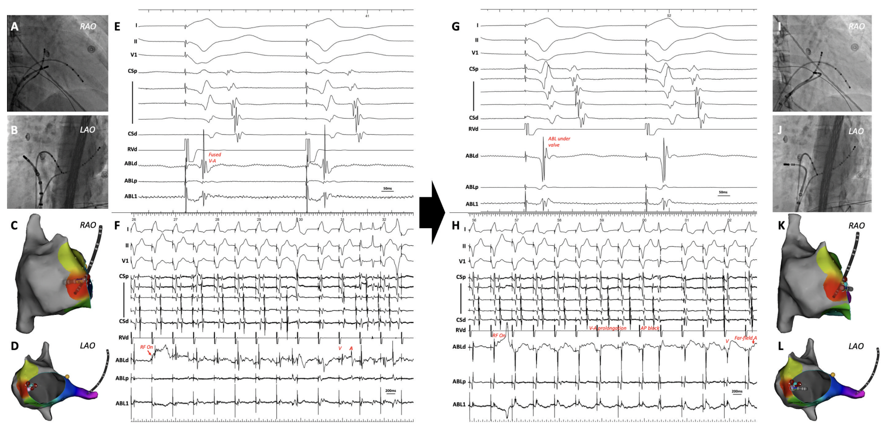
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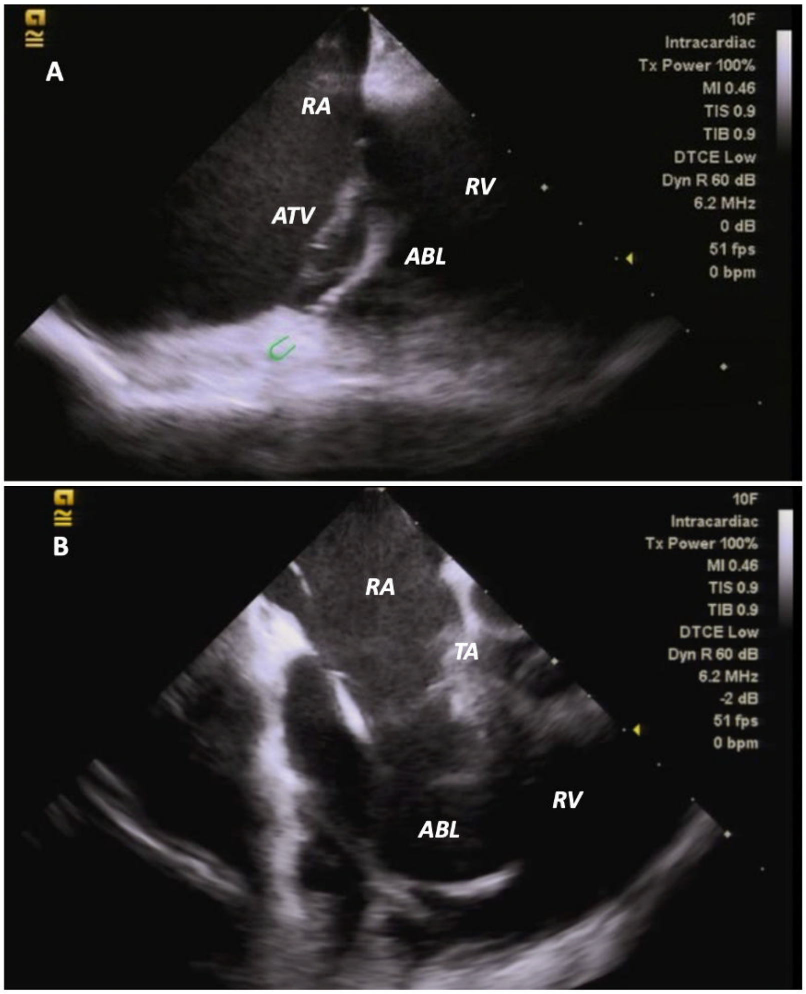


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`Table 1.docx` available at https://authorea.com/users/447308/articles/620215-sequential-supra-to-subvalvular-approach-for-ablation-of-right-anterolateral-accessory-pathway