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Ultrasound ablation of pulmonary veins for treatment of paroxysmal atrial fibrillation

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Abstract: Objective: to evaluate the efficacy and safety of ultrasound ablation of pulmonary veins for treatment of paroxysmal atrial fibrillation. Methods: The study population consisted of 9 patients with 5 males and 4 females enrolled consecutively who had idiopathic paroxysmal atrial fibrillation(AF). The ultrasound balloon was positioned through a special sheath to the orifice of the target vein by a transseptal procedure. The balloon was inflated with contrast-mixed saline (contrast: saline = 1:4) whose volume was decided by the diameter of the target pulmonary vein. The ablation energy was usually set up at 35 to 40 watts with temperature controlled at 60℃. The duration of each ablation was about 120 seconds which was repeated not over 10 times. Results: The average duration of the total procedure was 132 ± 68 min for our patients. The average fluoroscopy time was 33 ± 17 min. With a mean follow-up of 16 ± 8 months after the procedure, AF was completely eliminated in 4 patients without antiarrhythmic drugs. The episodes of atrial fibrillation were eliminated in 2 patients with low dosage of oral amiodarone (0.1, once daily) which was ineffective before the procedure. The frequency of episodes was similar to that before the procedure in 3 patients. There were no complications such as hemopericardium, air embolism and stenosis of the pulmonary veins by angiography, related to the procedure. Conclusion: Ultrasound ablation of the pulmonary veins is a new approach to treat paroxysmal atrial fibrillation. Before we determined its value, we need to do more researches with bigger sample, randomization and comparison design.

Key words: Ultrasound ablation, Paroxysmal atrial fibrillation, Pulminary veins
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INTRODUCTION

Most paroxysmal atrial fibrillation is activated by atrial ectopies originating in the pulmonary veins. Several researches demonstrated that almost 50% of focal atrial fibrillation originates in the left superior pulmonary vein and about 30 % in the right superior pulmonary vein (Haissaguerre *et al.*, 1998; Chen *et al.*, 1999). Radiofrequency ablation has been used to isolate the conductivity of pulmonary vein potential or eliminate the potential. However, the procedure was limited by a high percentage of recurrence and unknown frequency of stenosis of the pulmonary veins (Haissaguerre *et al.*, 1998; Chen *et al.*, 1999).

Initial animal studies demonstrated that the ultrasound ablation of pulmonary veins may be a safer procedure with acceptable successful rate than radiofrequency catheter ablation. During the last year, we followed up 9 patients on whom we inplemented ultrasound ablation of the pulmonary veins for treatment of paroxysmal atrial fibrillation. The results are reported here.

METHODS

Patient selection

The study population consisted of 9 patients with 5 males and 4 females enrolled consecutively (Table 1) who met the following criteria: having idiopathic atrial fibrillation resistant to more than two drugs and at least 2 episodes of atrial fibrillation every week, and providing consent form. The average age of the population was 53.4 ± 5.2 years. Except 2 patients with mild primary hypertension, there were no overt heart disease in the other 7 patients. The average duration of atrial fibrillation was 4.3 ± 3.7 years in the patients.

Table 1 Patient characteristics and follow-up post ultrasound ablation

Case	Gender	Age	Pulmonary Potential Spike post procedure	Length of follow-up	Result
1	Male	40	Persisting in RSPV[a]	28 months	Recurrence
2	Female	51	Elimination in all 3 veins	28 months	No episodes of AF
3	Female	41	Elimination in all 3 veins	28 months	No episodes of AF
4	Female	68	Elimination in all 3 veins	22 months	No episodes on low dosage of amiodarone
5	Female	47	Persisting in LSPV[b]	22 months	No episodes
6	Male	46	Persisting in LIPV[c]	11 months	Recurrence
7	Male	50	Elimination in all 3 veins	6 months	No episodes on low dosage of amiodarone
8	Male	52	Persisting in LSPV	6 months	Recurrence
9	Female	65	Elimination in all 3 veins	6 months	No episodes of AF

[a] RSPV: right superior pulmonary vein; [b] LSPV: left superior pulmonary vein; [c] LIPV: left inferior pulmonary vein

Electrophysiological study and ultrasound ablation procedure

Two multielectrode catheters were introduced percutaneously through the femoral veins: one catheter in the coronary sinus and the other in the right ventricular apex. Quadripolar roving ablation catheter with a thermocouple or an A-focus circular mapping catheter was introduced to the pulmonary veins by transseptal way through left the No. 1 Swartz sheath for mapping the pulmonary vein muscle potentials.

A special sheath for the ultrasound balloon was introduced along a two and half-circle wire to the target vein and then the balloon was positioned through the sheath at the orifice of the target vein. The balloon was inflated with contrast-mixed saline (contrast: saline = 1:4) whose volume was decided by the diameter of the target pulmonary vein. After the balloon was fixed in the ostium of the pulmonary vein, angiography of the pulmonary vein was done through the sheath to view the image of the balloon to make sure it was attached very tightly to the wall (Fig. 1). Then, the balloon catheter was connected to the IBI-2000 ultrasound generator. The ablation energy was usually set up at 35 to 40 watts with temperature controlled at 60 ℃. The duration of each ablation was about 120 seconds. The ablation was usually repeated at one target point for 3 times and then the electrophysiological mapping was repeated (Figs. 2a and 2b). If the muscle potential spikes still existed or were not isolated, the ablations would be repeated for an other 3 times. At one targeted point, the ablation was usually not repeated over 10 times. However, the right lower pulmonary vein was not ablated in all cases because the ultrasound balloon was too stiff to enter the right lower pulmonary vein.

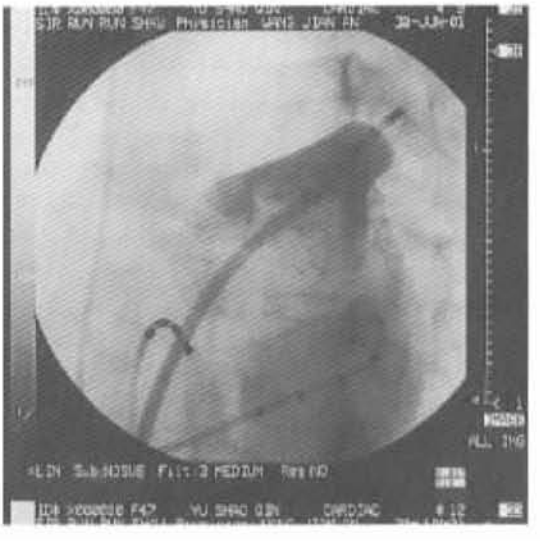

Fig. 1 Ultrasound balloon is inflated in the ostium of the left superior pulmonaryvein. Angiography shows no contrast into the main branch of the vein because the inflated balloon blocks the ostium of the vein

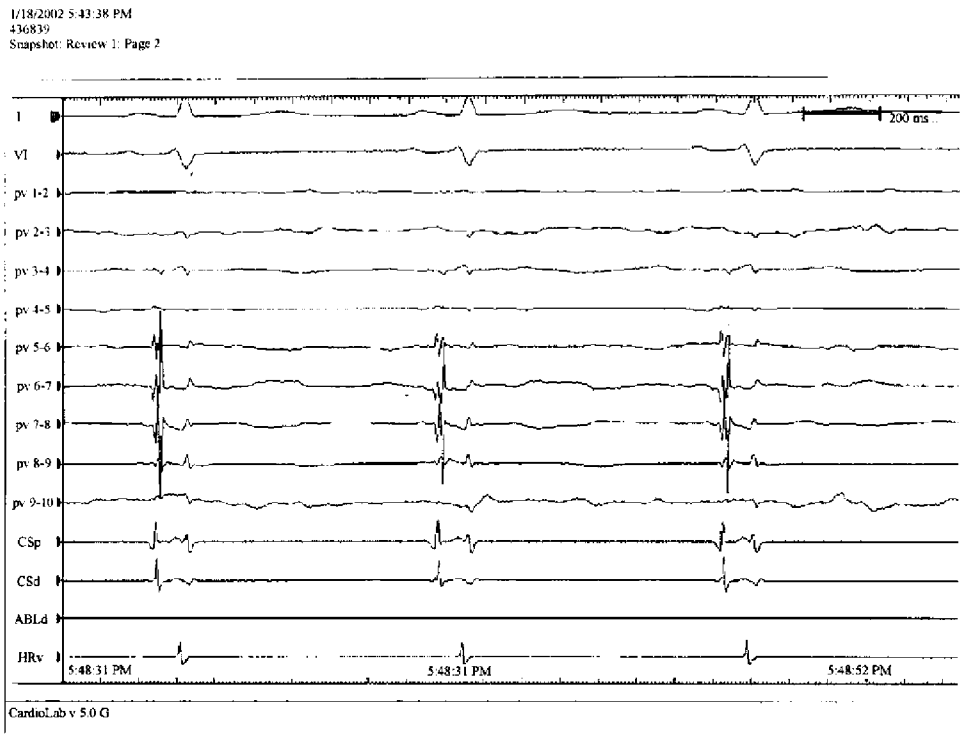

Fig.2a The spike potentials are very clear on lead 5 – 6, 6 – 7, 7 – 8 and 8 – 9 before ultrasound ablation in LSPV(in the front of the left lung)

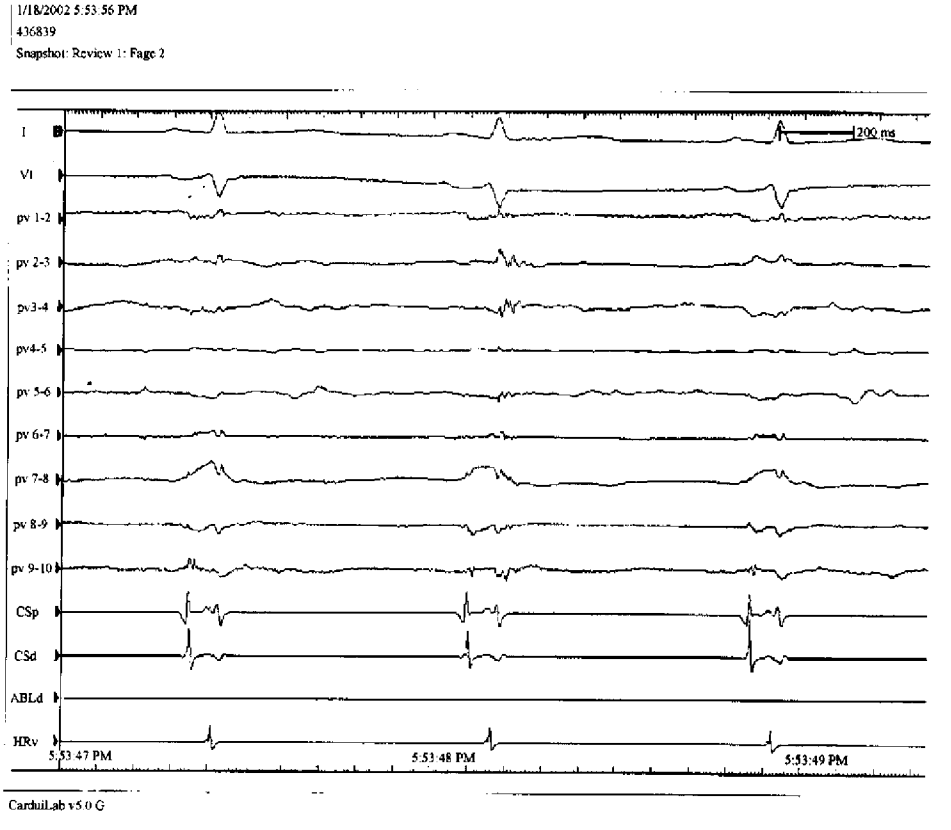

Fig.2b The spike potentials on lead 5 – 6, 6 – 7, 7 – 8 disappear after the ultrasound ablation in LSPV(in the rear of the left lung)

RESULT

The average duration of the total procedure was 132 ± 68 min for our patients. The average fluoroscopy time was 33 ± 17 min. The follow-up results were given in Table 1. With a mean follow-up of 16 ± 8 months after the procedure, AF was completely eliminated in 4 patients without antiarrhythmic drugs. The episodes of atrial fibrillation were eliminated in 2 patients with low dosage of oral amiodarone (0.1, once daily) which was ineffective before the procedure. The frequency of episodes was similar to that before the procedure in 3 patients. There were no complications such as hemopericardium, air embolism and stenosis of the pulmonary veins by angiography related to the procedure.

DISCUSSION

Radiofrequency ablation may cause stenosis of the pulmonary veins. Usually the radiofrequency ablation procedure takes longer time, because the ablation catheter must be fixed point to point around the ostium of the veins (Haissaguerre *et al*., 2000b). Ultrasound ablation is simpler than radiofrequency ablation. The average duration of the whole procedure was much shorter than that reported before (Haissaguerre *et al*., 2000a). The procedure seemed safer than that for the radiofrequency ablation of the pulmonary veins. In our patients, there was no narrowing of the pulmonary veins. Haissaguerre reported stenosis in 6 ablated pulmonary veins in 86 patients (Haissaguerre *et al*., 2000a). The possible reason for unsuccessful cases is one or all of the following factors. First, we did not achieve the extinguishment or dissociation of electrical potentials in all pulmonary veins ablated in some patients. Table 1 shows that patients with complete dissociation of pulmonary vein potentials had better results than those without complete dissociation. Higher energy and more delivery of the energy may be needed to ablate the ostium of pulmonary veins in some patients. The ultrasound balloon must be improved in design to make it attach more tightly to the wall of the pulmonary veins. We could not ablate the right inferior vein because the ultrasound balloon was not flexible enough to be manipulated into the right pulmonary inferior vein. There had been some success in diminishing still further the low incidence of AF originating in the right inferior pulmonary vein. Finally, the focal atrial fibrillations mechanism is still not very clear and some of them may originate outside the pulmonary veins.

In conclusion, ultrasound ablation of the pulmonary veins is a new approach to treat focal atrial fibrillation. Before we determined its value, we need to do more researches with bigger sample, randomization and comparison design.

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