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Segmental radiofrequency ablation of pulmonary vein ostia for patients with refractory paroxysmal atrial fibrillation using multi-slice spiral computed tomography guidance

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Abstract: Objective: To evaluate the safety and clinical efficacy of segmental radiofrequency ablation of pulmonary vein (PV) ostia for patients with refractory paroxysmal atrial fibrillation (AF) under multi-slice spiral computed tomography (MSCT) guidance before the procedure. Methods: A series of 58 consecutive patients with refractory paroxysmal AF were enrolled to undergo segmental radiofrequency ablation of PV ostia. The 36 male and 22 female patients with mean age of (57.4±9.5) (32~79) years and no obvious organic heart disease. Before ablation, patients received MSCT to generate 3-dimentional image of the left atrium (LA) and proximal PVs. Patients then underwent segmental radiofrequency ablation of PV ostia using PV circular mapping catheter manipulated several times to ensure complete isolation between PVs and LA. Results: No complications occurred during the procedure. One patient developed delayed cardiac tamponade, which was drained percutaneously. The mean follow-up time was (17.1±9.3) months. Forty-one patients (95%) experienced improved quality of life one month after the procedure. Thirty-six patients (83%) showed stable sinus rhythm, while 10 patients (23%) required additional anti-arrhythmic drugs. AF returned≥1 time in 6 (14%) patients who underwent anti-arrhythmic drug therapy, but the number of episodes was less than that before the procedure. However, one patient experienced recurrent episodes of atrial flutter. Conclusion: It is safe and effective to perform segmental radiofrequency ablation of PV ostia for patients with refractory paroxysmal AF using MSCT guidance mappening.

Key words: Atrial fibrillation, Pulmonary vein, Radiofrequency ablation, Multi-slice spiral computed tomography
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INTRODUCTION

Pulmonary veins (PV) may play an important role in both the initiation and maintenance of paroxysmal atrial fibrillation (AF) (Fynn and Kalman, 2004). Curative treatment of patients with paroxysmal AF is possible by radiofrequency ablation, making segmental or linear lesions around the ostia of PVs using a 3-dimentional mapping system (Carto) (Pappone *et al*., 2000; 2001; Oral *et al*., 2003). Multi-slice spiral computed tomography (MSCT) could generate a 3-dimentional image of left atrium (LA) and proximal PVs (Wood *et al*., 2004; Jongbloed *et al*., 2005). The aim of this study was to evaluate the safety and clinical efficacy of segmental radiofrequency ablation of PV ostia for patients with refractory paroxysmal AF using MSCT guidance before the procedure.

MATERIALS AND METHODS

Selection of patients

Inclusion criteria: (1) age ≥30 years, but ≤80 years; (2) refractory or drug-intolerant paroxysmal

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AF; (3) minimum of one episode per month; (4) no obvious organic heart disease; (5) written informed consent. Exclusion criteria: (1) obvious organic heart disease or hyperthyroidism; (2) incessant AF; (3) thrombosis in LA; (4) severe systemic disease, including but not limited to: malignancy, renal failure (serum creatinine>25 mg/L); (5) pregnancy; (6) hypersensitive to contrast; (7) refusal to undergo or intolerance to, the ablation procedure. On the basis of the above criteria, 58 patients with refractory paroxysmal AF were enrolled to undergo segmental radiofrequency ablation of PV ostia between October 2002 and November 2004 in Sir Run Run Shaw Hospital. There were 36 men and 22 women with mean age of (57.4±9.5) (32~79) years. Except for 30 patients with hypertension, no organic heart disease was found. Their average history of AF was (5.5±5.1) (1.1~20.0) years. The episode was more than once every month. They were either intolerant of or resistant to, multiple anti-arrhythmic drugs.

Procedure approach

The patients underwent 16 detector row spiral CT (computed tomography) scannings on regular sinus rhythm to reconstruct a 3-dimentional structure of LA and all proximal PVs before the ablation procedure. Ostia were measured in one direction (superior-inferior) with MSCT (Figs.1, 2 and 3). Pre-procedure patient preparation and mapping protocol is described in Yang *et al.*(2003). Left atrial catheterization was done by a trans-septal route with a standard Brockenbrough needle and a long sheath. Under the guidance of ablation catheter, the long sheath was inserted into the PV. PV mapping and ablation was done according to following protocol: left superior→left inferior→right superior→right inferior. The size of the circular mapping catheter was chosen according to the measurement of PV diameter by MSCT and retrograde PV angiogram. The circular mapping catheter was placed exactly at the ostium of the PV. A standard or an irrigated-tip ablation catheter was used. The ablation target was the junction of PV and LA. Radiofrequency energy was applied in temperature-controlled mode, with a power limit of 40 W, a target temperature of 50 °C for the standard catheter and 45 °C for the irrigated-tip ablation catheter. PV potential disappearance after thirty-second ablation was considered effective, and further ablation was delivered at the same focus for 90~120 s. The PV circular mapping catheter was manipulated several times to ensure there was complete isolation between the PVs and the LA. Successful PV isolation was defined according to the following criteria: PV

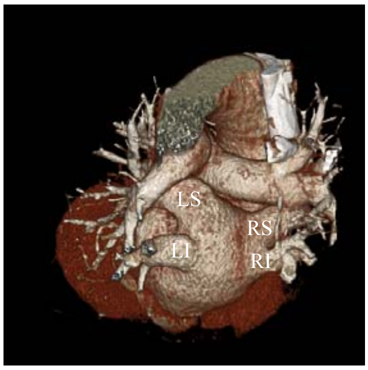

Fig.1 An MSCT 3-dimentional structure of LA (posterior to anterior view)
LS: Left superior PV; LI: Left inferior PV; RS: Right superior PV; RI: Right inferior PV

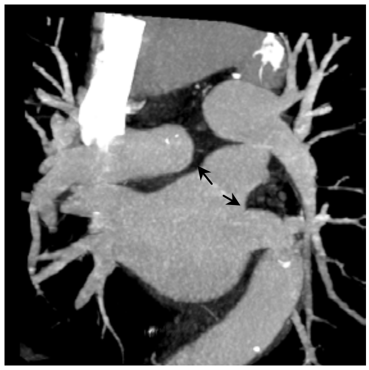

Fig.2 Measurement of left superior PV ostium diameter in MSCT

Fig.3 Measurement of right superior PV ostium diameter in MSCT

potential completely disappeared under distal coronary sinus pacing for left PVs and under sinus rhythm or proximal coronary sinus pacing for right PVs, and no atrial capture of spontaneous PV potential or PV pacing. Retrograde PV angiogram was repeated to determine if there was significant PV stenosis after successful PV isolation. After finishing all ostial segmental ablation, mapping all PV ostia was repeated and additional radiofrequency energy was delivered if there was restoration of PV potential. Both procedure time and X-ray exposure time were recorded.

Follow-up and end points

Serious complications during the procedure include: obvious pulmonary stenosis (≥50%) or occlusion, arterial thrombosis, or cardiac tamponade. The procedure was considered successful if the patient became asymptomatic without any anti-arrhythmic drug, improvement of quality of life, no recurrence of AF lasting >30 s during post-discharge follow-up. The procedure was considered effective if there was improvement of symptoms and quality of life, the AF episodes became less and shorter than pre-ablation whether the patient was on or off anti-arrhythmic drug.

RESULTS

The diameter of PV ostium on MSCT was as follows: left superior PV (18.2±2.4) mm; left inferior PV (16.1±2.3) mm; right superior PV (15.6±2.2) mm; right inferior PV (14.4±2.4) mm. No clot was found in the LA of all patients.

All patients received a single segmental radiofrequency ablation of PV ostia. Thirty-one patients were mapped with a fixed circular mapping catheter, 27 patients with an adjustable circular mapping catheter. Thirty-seven patients were ablated using a standard temperature-controlled catheter, 21 patients using an irrigated-tip catheter. Mean procedure time was (149±26) min, and mean X-ray exposure time was (57±12) min. There were totally 191 PVs isolated successfully, 58 left and right superior PVs respectively, 53 left inferior PVs, and 22 right inferior PVs. No energy was applied to 21 right inferior PVs with no pulmonary vein potential. Twenty-two patients developed AF during the procedure, 19 patients recovered to sinus rhythm spontaneously. However, three patients still had AF after the ablation procedure, and the arrhythmia was terminated by direct-current shock.

No serious complication occurred during the procedure. Fourteen hours after the procedure, one patient developed delayed cardiac tamponade, which was drained transcutaneously. All patients were routinely given anticoagulation therapy of warfarin after the procedure, maintaining INR at 2.0~3.0. Fifty-two patients took anti-arrhythmic drugs initially after the procedure (43 patients on amiordarone, 9 on propafenone). The mean follow-up duration was (17.1±9.3) months. Forty-one patients (95%) experienced improvement of quality of life one month after the procedure. Twenty-six patients (60%) were free of recurrence without anti-arrhythmic drugs. Ten (23%) had no episode, but were on anti-arrhythmic drugs. Six (14%) had recurrent AF with fewer and shorter episodes. One patient (2.3%) had recurrent episodes of atrial flutter.

DISCUSSION

It is safe and effective to perform PV ostia isolation under 3-dimentional reconstruction of LA by MSCT scanning for patients with refractory paroxysmal AF. Three-dimensional MSCT of the PVs and LA provides the necessary anatomic information (location, and angulation of PVs and their ostial branches unobscured by adjacent cardiac and vascular anatomy) for successful radiofrequency ablation of pulmonary vein ostia. The MSCT scanning and postprocessing techniques used for pre-radiofrequency ablation planning are straightforward (Lacomis *et al.*, 2003). With pre-procedure 3-dimentional reconstruction of LA, it is easy to manipulate catheters in the LA. It helped get the circle of the circular mapping catheter to the correct position and reduce contrast injection times, so that the volume of contrast and the X-ray exposure time used during the procedure is reduced. Mapping and ablation is difficult in the inferior PVs, especially the right inferior PV. Recognizing the anatomical relationship between right superior and inferior PV before procedure makes the procedure easier.

However there is a limitation on the getting 3-dimentional image of LA by MSCT so far. Patients should be in sinus rhythm without premature contractions during CT scanning. Otherwise, the 3-dimentional LA cannot be reconstructed accurately.

Careful ostial ablation is the key for success. It is difficult to put the circular mapping catheter exactly at the ostium of the PVs with the current catheter design. Two pitfalls of this catheter are: (1) The circle of the mapping catheter may be deep in the PVs. For example, there is no significant mark between LA and right superior PV on the X-ray. Therefore, it is hard to determine if the mapping catheter was located exactly at the ostium of the right superior PV. When the mapping catheter was deep in the vein, the PV potential became lower or even disappeared. Ablation at this site could result in PV stenosis or occlusion. Complete PV isolation is impossible because there is residual PV proximally which still could induce AF. It may be one of the reasons why success rate of segmental ostial ablation is lower compared with that of circumferential ablation. (2) There was relatively a large angle between the circle plane of the mapping catheter and the one of PV ostium. i.e, the circle plane of the mapping catheter was hard to get parallel to the ostium plane of the right inferior PV because of the current catheter design. In order to overcome these pitfalls, every PV should be mapped at least twice as follows: mapping→ablation→mapping again→ablation again. The final goal is total PV isolation. Tritto *et al.*(2004) found that adenosine may transiently or permanently re-establish LA to PV conduction after apparently successful PV isolation. Therefore, after completing all PV isolation, all PVs should be inspected once again and additional ablation may need to be applied until total isolation between PVs and LA if there was re-establishment of LA to PV conduction.

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