Ablation of Manifest Left Free Wall Accessory Pathways with Polarity Reversal Mapping: Ventricular Approach

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Polarity reversal mapping for localization of the left free wall accessory pathway(AP) at the atrial insertion site has been shown to be effective for successful ablation, but this technique requires atrial septal puncture. We evaluated the safety, efficacy, and reproducibility of two-dimensional polarity reversal mapping at the ventricular insertion site of the accessory pathway without atrial septal puncture in symptomatic patients with manifested left free wall AP. Polarity reversal mapping under the mitral annulus by transaortic approach was performed in 10 consecutive patients with conventional ablation catheter(6 French, 4 mm tip, 2 mm interelectrode distance), during sinus rhythm or atrial pacing. A low set high, bandpass filter(0.05-400Hz) was used. Radiofrequency(RF) ablation was performed at the site of ventricular electrogram polarity reversal during sinus rhythm. Polarity reversal was identified in all patients at the ventricular side of the mitral annulus. Ablation was successful in all patients without complications. The procedure time was 86.0±21.1 min, the fluoroscopic exposure time was 16±12 min, the number of RF applications was 8±6, the power level 21±7 watts, and the time to initial AP block was 3.0±0.9 sec. Polarity reversal mapping is a safe and efficient technique at the ventricular insertion site. This technique might be complementary to the currently-utilized activation mapping technique.

The ablation of accessory pathway (AP) using radiofrequency energy has been successfully established as an effective primary modality of treatment

for symptomatic tachyarrhythmias related to Wolff-Parkinson-White syndrome. Radiofrequency (RF) technique for catheter ablation of the accessory pathway demands accurate anatomical localization of the AP because of small lesion size resulting from RF ablation (Calkins *et al.* 1991; Jackman *et al.* 1991; Lesh *et al.* 1992), and requires catheter stability during radiofrequency energy delivery. For the meticulous localization of AP, various electrophysiological criteria have been proposed, however, they are not always accurate due to individual anatomical variation, instrumentation error, or measurement error (Miles *et al.* 1986; Gallagher *et al.* 1987; Milstein *et al.* 1987; Szabo *et al.* 1989; Teo *et al.* 1991). Although the recording site of Kent bundle activity(accessory pathway potential) would

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be the optimal ablation site, its identification and validation are very arduous and time-consuming (Haissaguerre *et al.* 1986; Jackman *et al.* 1988; Ruder *et al.* 1988; Warin *et al.* 1988; Kuck *et al.* 1990; Silka *et al.* 1992; Twidale *et al.* 1991). Inadequate localization of the accessory pathway insertion site during radiofrequency ablation not only increases the difficulty of successful ablation but also increases the probability of recurrent accessory pathway conduction following an initially successful ablation attempt (Twidale *et al.* 1991).

Recently, Fisher and Swartz reported that polarity reversal mapping for localization of the left free wall accessory pathway at the atrial insertion site has been shown to be effective (Fisher and Swartz, 1992). As well, it reduced the procedure and radiation exposure time. However, this technique requires atrial septal puncture, and the majority of electrophysiologists prefer the transaortic approach for ablation of the left free wall accessory pathway which avoids atrial septal puncture. Therefore, we evaluated the safety, efficacy and reproducibility of two-dimensional polarity reversal mapping at the ventricular insertion site of the accessory pathway in patients with manifested left free wall accessory pathway.

MATERIALS AND METHODS

Patient population

Between March 1996 and September 1996, 10

consecutive patients with manifest left-side accessory pathways and symptomatic supraventricular tachyarrhythmias underwent transcatheter ablation. There were 8 men and 2 women with a mean age of 35 years (range 21 to 58 years). The mean duration of their symptoms was 152 months. Three patients experienced symptomatic orthodromic atrioventricular reentrant tachycardia, and 2 had spontaneous atrial fibrillation (Table 1).

Preablation evaluation

All patients underwent preprocedure evaluation including routine physical examination, 12-lead ECG, chest PA and routine blood chemistry. After giving informed consent for the electrophysiologic study and ablation, patients underwent a complete electrophysiologic study without sedation. All antiarrhythmic medications were discontinued at least five half-lives before the procedure. Percutaneous venous access was established via the right and left femoral and left subclavian veins. A modified Seldinger technique was also used for right femoral arterial access for the mapping catheter and for continuous blood pressure monitoring. All patients received 3000 units of heparin intravenous injection bolus with an additional 1000 units bolus per hour. Three 5-French quadripolar electrode catheters (Daig Corporation, Minnetonka, MN, USA), with 5 mm interelectrode spacing, were inserted via the left femoral vein and, under fluoroscopic guidance, were positioned in the high right atrium, His bundle region, and right ventricular apex for local intra-

Table   The clinical parameters of the patients

Case No.	Age/Sex	Clinical/Induced Arrhythmias	Symptom Duration(yr.)
	41/M	ND/AVRT	10
2	21/M	AVRT/AVRT, AF	12
3	44/M	ND/AVRT	
4	36/M	ND/AVRT	20
5	34/M	ND/AF	5
6	34/F	AVRT/AVRT	5
7	23/M	AF/AVRT, AF	6
8	58/M	AVRT/AVRT	37
9	29/F	ND/AVRT	15
.0	26/F	AF/AVRT	16

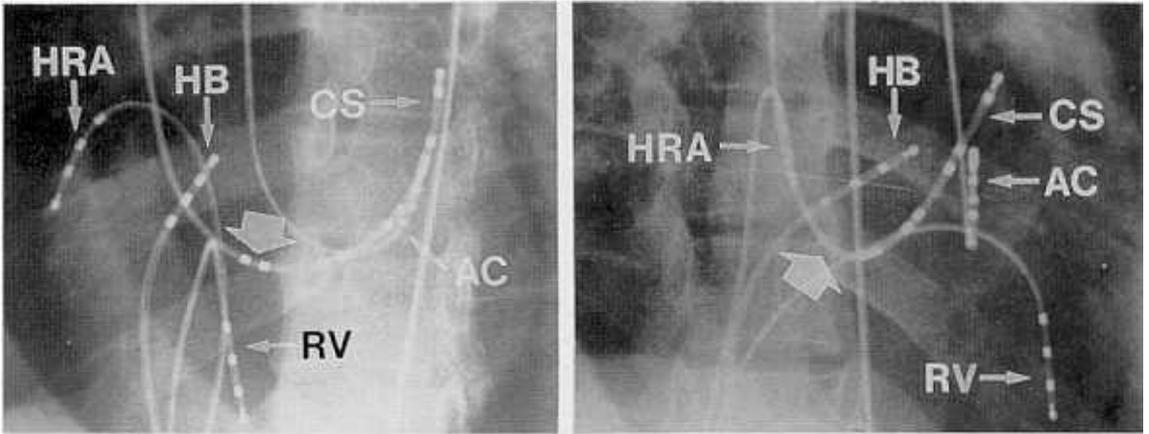AF: atrial fibrillation, AVRT: atrioventricular reentrant tachycardia, ND: not documented

Fig. 1. Location of all catheters. Left anterior oblique (left) and right anterior oblique (right) views are shown. Intra-cardiac catheters are positioned in high right atrium (HRA), His bundle (HB), right ventricular apex (RV), coronary sinus (CS), and ablation/mapping catheter (AC). Large arrow points to the location of the most proximal bipolar elec-trode, which was at the coronary sinus ostium.

cardiac electrogram recording and pacing. A 7-French decapolar electrode catheter (Daig Corporation, Minnetonka, MN, USA) was introduced via the left subclavian vein and positioned in the coronary sinus. Coronary sinus recordings were obtained from five bipolar recording pairs. The distance between two bipoles was 2 mm, and the distance between each bipolar recording pair was 10 mm. Bipolar pair 1 was the most distal pair and bipolar pair 5 was the most proximal pair. The proximal pair of electrodes was positioned at the coronary sinus ostium (Fig. 1). Surface electrocardiographic leads (I, aVF, V1), intracardiac electrogram, and blood pressure were displayed simultaneously on the multichannel moni-tor of a digitalized Quinton EPLab System. The 12-lead ECG, intracardiac electrograms and fluoro-scopic images were recorded by the Quinton EP Lab System. Cine films were also obtained in some patients to record the catheter locations. The elec-trogram signals were filtered at 30 to 400 Hz for conventional mapping and filtered at 0.05 to 400 Hz for polarity reversal mapping. The activation times were determined by the usual criteria (Josephson, 1993).

Electrophysiologic study protocol consisted of atrial and ventricular incremental pacing and prema-ture stimulation to evaluate the anterograde and retrograde atrioventricular nodal and accessory path-way conduction properties and the characteristics of atrioventricular reentrant tachycardia (AVRT). If atrioventricular reentrant tachycardia could not be induced at baseline study, isoproterenol ($1 \sim 2$ μ g.min^{-1}) was used to facilitate the induction of atrioventricular reentrant tachycardia.

Left heart catheterization

A 6 French 4 mm tip steerable quadripolar ablation catheter with 2 mm interelectrode distance (EP Technologies Inc., Sunnyvale, CA, USA) was inserted into the root of the aorta percutaneously via the right or left femoral artery. The catheter was then advanced to the left ventricular cavity. In the left ventricle, the catheter tip was fully straightened and rotated in a counterclockwise fashion to reach the posterior inflow track where, by deflection and continued clockwise rotation, the tip of the catheter was advanced into the posterior ditch between the left ventricular and the posterior mitral leaflet. The catheter was manipulated to move along beneath the mitral annular area. Using this approach, a consis-tent bipole orientation parallel to the mitral annulus was maintained throughout the mapping and abla-tion procedure (Fig. 2, 5).
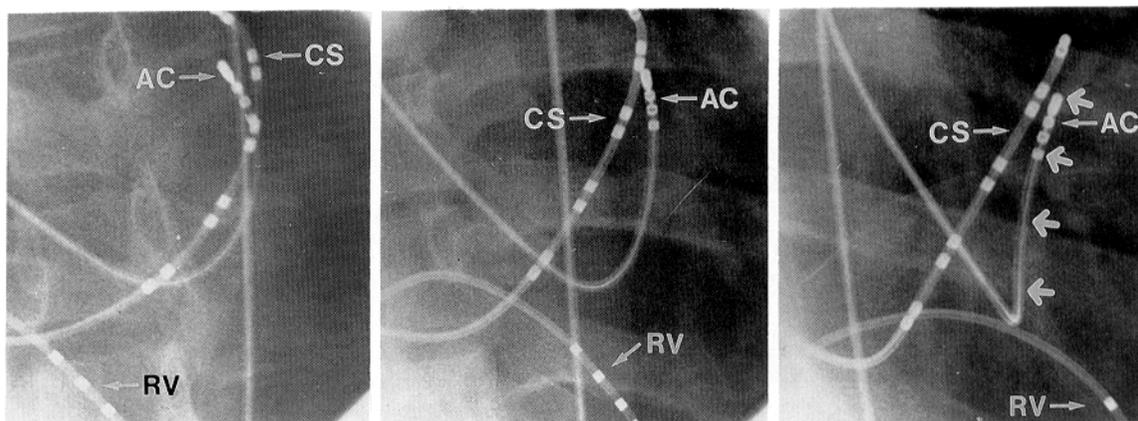
Fig. 2. Radiographic views of ablation/mapping catheter location in a patient. Left anterior oblique (left), posterior-anterior (mid), and right anterior oblique (right) views are shown. The ablation catheter is positioned in the left ventricular ditch (thick arrow) between the mitral leaflet and basal portion of left ventricular free wall using the transaortic approach. Abbreviations as in Fig. 5.
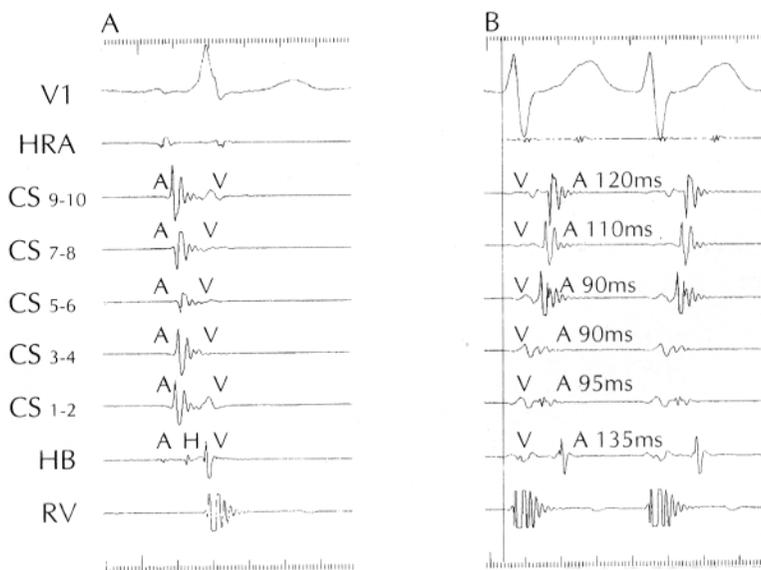

Fig. 3. Tracings of antrograde and retrograde epicardial localization of manifest left free wall accessory pathway during sinus rhythm (A) and orthodromic atrioventricular tachycardia (B) with conventional bandfilter (30-400Hz). Surface ECG lead V1 is displayed at the top of the figure. Intracardiac recordings from the high right atrium (HRA), coronary sinus (CS) bipolar pair from far proximal (10-9) to far distal (1-2), His bundle (HB), and right ventricle (RV) are shown in descending order. Earliest anterograde ventricular activation point is not clear during sinus rhythm in this tracing (A). Earliest retrograde atrial activation occurs at the CS 5-6 and CS 3-4 pairs during orthodromic atrioventricular tachycardia (B).

Conventional accessory pathway localization

Localization of the accessory pathway was achieved by observing the intracardiac recordings from a coronary sinus catheter during sinus rhythm, atrial pacing, ventricular pacing and orthodromic atrioventricular reentrant tachycardia. The earliest retrograde atrial activation or the earliest anterograde ventricular activation site was assumed to be the optimal ablation site (Fig. 3).

Conventional endocardial localization of the accessory pathway ventricular insertion was performed via transaortic approach. Bipolar electrograms were filtered at 30 to 400 Hz for conventional mapping. A bipolar AV electrogram amplitude ratio ≤ 1 and fluoroscopic evaluation were used to identify the ventricular aspect of the AV groove. The earliest anterograde ventricular activation site or AV fusion site during sinus rhythm and the shortest

surface QRS onset to local atrial activation time (QRS-A) during AVRT were used as the method of accessory pathway identification. Catheter stability was deduced from the consistent local atrial and ventricular electrogram amplitudes and ratios.

Polarity reversal accessory pathway localization

Epicardial coronary sinus bipolar electrogram was obtained through minimizing the filter bandpass at 0.05 to 400 Hz during sinus rhythm or atrial pacing. Approximate localization of the anterograde ventricular insertion site was identified by the site of earliest ventricular activation and the region of the ventricular electrogram polarity reversal (Fig. 4).

Endocardial localization of the ventricular insertion site was performed with a large tip ablation catheter with bandpass filter at 0.05 to 400 Hz. The local electrograms were obtained in bipolar fashion
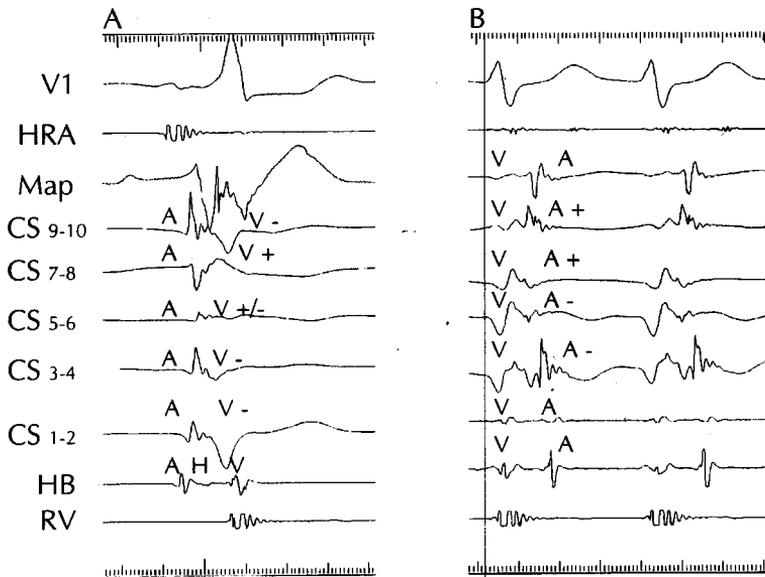

Fig. 4. Tracings of antrograde and retrograde epicardial localization of manifest left free wall accessory pathway during sinus rhythm (A) and orthodromic atrioventricular tachycardia (B) with minimal bandfilter (0.05-400Hz). Surface ECG lead V1 is displayed at the top of the figure. Intracardiac recordings from the high right atrium (HRA), mapping catheter (Map), coronary sinus (CS) bipolar pair from far proximal (10-9) to far distal (1-2), His bundle (HB), and right ventricle (RV) are shown in descending order. Ventricular electrogram polarity reversal occurs at the CS 5-6 pair during sinus rhythm (A). Retrograde atrial electrogram polarity reversal occurs at the CS 5-6 during orthodromic atrioventricular tachycardia (B). The proximal CS pairs reveal positive polarity and distal CS pairs reveal negative polarity in both tracings.
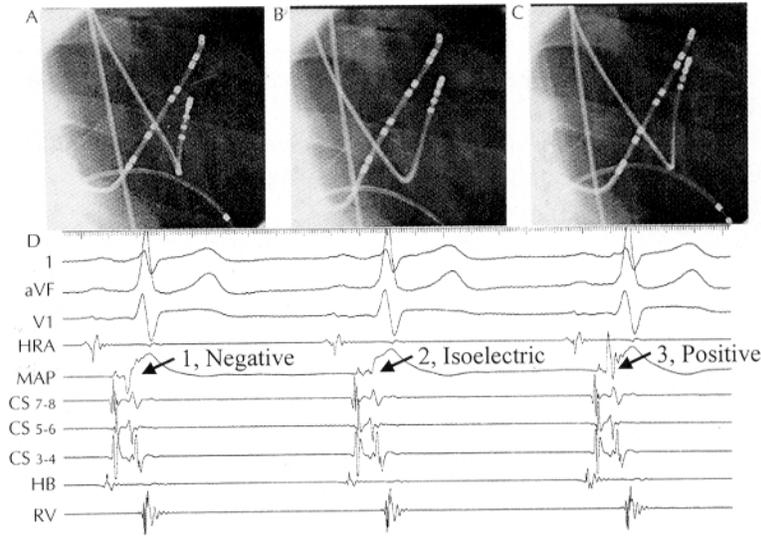
Fig. 5. Radiographic views of mapping catheter at various locations in the ventricular ditch (A, B, C) and tracings of antrograde endocardial localization of the manifest left free wall accessory pathway during sinus rhythm (D). Consistent bipole orientation parallel to the mitral annulus was maintained throughout the mapping and ablation procedure (A, B, C). Surface ECG leads I, aVF, and V1 are displayed at the top of the figure. Intracardiac recordings from the high right atrium (HRA), mapping catheter (Map), coronary sinus (CS) bipolar pair from proximal (7-8) to distal (3-4), His bundle (HB), and right ventricle (RV) are shown in descending order. Endocardial minimal filtered bipolar electrograms (1, 2, 3 in D) from the ablation catheter are matched with the locations of ablation catheter (A, B, C). Ventricular electrogram polarity reversal occurs at the ventricular insertion site recorded from the mapping catheter between the CS 3-4 pair and the 5-6 pair during sinus rhythm (isoelectric point). The proximal ventricular electrogram reveals negative polarity and the distal ventricular electrogram reveals positive polarity.

The catheter was sliding underneath the anterior and posterior annular areas in the ditch between the left ventricle and mitral leaflets. Precise localization of the ventricular insertion site was presumed to be the point of the ventricular electrogram polarity reversal during sinus rhythm or atrial pacing (Fig. 5D).

Radiofrequency catheter ablation

Radiofrequency ablating energy was unmodulated 500 KHz alternating current derived from a standard radiofrequency energy generator (HAT 300, Dr. Osypka GmbH Medizintechnik, Grenzach-Wyhlen, Germany). Energy was delivered in a monopolar fashion between the ablation tip electrode and a large surface skin patch. Ablation was performed at the site of ventricular electrogram polarity reversal

during sinus rhythm. The energy delivery protocol used was 20 watts delivered for a maximum of 45 seconds. Radiofrequency energy delivery was terminated if no effect was noted within 10 seconds. Repeated ablation attempts were pursued after ablation catheter repositioning within 2 mm by pull and push until accessory pathway block was achieved. The ablation catheter position was monitored fluoroscopically during each energy application to ensure stable catheter position and appropriate delivery of energy to the targeted region. Patients were observed for recurrent accessory pathway conduction in the electrophysiology laboratory for 10 minutes after successful ablation. Repeated electrophysiological evaluation was performed including anterograde and retrograde conduction properties.

Definitions

Total procedure time was recorded from injection of local anesthetics to removal of all sheaths, including 10-minutes of observation time after successful ablation. Fluoroscopy time is the time for using fluoroscopy during all the procedures.

Follow-up evaluation

All patients were continuously monitored in the telemetry ward for 1 day after the procedure. A 12-lead ECG was taken just after ablation and just before discharge on the first postablation hospital day. The patients were followed after one week, one month, and then once every 3 months for one year using a 12-lead ECG in an outpatient clinic.

RESULTS

Accessory pathway physiology

Among 10 consecutive patients, nine had bidirectional conduction via AP and one had only anterograde conduction. Anterograde accessory pathway refractory period was 295 ± 53 msec and maximal 1 : 1 atriventricular conduction occurred at 287 ± 63 msec. Retrograde accessory pathway refractory period was 294 ± 46 msec and maximal 1 : 1 conduction occurred at 283 ± 102 msec. Sustained atrial fibrillation was induced in 3 patients with a mean shortest preexcited RR interval of 291 ± 101

msec. Orthodromic atrioventricular reentrant tachycardia was induced in 9 patients and had a mean tachycardia cycle length of 406 ± 38 msec.

Accessory pathway localization by conventional mapping technique

Conventional electrogram intervals obtained at the site of successful ablation of ventricular insertion are listed in Table 2. Surface QRS onset to local atrial electrogram interval was 65.0 ± 21.7 msec during orthodromic atrioventricular reentrant tachycardia at the ventricular insertion site. Anterograde mapping at the accessory pathway ventricular insertion site in all patients revealed a local ventricular electrogram to the onset of the delta wave interval of -19.3 ± 7.7 msec (Table 2).

A typical orthodromic atriventricular reentrant tachycardia electrogram sequence obtained from a left free wall accessory pathway is shown in Fig. 3.

Accessory pathway localization by polarity reversal mapping technique

Polarity reversal electrograms were successfully obtained for all patients at the accessory pathway ventricular insertion site in this study. In all cases studied, a characteristic polarity reversal of the minimally filtered (0.05~400Hz bandpass) anterograde ventricular activation vector occurred at the site of earliest endocardial ventricular activation by the conventional filter setting (30~400Hz bandpass).

A representative epicardial intracardiac electrogram

Table 2. The electrophysiologic parameters of the patients

Case No	TCL(msec)	Shortest VA(msec)	Delta-V(msec)	Polarity of ablation site
1	350	65	−25	isoelectric
2	370	65	−30	isoelectric
3	420	20	−15	isoelectric
4	400	70	−15	negative
5	NA	NA	−20	negative
6	420	70	−10	negative
7	470	100	−6	negative
8	440	50	−25	isoelectric
9	370	80	−20	negative
10	410	70	−27	negative

NA: not available, TCL: tachycardia cycle length, V: ventricle, VA: ventricular atrial
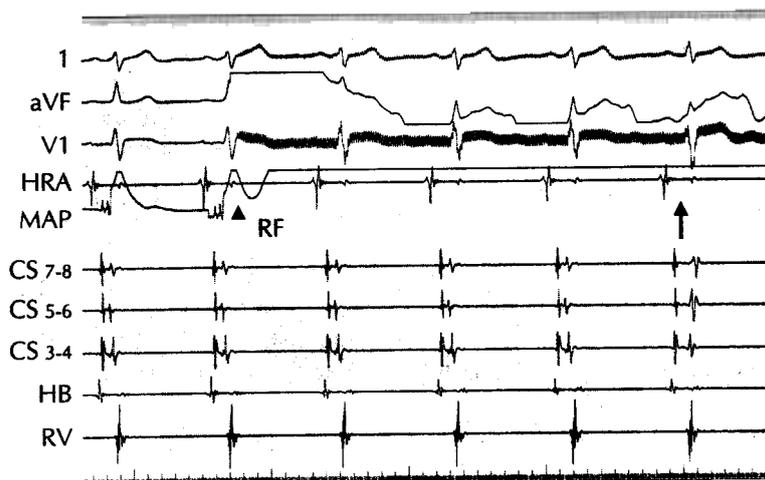
Fig. 6. Tracing from the same patient as in Fig. 5 shows successful radio-frequency ablation at the ventricular insertion site (isoelectric point) within 3 seconds during sinus rhythm. Arrow head, start of current; arrow, loss of antero-grade accessory pathway conduction. Abbreviations as in Fig. 5.

pattern obtained by the polarity reversal mapping technique during sinus rhythm and orthodromic atrioventricular reentrant tachycardia from a left free wall accessory pathway is shown in Fig. 4. Fig. 5 shows endocardial and epicardial intracardiac electrogram patterns in the same patient shown in Fig. 4 by polarity reversal mapping technique during sinus rhythm, including five bipolar epicardial atrioventricular electrograms obtained from coronary sinus catheter site 1 through 5. As well, 3 continuous bipolar endocardial electrograms obtained during pull back of the mapping catheter including the epicardial polarity reversal site are displayed. Characteristic accessory pathway ventricular insertion site polarity reversal of the ventricular electrogram occurred between annular site 2 and 3. The ventricular electrograms of distal (relative to accessory pathway insertion site) annular sites 1 and 2 were negative while proximal sites 3 through 4 were positive during sinus rhythm (Fig. 4A). The polarity of annular site 5 was negative because the proximal portion of mitral annulus was activated by antero-grade conduction through AV node during sinus rhythm (Fig. 4A). Serial endocardial electrograms which were successfully obtained from mapping catheter revealed the same phenomenon at the ventricular side of mitral annulus (Fig. 5D).

Table 3. Technical parameters of the patients

Total procedure time(minutes)	86.0 ± 21.1
Fluoroscopy time(minutes)	16.0 ± 12.0
Number of RFs	8 ± 6
Time to effect(seconds)	3.0 ± 0.9
RF energy(watts)	20.7 ± 6.9

RF: radiofrequency

Ablation results

All accessory pathways were successfully ablated using a radiofrequency power of 21 ± 7 W without complication. A mean of 8 ± 6 radiofrequency energy applications were required for successful ablation. The mean time to effect of radiofrequency energy application was 3.0 ± 0.9 seconds at the site of successful ablation outcome (Fig. 6). The total procedure time was 86.0 ± 21.1 minutes and required 16.0 ± 12.0 minutes of fluoroscopic exposure (Table 3).

There was no recurrence of delta wave or tachycardia during 19.3 ± 1.9 months follow-up in the abscence of all antiarrhythmic medications.

DISCUSSION

In this study, we evaluated a left ventricular application of polarity reversal mapping technique for manifest left-sided accessory pathway localization and ablation. Ventricular electrogram polarity reversal at the ventricular insertion site of the accessory pathway using the less-filtering technique was a sensitive and specific marker of a successful ablation site. These results are comparable with those of other investigators with conventional mapping technique (Calkins *et al.* 1991; Jackman *et al.* 1991; Kuck and Schlutter, 1991).

The analysis of recorded intracardiac electrograms by conventional bandpass filter during radiofrequency ablation procedure is sometimes difficult. Determining a reliable, reproducible activation point of the ventricle or atrium is often difficult to measure, particularly in comparing electrograms between different recording positions. Interobserver variability in measuring electrogram intervals may also adversely effect electrogram interval measurement.

Previously described accessory pathway localization methods have included identification of an accessory pathway potential(Jackman *et al.* 1988; Jackman *et al.* 1991; Calkins *et al.* 1992b), recording the shortest anterograde atrioventricular conduction time (Warin *et al.* 1990; Jackman *et al.* 1991; Kuck and Schluter, 1991), or the shortest retrograde ventriculoatrial conduction time(Swartz *et al.* 1993). The inadequacy of conventional electrogram mapping variables as predictors of ablation success was confirmed by Swartz *et al.* and Calkins *et al.* (Swartz *et al.* 1991; Calkins *et al.* 1992a). Swartz *et al.* could identify a proper ablation site with only 61% sensitivity and 70% specificity using multiple conventional electrogram variables at the accessory pathway atrial insertion sites (Swartz *et al.* 1991). Calkins *et al.* reported a 57% probability of successful ablation of manifest accessory pathways when a stable electrogram combining accessory pathway potentials and local ventricular activation preceding a surface delta wave onset was identified (Calkins *et al.* 1992a). Additionally, these conventional mapping techniques of the accessory pathway are non-directional in nature due to variable catheter-to-accessory pathway orientation and the

use of bandpass filtering. Most catheter ablation studies to date have reported between 20 and 50 Hz highpass filter cutoff frequency, despite evidence that the most significant signal components of myocardial tissue are less than 30 Hz (Slocum *et al.* 1988; Klitzner and Stevenson, 1990). Significant reductions in electrogram amplitude and distortion of local electrogram morphology are seen with highpass filters above 10 Hz (Klitzner and Stevenson, 1990; Jenkins *et al.* 1991; Pieper *et al.* 1991). The minimally-filtered electrograms avoid signal distortion while providing a directional guide to the source of the incident wavefront of myocardial activation.

In an attempt to circumvent the inadequacies of conventional catheter-based mapping methods, Fisher and Swartz recently developed the three-dimensional mapping technique representing the endomyocardial activation pattern over a large extent of the AV groove improve accessory pathway localization and increase ablation procedure efficiency (Fisher and Swartz, 1992). The distal recording bipolar polarity orientation of the mapping catheter with the distal electrode negative and the more proximal electrode positive provided consistent bipolar orientation from which to perform vector-oriented interpretation. Using this convention, accessory pathways anterior to the recording bipole produced an initially negative electrogram. Conversely accessory pathways posterior to the recording bipole produced an initially positive electrogram (Fig. 7). Fisher and Swartz reported a 97% sensitivity and 72% positive predictive value for effective radiofrequency ablation sites at atrial insertion sites by polarity reversal technique with minimal bandpass filter (Fisher and Swartz, 1992). In addition, polarity reversal mapping technique could differentiate two adjacent accessory pathway insertion sites if the insertion sites of the accessory pathways were separated by at least 1 cm.

However, the three-dimensional mapping technique requires expertise with transseptal catheterization for patients with left-sided accessory pathways. The previous investigators reported that the multi-dimensional electrogram mapping technique could not be successfully used in efforts to localize accessory pathway ventricular insertion sites due to difficulties associated with access to the ventricular aspect of the mitral annulus (Fisher and Swartz, 1992). These
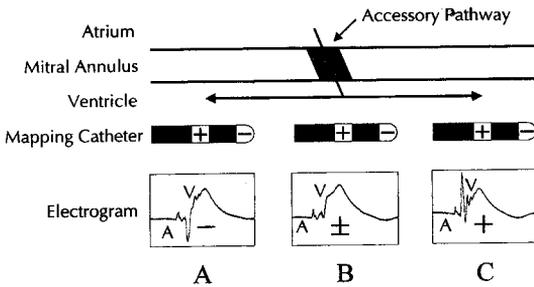
Fig. 7. Schematic representation of ventricular activation spread immediately adjacent to the mitral annulus from a discrete point source. A bipolar recording site proximal to the accessory pathway ventricular insertion site (A) shows a negative electrogram. Distal movement of the recording bipole to a position over the accessory pathway insertion site (B) results in a fractionated and isoelectric recording. Further distal movement of the recording bipole (C) reveals completion of polarity reversal to a positive ventricular electrogram.

were limitations and unsolved problems of three-dimensional mapping technique. In contrast to previous studies, we successfully performed polarity reversal mapping and ablation technique at the ventricular aspect of the mitral annulus via transaortic approach without atrial septal puncture. The commercialized 6 French large tip quadripolar ablation catheter with 2 mm interelectrode distance (EP Technologies Inc., Sunnyvale, CA, USA) was used for polarity reversal mapping. In all patients, polarity reversal was documented via coronary sinus and endocardial mapping catheter at the ventricular ditch which is the counterpart of the atrial mitral annulus.

Usually, the ablation and mapping are performed during tachycardia. The ventricular approach for the ablation of left-side manifest accessory pathway with polarity reversal technique, has some advantages. The first; ventricular approach does not require atrial septal puncture. The second; the polarity reversal mapping and ablation may be more stable than conventional methods because the former technique can be performed during sinus rhythm. Tachycardia or sudden cessation of tachycardia could be deformed by the geometry of the left ventricle, therefore the ablation catheter cannot maintain stability while tachycardia was terminated during RF energy delivery. This may be a reason for

the recurrence of accessory pathway conduction. The third; for the electrophysiologist who prefers the ventricular approach for the ablation of left-sided accessory pathway, the polarity reversal technique is more precise and physiologic. Sometimes a discrepancy in the atrial and ventricular insertion site of the accessory pathway is present (Jackman *et al.* 1988), so while mapping and ablating from the ventricular end, exact localization of the ventricular insertion site of the pathway is more precise and physiologic during sinus rhythm or atrial pacing.

For the catheter ablation procedures, the long-term effects of ionizing radiation exposure should be considered. The fluoroscopy time of 16.0 ± 12.0 minutes reported in this study reflects early learning experience. Nevertheless, mean patient radiation exposure in this study compares favorably with that reported by other investigators (Calkins *et al.* 1991; Schluter *et al.* 1991). The polarity reversal technique could reduce the fluoroscopy exposure to the minimum. If the endocardial ablation catheter is well tracked in the ventricular ditch, catheter repositioning for the precise targeting does not require fluoroscopic guidance. Development of more efficient and accurate accessory pathway localization techniques and the future use of pulsed fluoroscopy technology will result in even further reduction of an already acceptable level of ionizing radiation exposure.

The safety of a left ventricular application of polarity reversal technique was documented in this study. There were no complications associated with left ventricular catheterization or ablation. A ventricular approach to the left-sided manifest accessory pathway ablation avoids the inherent risks of atrial septal puncture. Reported complications associated with septal puncture procedures include cardiac tamponade and cardiac perforation.

In conclusion, the retrograde polarity reversal mapping technique at the ventricular insertion site in the left-sided manifest accessory atrioventricular connection ablation is very safe and highly effective. Overall, ventricular insertion ablation efficacy is equivalent to previously-reported accessory pathway ablation results. The polarity reversal mapping technique may have advantages in safety when used for manifest left-sided accessory atrioventricular connections, since atrial septal puncture is not necessary. Prospective direct comparative studies of

conventional and polarity reversal mapping and ablation techniques will be required to establish firm guidelines for the optimal accessory pathway ablation method.

This study had some limitations. We acknowledge that these data lacked comparable data with conventional mapping technique, as well as a small number of patients. However, the study was comprised of consecutively-enrolled patients with single, left-sided, manifest accessory pathways for the evaluation of efficacy, feasibility, safety and reproducibility of polarity reversal mapping at the ventricular insertion sites of accessory pathways. Further, the study was initiated after accumulation of extensive ablation experience using the ventricular tracking technique.

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