Radiofrequency catheter ablation of atrial tachycardias related to myocardial scar or incision

Jianqiang HU,1 Jiang CAO,1 Shengqiang WANG,2 Yongwen QIN,1 Bingyan ZHOU1

1 Department of Cardiology, Shanghai Hospital, Second Military Medical University, Shanghai 200433, China
2 Department of Cardiology, PLA 148th Hospital, Zibo, Shandong 255300, China

Objectives Intra-atrial re-entrant tachycardias (IARTs) are common late after heart surgery. Conventional mapping and ablation is relatively difficult because of the complicated anatomy and multiple potential re-entry loops. In this study we aimed to evaluate the electrophysiological characteristics and radiofrequency catheter ablation of atrial tachycardia (AT) induced by myocardial scar or incision.

Methods In 6 patients (three male and three female, aged 33.3±11.8 years) who had AT related to myocardial scar or incision, electrophysiological study and radiofrequency catheter ablation (RFCA) were performed. Earliest activation combined with entrainment mapping was adopted to determine a critical isthmus. Results Re-entry related to the lateral atriotomy scar was inducible in 5 of 6 patients. With entrainment mapping, the PPI (post-pacing interval)-TCL (tachycardia cycle length) difference was <30 ms when pacing at the inferior margins of the right lateral atriotomy scar. Among them, 3 patients had successful linear ablation between scar area to inferior vena cava, and 2 patients between scar area to tricuspid annulus. Re-entry involving an ASD patch was demonstrated in 1 of 6 patients. PPI-TCL differences <30 ms were observed when entraining tachycardia at sites near the septal patch. But linear ablation failed in terminating AT. There was no complication during procedure. No recurrence of AT related to incision was observed during follow-up except for the failed patient. Conclusion Under conventional electrophysiological mapping, adopting linear ablation from scar area to anatomic barrier, successful ablation can be obtained in patients with IARTs related to myocardial scar or incision. (J Geriatr Cardiol 2006;3:250-253.)

Key Words atrial tachycardia; radiofrequency catheter ablation; heart surgery

Introduction

Intra-atrial re-entrant tachycardias (IARTs) are common late after surgical repair of congenital heart disease or other heart surgery. Although catheter ablation has been remarkably successful for the management of patients with common atrial tachycardia (AT) in normal heart, conventional mapping and ablation is relatively difficult in patients with prior heart surgery because of the complicated anatomy and multiple potential re-entry loops. It is also difficult to identify a narrow isthmus with entrainment mapping alone. In order to investigate the clinical and electrophysiological characteristics of AT related to myocardial scar or incision, we reported the results of radiofrequency ablation in 6 patients with previously heart surgery and evaluate the effect of radiofrequency ablation.

Methods

Patients

In 76 consecutive patients with AT who underwent the electrophysiological study and radiofrequency catheter ablation (RFCA) from February 1997 to December 2005, 6 patients (three male and three female aged 33.3±11.8 years) had AT related to myocardial scar or incision. Among them, 4 patients were after atrial septal defect (ASD) repair surgery, 1 after ventricular septal defect (VSD) surgery, and 1 after partial right ventriculectomy because of arrhythmogenic right ventricular dysplasia (ARVD). The mean duration of symptoms was 4.5±1.9 years (range, 2-7 years). Before procedure, informed consents were obtained and antiarrhythmic drugs were ceased for a minimum of five half-lives.

Electrophysiological study

Quadrupolar electrode catheters were placed in the His bundle position and right ventricular apex, and 20-polar catheter was placed in the high right atrium along tricuspid annulus through the femoral veins. Decapolar catheter was
positioned in the coronary sinus through right internal jugular vein. Right atrial mapping was performed with an 8F ablation catheter with a 4-mm tip electrode.

Atrial overdrive pacing and right atrial extrastimuli were used to induce AT. IART was defined as a sustained (>60 s) and entrainable atrial rhythm, induced and/or terminated by pacing, independent of atrioventricular conduction, and with sudden onset and constant cycle length.

In all patients different P-wave configuration was observed during tachycardia compared with sinus rhythm. During mapping, potential obstacles to conduction (atriotomy scar, ASD patch) were identified as regions with very low signal amplitude, double potentials and striking changes in signal amplitude and/or timing, with very small changes in catheter position.

Entrainment mapping was attempted for all sustained IARTs at various sites in the right atrium according to the earliest activation site and the sites close to the areas of scar detected, including the cavotricuspid isthmus, the lateral right atrial wall and right atrial septum. The site where earliest activation detected was considered as the exit of slow conduction area. If the tachycardia was entrained, the post-pacing interval (PPI) was measured. If PPI-TCL (tachycardia cycle length) difference was <30 ms, pacing site was considered in the re-entrant loop.

Radiofrequency ablation

Ablation sites were selected as follows: 1) the earliest activation site; 2) the site was in the circuit by entrainment mapping; 2) the site was between two unexcitable regions (scar, valve annulus or great vessel), creating an isthmus that could be transected. Radiofrequency energy (10 to 50 W; maximal temperature, 60°C) was delivered during tachycardia. The power was progressively increased until a temperature of >50°C was reached.

The end point of ablation was tachycardia termination and completion of the series of radiofrequency lesions across the critical isthmus. For ablation across the cavotricuspid isthmus, bi-directional conduction block was assessed during pacing from the coronary sinus and low lateral right atrium.

After ablation, attempts were made to re-induce tachycardia, using two to three atrial extrastimuli at two paced cycle lengths, as well as burst atrial pacing. Ablation was considered successful if no sustained monomorphic IARTs were inducible after the ablation procedure.

Results

Characteristics of atrial tachycardia

In 6 patients, both extrastimuli and rapid stimulation initiated sustained atrial tachycardia easily. The mean tachycardia cycle length was 263.3±14.7 ms. Local bipolar activation electrograms at the earliest site were consistent with an area of slow conduction because local potentials were of longer duration and lower amplitude.

Re-entry related to the lateral atriotomy scar was inducible in 5 of 6 patients and was the most common circuit found in the study group. With entrainment mapping, the PPI-TCL difference was <30 ms when pacing at the inferior margins of the right lateral atriotomy scar (Fig. 1). Re-entry involving an ASD patch was demonstrated in 1 of 6 patients. PPI-TCL differences <30 ms were observed when entraining tachycardia at sites near the septal patch.
inferior leads, but in inferior leads positive amplitude was smaller than those in sinus rhythm. P-wave was negative in aVR, positive component followed by negative component in V1 and became positive in left precordial leads. In 1 patient whose tachycardia was related to the ASD patch, the P waves were negative in leads I, aVL, and isoelectric and lower positive in inferior leads. P-wave was isoelectric in aVR, positive component followed by negative component in V1 and became negative in left precordial leads.

Radiofrequency ablation

During linear ablation, AT terminated abruptly in 2 patients, after transient acceleration in 1 patient, and after transient slow-down in 2 patients.

AT related to the lateral atriotomy scar terminated in 3 patients during linear ablation between scar area to inferior vena cava, and in 2 patients during linear ablation between scar area to tricuspid annulus. But in 1 patient whose AT was related to an ASD patch, ablations performed from the ASD patch to the superior vena cava, inferior vena cava and tricuspid annulus all failed in terminating AT. No complication was observed during ablation procedure.

Follow-up

During a follow-up period of 30±29 months without antiarrhythmic medications, none of the 5 patients had recurrent AT related to incision. One patient had atrial flutter during the follow-up and underwent another electrophysiological study, which showed cavotricuspid isthmus-dependent atrial flutter with PPI-TCL differences <30 ms when pacing at cavotricuspid isthmus (Fig. 2), and linear ablation between the tricuspid annulus and inferior vena cava was performed successfully. No recurrence was found for this patient during another follow-up of 14 months.

Discussion

Radiofrequency catheter ablation of IARTs are always considered as a challenge in patients with previously heart surgery, because of complicated anatomy, multiple circuits and broad re-entry paths. Delacretaz et al.,1 in their study of patients with previously repaired congenital heart disease, identified three general right atrial tachycardia circuits: 1) lateral wall circuits with re-entry around or related to the lateral atriotomy scar which was the commonest and had higher success rate of ablation; 2) septal circuits with re-entry around an ASD patch which may be difficult in ablation because left atrial septum might be involved in circuits; and 3) typical flutter circuits utilizing the isthmus between the tricuspid annulus and inferior vena cava. Several studies,2,3 reported the similar results. Markowitz et al.4 reported lesional tachycardias related to mitral valve surgery. Macro-re-entrant circuit was mapped involving lesions both in the lateral wall of right atrium or left atrium septum and right pulmonary veins corresponded to atrial incisions or cannulation sites.

In our study group, IARTs related to the lateral atriotomy scar in 5 patients were successfully ablated and no recurrence was observed during a followed-up period of more than 2 years, which was consistent with previously reported results. Although the population of our study was small, we had some findings regarding the electrophysiological study of IARTs.

Unlike that in typical flutter, P waves during IARTs were relatively definitive and had isoelectric line between two nearby P waves in the inferior leads. Our explanation for this phenomenon is that re-entrant circuits in AT are smaller than those in typical flutter. IARTs related to the lateral atriotomy scar had a characteristic P-wave morphology, by which the site of circuit could be located roughly. But fusion was difficult to assess by body surface ECG during entrainment mapping, because the pacing artifact and/or QRS complex often obscured the P waves.

In our experiences, on the basis of understanding of abnormal anatomy, earliest activation combined with entrainment mapping is a useful measure to determine the critical isthmus. Careful design and absolute completion of ablation lines is important in preventing AT recurrence.

Although entrainment mapping allows localization of the substrate supporting macro-re-entry and design of an ablation strategy, there are several limitations. First, although we could locate the site in the re-entry circuit by the PPI-TCL difference, we were not sure about whether the site is a narrow isthmus or a broad path. Second, it is difficult to identify exact catheter positions in relation to anatomic barriers, because visualization fluoroscopically of these barriers is not possible. Now these problems have been partially solved by new techniques.

The three-dimensional electroanatomic mapping system enables detailed mapping of the heart chambers, with accurate localization of anatomic barriers and zones of scar. It also improves understanding of the clinical mechanisms of IART circuits in patients with congenital heart disease and the relations of these circuits to the underlying atrial myocardial substrate.1,4,5,8,9 In addition, irrigated ablation catheter creates deeper and wider lesions, which are useful in some cases with critical isthmus involves thick scar tissues or myocardium. It was reported that these novel techniques might contribute to shorter fluoroscopy times and higher success rate of ablation.12,13

Success rates and recurrence rate varied in previously reported studies of RFCA for incision-related atrial tachycardia.1,4,5,14 Many factors may contribute to this difference, such as the ablation method, application of novel technologies, the underlying disease and the nature of the remote surgical procedure, and the length of follow-up. By use of novel techniques, high success rate of >90% could be achieved. Arrhythmia recurrence after an initially suc-
cessful ablation procedure often indicate the presence of other re-entry circuits in the scarred atrium.

In our study, radiofrequency ablation failed in 1 patient with IART related to atrial septum. We found that it was impossible to define an entire re-entry circuit in this case, possibly because a portion of it was beneath the patch or involved the left atrial side of the septum.

In summary, surgical incisions for heart surgery provide a substrate for atrial arrhythmias and macro-re-entrant may be the main mechanism contributing to AT. Ablation of macro-re-entrant atrial tachycardia is feasible and facilitated by a mapping approach that combines entrainment with activation mapping. If a critical isthmus is identified, successful ablation can be achieved by a series of linear lesions between two unexcitable regions (scar, valve annulus or great vessel).

References