Atrioventricular Node Reentrant Tachycardia in Patients with Congenitally Corrected Transposition of the Great Arteries and Results of Radiofrequency Catheter Ablation

Running title: Liao et al.; RFCA of AVNRT in CCTGA

Zili Liao, MD1; Yu Chang, MD2; Jian Ma, MD1; Pihua Fang, MD1; Kuijun Zhang, MD1; Xiaqing Ren, MD1; Pingzhen Yang, MD3; Bo Yu, MD4; Jiqiang Hu, MD1; Qian Yang, MD1; Feifan Ouyang, MD1,5; Shu Zhang, MD1

1Arrhythmia Center & Clinical Electrophysiological Laboratory, FuWai Hospital, Chinese Academy of Medical Sciences, Peking Union Medical College, Beijing; 2Dept of Cardiology, Qingdao FuWai Hospital, Qingdao; 3Dept of Cardiology, Guangdong General Hospital, Guangdong Provincial Cardiovascular Institute, Guangzhou; 4Dept of Cardiology, the First Affiliated Hospital of China Medical University, Shenyang, China; 5Medizinische Abteilung, Asklepios Klinik St. Georg, Hamburg, Germany

Corresponding Author:
Jian Ma, MD
Arrhythmia Center &
Clinical Electrophysiological Laboratory
FuWai Hospital
Chinese Academy of Medical Sciences
Peking Union Medical College
167 Beilishi Road
Xicheng District, Beijing 100037, China
Tel: (86) 010-88398448
E-mail: majianfuwai@163.com

Abstract:

Background - We sought to investigate the feasibility of radiofrequency catheter ablation (RFCA) of atroioventricular node reentrant tachycardia (AVNRT) and ideal site for slow pathway (SP) ablation in Congenitally Corrected Transposition of the Great Arteries (CCTGA).

Methods and Results - Nine patients with CCTGA referred for catheter ablation of AVNRT were studied. A single His potential was recorded in 8 patients (89%, 6 {S,L,L} and 2 {I,D,D}). The earliest atrial activation during retrograde atrioventricular node (AVN) conduction occurred at His bundle region (HBE) (n=7) or shifting from HBE to coronary sinus ostium (n=1, {S,L,L}). Two anatomically separate His potentials were recorded in 1 patient (11%, {S,L,L}), one at the anteroseptum (HBE-1), the other at the confluence of the pulmonary and mitral annulus (HBE-2). In 8 cases with a single His potential recorded, SP was abated at the posterior-mid septum: 2 ({S,L,L}) at the right posteroseptum, 1 ({S,L,L}) at the left posteroseptum, and 5 (3 {S,L,L} and 2 {I,D,D}) at the midseptum after failure of energy application at the posteroseptum. Junctional rhythm was observed during RFCA in all 8 cases. In the remaining patient with two anatomically separate His potentials recorded, SP was successfully ablated from the confluence of the pulmonary and mitral annulus, slightly below the HBE-2. Junctional rhythm was also induced during RFCA.

Conclusions - In {S,L,L} or {I,D,D}, RFCA of AVNRT is feasible. SP input region can mainly be found in the posterior-mid septum, especially in patients with single penetrating AVNs. SP could usually be successfully ablated in these regions.

Key words: ablation; atrioventricular node; supraventricular tachycardia; congenital heart disease
Congenitally corrected transposition of the great arteries (CCTGA) is characterised by the combination of atrioventricular (AV) discordance and ventriculoarterial discordance. Since it is physiologically a "corrected transposition", the associated anomalies, for example, ventricular septal defect (VSD) and Ebstein anomaly of the tricuspid valve, commonly complicate the malformation\(^1\). Further more, CCTGA may be associated with a variety of arrhythmias, including AV reentrant tachycardia, atrial tachyarrhythmias, and rarely AV nodal reentrant tachycardia (AVNRT), and ventricular tachycardia\(^2-9\).

The location of the AV node (AVN) and its continuity with the penetrating His bundle in CCTGA are relate to both the cardiac loop and structure lesions\(^10\). Histopathologic studies and intraoperative mapping studies have demonstrated a displaced anterior location for the AVN and penetrating His bundle far away from the conventional location in majority of \{S,L,L\} patients\(^11,12\). On the base of these observations, one may postulate that the target area for slow pathway (SP) ablation might also be displaced in patients with \{S,L,L\}. Two case reports have described that SP could be successfully ablated at the posteroseptal site and right anteroseptal site\(^3,9\). However, the ideal sites for catheter ablation of the SP in such patients have not been described in detail. In this study, we report on radiofrequency catheter ablation (RFCA) in 9 cases of AVNRT associated with CCTGA.
Methods

Study population

Nine patients (5 female; age 32±14 years, range 18 to 58 years) with CCTGA referred for catheter ablation of AVNRT to our centers experienced in ablative therapy were retrospectively analyzed (Table 1). Median age of first supraventricular tachycardia episode was 21 years old (rang 15 to 40) and a median of one (range 1 to 3) oral antiarrhythmic drug had been tried in all 9 patients. An electrophysiological study had previously been performed in 2 of the 9. Ablation was unsuccessful with one procedure in both patients. Two patients had additional anatomical abnormalities, one had atrial septal defect (ASD), the other had both ASD and VSD. Severity of tricuspid valve insufficiency was mild in 2 patients (25%), moderate in 5 (63%), and severe in one (12%), respectively. Left ventricular ejection fraction was 51±6%. One patient (11%) underwent previous surgical VSD and ASD closure.

Definitions

Two-dimensional transthoracic echocardiogram and cardiac computed tomography were used to diagnosis of CCTGA. Anatomical arrangement of \{S,L,L\} is situs solitus with L-looping of the ventricles and the aorta anterior and leftward of the pulmonary artery, and \{I,D,D\} is situs inversus with D-looping of the ventricles and the aorta anterior and rightward\(^1\). AVNRT was diagnosed according to standard with typical slow-fast form of AVNRT, fast-slow variant,
slow-slow variant, left-sided variant\textsuperscript{13}.

**Electrophysiological study**

Electrophysiological study and catheter ablation were performed in a single session in all patients. All antiarrhythmic drugs were discontinued for at least 5 half-lives. Written informed consent for the electrophysiological study and ablation was obtained from each patient. Three catheters were introduced to the morphological right atrium (MRA), the morphological left ventricular apex (MLVA), and at the His bundle region (HBE) via the femoral veins. Also, a 6-F multipolar catheter was advanced within the coronary sinus via the internal jugular vein. The stimulation protocol consisted of programmed stimulation at two basic cycle lengths with up to two extrastimuli and burst pacing at the MRA and the MLVA\textsuperscript{14,15}. During single atrial extrastimulus (A1A2) testing, an AH jump was defined as prolongation of 50 ms or longer in the A2H2 interval following a shortening in the A1A2 interval by 10 ms. When two atrial extrastimuli are delivered, a jump from fast pathway to SP conduction is defined as an increase in the A3H3 interval of 50 ms or more in response to a decrement of 10 ms in the A2A3 interval (A1A2 being constant). If the clinical tachycardia did not occur spontaneously and was not inducible during the baseline state, intravenous isoproterenol infusion (2 to 5 µg/min) was administered to provoke the clinical arrhythmia or facilitate the tachycardia induction, and the stimulation protocol was repeated.
RFCA

RFCA was done using a 4-mm-tip ablation catheter (Biosense-Webster, Inc., Diamond Bar, California). Antegrade SP was attempted to ablate with electrogram-guided anatomic approach. Initially, the ablation procedure was started at the posterior/inferior aspect of the right or left sided mitral annulus anterosuperior to the coronary sinus ostium (CSO) or within the coronas sinus ostium. Target sites with the ratio of the atrial to ventricular electrograms amplitudes between 0.1 and 0.5 were considered optimal. Twenty watts of energy with non-temperature limit was initially applied at successful sites. After for 15 seconds, the power was gradually titrated to 30 watts for 30 to 60 seconds. Application of radiofrequency energy was terminated when accelerated junctional beats were not observed within 15 seconds. If this conventional approach failed to eliminate or modify the SP, ablation at the midseptal and eventually anteroseptal site was attempted, respectively. If AVNRT remained inducible after about 8-10 radiofrequency energy applications with junctional beats or rhythm during ablation at the right or left sided mitral annulus, the mapping and ablation of SP was switched to the other-sided. In case of an evidence of retrograde SP, the initial mapping was performed in the region between the CSO and the mitral annulus, and ablation was targeted at the site showing the earliest retrograde atrial activation. In all patients, ablation was considered successful if neither AVNRT nor more than one AV echo beat could be induced even after isoproterenol infusion.
Statistical Analysis

Categorical variables are expressed as numbers and percentages. Continuous values are presented as median and range, or mean ± SD, as appropriate.

Results

Electrophysiological study and ablation Procedures

Among these 9 patients, 7 were diagnosed with \{S,L,L\} and 2 with \{I,D,D\} (Table 1). In one of 2 patients with \{I,D,D\}, the coronary sinus catheter was advanced within the coronary sinus with effort. A single His potential was recorded on the anteroseptal aspect of the mitral annulus in 8 patients (6\{S,L,L\}, 2\{I,D,D\}). The earliest atrial activation during retrograde AVN conduction occurred at HBE (7 patients) or shifting from HBE to CSO (1 patient, \{S,L,L\}). The QRS morphology during atrial programmed stimulation, atrial burst pacing and sinus rhythm remained the same. Two anatomically separate His potentials were recorded at the anteroseptum (HBE-1) and at the confluence of the pulmonary and mitral annulus (HBE-2) respectively in the remaining patient No.8 with \{S,L,L\} (Figure 1). Both HV intervals were normal during sinus rhythm. In this patient, ventricle extrastimulus testing demonstrated a left-sided free wall accessory pathway (concealed) existed. After ablation of this accessory pathway by retrograde approach, a single decremental retrograde conduction pattern was observed during ventricular extrastimulus with
the earliest atrial activation recorded from HBE-2. Three distinct nonpreexcited QRS morphologies (Type A, Type B, and fused QRS morphology of both) were identified during sinus rhythm, with Type B appeared occasionally (Figure 2). Shift from Type A to Type B occurred during incremental atrial pacing or the delivery of atrial extrastimuli from a single pacing site. When the MRA was paced at cycle lengths of 600-400ms, the paced rhythm preexcited the ventricle with the QRS morphology of Type A. When the paced cycle length was reduced to 355 ms or less, the QRS morphology shifted to Type B.

AVNRT with a cycle length of 352 ± 48 ms was reproducibly induced in all 9 patients before the application of radiofrequency energy. The ventricular extrastimulus testing during tachycardia ruled out the possibility of a concealed accessory pathway. Among 8 patients with a single His potential recorded, QRS morphology of tachycardia was the same with that during sinus rhythm. The earliest atrial activation was recorded at the HBE in 7 and at the CSO in one. In the remaining patient with twin AVNs, QRS morphology of AVNRT was the same with Type B with earliest atrial activation recorded in the HBE-2 (Figure 2). AV reciprocating tachycardia involving the twin AVNs or orthodromic reciprocating tachycardia using the accessory pathway was not induced in this patient. All targets were successfully ablated (9 AVNRT, 1 accessory pathway). A median of 9 (range 7 to 21) radiofrequency applications were delivered. Median radiofrequency duration, procedure time and fluoroscopy time was 420 seconds (range 230 to
Among 5 of 7 patients (71%) with \( S,L,L \), the SPs were successfully ablated at the posteroseptum in 2, one anterior to CSO, the other at the edge of CSO (slow-slow variant); 3 patients crossed over to the midseptum after failure of posteroseptal SP ablation and also had SPs eliminated (Figure 3,4). In the patient with slow-slow variant, ablation at the edge of CSO eliminated both antegrade and retrograde SPs. During radiofrequency energy delivery, accelerated junctional beats with retrograde conduction were induced in all these 5 patients. The QRS morphology of junctional beat was equal to that during tachycardia and sinus rhythm.

In patient No.8 with two anatomically separate His potentials recorded, the electrophysiological study was performed using electroanatomical mapping system (CARTO XP, Biosense Webster, Diamond Bar, CA, USA). Although with accelerated junctional rhythm (QRS morphology of Type A and fusion of Type A and Type B), conventional right-sided approach failed to ablate the SP (Figure 5). When the ablation catheter was moved to the region slightly below the HBE-2, a fractionated atrial potential was recorded with a small His potential (Figure 1). SP was successful ablated at this site with junctional rhythm (QRS morphology of Type B, mean cycle length of 588 ms) observed during radiofrequency ablation (Figure 5). No attempt was made to completely eliminate one of the AVNs.
In patient No.5, although right-sided approach including midseptum and anteroseptum was performed with effective junctional ectopic beats, AVNRT were still inducible. At last, SP was successfully ablated from the left-sided postero-septal aspect of the tricuspid annulus by the transseptal approach (Figure 3,4). Junction beats with the same QRS morphology of tachycardia was still observed during radiofrequency ablation at successful left-sided ablation site.

**Ablation of SP in patients with {I,D,D}**

In 2 patients with {I,D,D}, although with induced junctional beats, radiofrequency energy delivery at the left-sided postero-septal aspect of the mitral annulus failed to ablate or modify the SP. When the ablation catheter was moved to the middle point between CSO and HBE, a fractionated atrial potential was recorded with A/V ratio < 0.5 (Figure 3,4). RFCA performed at this site eliminated SP in both patients. A junctional rhythm was also induced during radiofrequency energy application. The QRS morphology during sinus rhythm, tachycardia and junctional rhythm was equal.

**Follow-Up**

No procedure-related complication occurred in these 9 patients immediately after ablation and during follow-up. All 9 patients were free of arrhythmias without antiarrhythmic drugs during a mean follow-up of 8±4 months (median, 9; range, 4 to 12).
Discussion

Histologic studies of autopsy specimens have described the presence of twin AVNs in CCTGA\textsuperscript{11}. Electrophysiological characteristics of AV reentrant tachycardia mediated by twin AVNs have been well described\textsuperscript{8}. Limited data evaluated the feasibility of RFCA and the ideal site of SP in CCTGA \textsuperscript{3,9}. This present study demonstrated that RFCA of AVNRT in \{S,L,L\} or \{I,D,D\} is feasible. In these patients, SP input region can mainly be found in the posterior-mid septum, especially in patients with single penetrating AVNs. SP could usually be successfully ablated in these regions.

Prevalence of multiple congenital cardiac abnormalities in CCTGA

In more than 80\% cases, CCTGA is associated with multiple structural lesions including VSD and pulmonary stenosis\textsuperscript{11,17}. In addition, the size of pulmonary trunk in CCTGA is associated with the degree of septal malalignment\textsuperscript{18}. Cases with well aligned septums often had atresia or stenosis of pulmonary trunk. However, in our cases, the incidence of multiple congenital cardiac abnormalities is low (22\%). The reason for this discrepancy may be related to all our cases composed of adult survivals. Two case presentations of AVNRT in CCTGA provide further supports to our speculation\textsuperscript{3,9}.

The AV conduction system in CCTGA

Among 8 of 9 patients (89\%, 6 \{S,L,L\} and 2 \{I,D,D\}) in the present study, a single His
potential recorded and maintenance of unique QRS morphology during sinus rhythm, tachycardia and junctional rhythm indicated that a single penetrating AVN existed. All single His potentials were recoded from the conventional position in Koch’s triangle. Junctional rhythm was induced during RFCA at the posterior-mid septum in all 8 cases. This finding is in agreement with the pathologic literature and intraoperative mapping data which suggest that the AVN is typically found in the conventional location in Koch’s triangle for \{I,D,D\} hearts\textsuperscript{10,19}. However, in our 6 cases of \{S,L,L\}, the course of penetrating His bundle was not mapped and catheter mapping really does not pinpoint the AVN location. Therefore, we can neither conclude that a normally located posterior AVN gives rise to the single penetrating His bundle, nor exclude the AVN actually is anterior as Anderson et al. and Dick et al. have shown\textsuperscript{11,12}. Twin AVNs was inferred in one patient (11\%) with \{S,L,L\} from the following electrophysiological characteristics: (1) three types of QRS morphologies appeared during both sinus rhythm and junctional rhythm: Type A, Type B and fusion of both, (2) two anatomically separate His potentials recorded, (3) a shift from Type A to Type B in QRS morphology when the refractory period of the primary conduction pathway in a single site was reached, and (4) during energy application, junctional rhythm was recorded both from two separate positions related to the two separate HBEs\textsuperscript{3,20}. Normal frontal axis in Type A was consistent with conduction over the posterior AVN, and inferior axis in Type B consistent with conduction over the anterior AVN.
The incidence of twin AVNs in CCTGA was 11%, similar to that previously reported\textsuperscript{11}.

**RFCA of AVNRT and the ideal site of SP ablation in CCTGA**

Recently, Eisenberger et al. demonstrated SP could be successfully ablated at the posteroseptal area in a patient with \{S,L,L\}\textsuperscript{9}. In the present study, AVNRT was successfully ablated with RFCA in all 9 patients with CCTGA. Among these 9 patients, 8 (88.9\%) had SPs successfully ablated at the posterior-mid septum: 3 at the posteroseptum [2 (\{S,L,L\}) at the right posteroseptum, one (\{S,L,L\}) at the left sided posteroseptum], 5 (3 \{S,L,L\} and 2 \{I,D,D\}) crossed over to the midseptum after failure of the posteroseptal SP ablation and all had SP eliminated. SP potentials were recorded from ablation catheter before ablation in 2 cases. Junctional rhythm was observed during RFCA in all cases. No complication occurred in these 8 patients. These results indicated that both in \{S,L,L\} and \{I,D,D\}, the SP input region can mainly be found in the posterior-mid septum, pretty close to the region of SP in a normal heart. RFCA performed in these regions could usually ablate SPs successfully.

In patient No.8 (\{S,L,L\}) with twin penetrating AVNs, RFCA of AVNRT in the conventional region of SP failed. The SP was finally successfully ablated at the confluence of the pulmonary and mitral annulus, slightly below the HBE-2. This finding was in accordance with that described by Tada et al. in a \{S,L,L\} patient with twin AVNs\textsuperscript{3}. In the case which they studied, His potential was not recorded near the anterior AVN. However, we did find two types of
nonpreexcitated QRS morphologies during junctional rhythm recorded from ablation near the posterior and the anterior AVNs respectively. In addition, there existed fused QRS morphology during both sinus rhythm and junctional rhythm, the same with that described in our patient No.8. On the basis of these findings, we hypothesize that in \{S,L,L\} with twin penetrating AVNs, the input of SP is located near the anterior penetrating His bundle and SP could be successfully ablated in this region.

**Limitations**

The present study had several limitations. Firstly, all of data of patients with CCTGA were retrospectively analyzed, but not on the base of any histological data. Secondly, AVNRT with CCTGA is a rare condition, further study in large samples sizes is necessary.

**Conclusions**

This study demonstrated that in \{S,L,L\} or \{I,D,D\}, RFCA of AVNRT is feasible. SP input region can mainly be found in the posterior-mid septum, especially in patients with single penetrating AVNs. SP could usually be successfully ablated in these regions. Occasionally in \{S,L,L\} with twin penetrating AVNs, SP could be successfully ablated near the anterior penetrating His bundle.

**Conflict of Interest Disclosures:** None.
References:


Table 1. Basic Characteristics

<table>
<thead>
<tr>
<th>Case</th>
<th>Gender</th>
<th>Age</th>
<th>First Arrhythmia</th>
<th>Type of CCTGA</th>
<th>TVR severity</th>
<th>Associated lesions</th>
<th>Ablation Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F</td>
<td>24</td>
<td>19</td>
<td>{S,L,L}</td>
<td>Moderate</td>
<td>Slow-fast</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>44</td>
<td>38</td>
<td>{S,L,L}</td>
<td>Moderate</td>
<td>Slow-slow</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>19</td>
<td>16</td>
<td>{S,L,L}</td>
<td>Moderate</td>
<td>Slow-fast</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>18</td>
<td>15</td>
<td>{I,D,D}</td>
<td>Moderate</td>
<td>Slow-fast</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>F</td>
<td>58</td>
<td>22</td>
<td>{S,L,L}</td>
<td>Severe</td>
<td>Left-side variant</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>25</td>
<td>23</td>
<td>{S,L,L}</td>
<td>Moderate</td>
<td>ASD, VSD</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>M</td>
<td>22</td>
<td>19</td>
<td>{S,L,L}</td>
<td>Mild</td>
<td>ASD</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>F</td>
<td>27</td>
<td>21</td>
<td>{S,L,L}</td>
<td>Mild</td>
<td>Slow-fast, AP</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>M</td>
<td>47</td>
<td>40</td>
<td>{I,D,D}</td>
<td>None</td>
<td>Slow-fast</td>
<td></td>
</tr>
</tbody>
</table>

TVR = tricuspid valve regurgitation; ASD = atrial septal defect; VSD = ventricular septal defect; AP = accessory pathway.

Figure Legends:

Figure 1. Anatomical CARTO map of the morphological right atrium in patient No. 8 with {S,L,L}. (A) in the right (30°) anterior oblique and (B) in the left (45°) anterior oblique. CS=coronary sinus; His bundle 1=the posterior penetrating His bundle; His bundle 2= the anterior penetrating His bundle.

Figure 2. Electrocardiograms recorded at rest (A) with QRS morphology of Type A: atrioventricular conduction through the posterior atrioventricular node. Electrocardiograms recorded during morphological right atrial pacing at 400 ms (B): the same QRS morphology with Type A. Electrocardiograms recorded at rest (C) with QRS morphology of Type B: atrioventricular conduction through the anterior atrioventricular node. Electrocardiograms recorded during morphological right atrial pacing at 355 ms (D) with QRS morphology of Type B. Electrocardiograms recorded during tachycardia (E) show the same QRS morphology with Type B (cycle length=254ms).
**Figure 3.** Sites of successful slow pathway ablation in 8 patients with a single penetrating AVN. (A) Left (45°) anterior oblique projection illustrating the 6 successful ablation sites in 6 patients with \{S,L,L\}. (B) Right (30°) anterior oblique projection illustrating the 2 sites in the remaining 2 patients with \{I,D,D\}. AS=anteroseptal; MS=midseptal; PS=posteroseptal.

**Figure 4.** Left (45°) oblique radiographic view shows the mapping catheter (Map) and diagram at the successful ablation site in patient No. 3, No.5 and No.4: right midseptum (A), left sided posteroseptal aspect of tricuspid annulus (B) and midseptum in the morphological right atrium (C). HBE= His bundle region; MLVA= morphological left ventricular apex. Other abbreviations as in Figure 1.

**Figure 5.** Electrocardiograms of junctional rhythm in patient No. 8 recorded (A) during ablation at posteroseptum: atrioventricular conduction through the posterior atrioventricular nodes with fused QRS morphology of Type A. (B) Junctional rhythm recorded during ablation at the confluence of the pulmonary and mitral annulus: atrioventricular conduction through the anterior atrioventricular node with the same QRS morphology of Type B. LAB=ablation catheter. Other abbreviations as in Figure 1 and 4.
Jiqiang Hu, Qian Yang, Feifan Ouyang and Shu Zhang

Zili Liao, Yu Chang, Jian Ma, Pihua Fang, Kuijun Zhang, Xiaoqing Ren, Pingzhen Yang, Bo Yu, Jiqiang Hu, Qian Yang, Feifan Ouyang and Shu Zhang

Circ Arrhythm Electrophysiol. published online November 16, 2012;
Circulation: Arrhythmia and Electrophysiology is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2012 American Heart Association, Inc. All rights reserved.
Print ISSN: 1941-3149. Online ISSN: 1941-3084

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circep.ahajournals.org/content/early/2012/11/16/CIRCEP.112.976597

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation: Arrhythmia and Electrophysiology can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation: Arrhythmia and Electrophysiology is online at:
http://circep.ahajournals.org//subscriptions/