ORIGINAL ARTICLE

Echocardiography-guided Radiofrequency Catheter Ablation of Atrioventricular Node and VVI Pacemaker Implantation

T Guo, Y Wang, Q-Y Dai, M-H Han, S-M Li, L Zhao, Z-M Liu

ABSTRACT

Objective: *This study is to evaluate the feasibility and safety of intracardiac radiofrequency catheter ablation (RFCA) of the atrioventricular node (AVN) and pacemaker implantation using transthoracic echocardiography.*

Methods: *Eleven patients – six males and five females (mean age 66 years) – with persistent or permanent atrial fibrillation/atrial flutter received RFCA of AVN and VVI pacemaker implantation (paces and senses the ventricle and is inhibited if it senses ventricular activity). Under transthoracic echocardiography, the electrode catheters were positioned intracardiac, and target ablation was performed, with the permanent pacemaking catheter in the left subclavian vein and the ablation catheter in the right femoral vein. The multi-view imaging and dynamic observation applied during the stable AV dissociation were successful.*

Results: *Atrioventricular node ablation and permanent pacemaker implantation in 11 patients were completed successfully without X-ray exposure. The operation success rate was 100%. All patients recovered well within the follow-up period.*

Conclusions: *Radiofrequency catheter ablation of AVN and VVI pacemaker implantation under transthoracic echocardiography guidance is a safe, easy and feasible approach. This procedure could be an important supplemental measure to catheter ablation of arrhythmia under routine X-ray fluoroscopy.*

Keywords: Catheter ablation, echocardiography, X-ray fluoroscopy

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INTRODUCTION

Ultrasonic orientation is relatively difficult in visualizing the ablation catheter *via* the femoral, descending aorta, aortic arch, aortic ring, or left ventricle to atrioventricular ring targets when operators are unfamiliar with the intracardiac catheter technique. When patients have emphysema or obesity, ultrasonic images of endocardiac catheters are not very clear, resulting in prolonged operation time and even affecting the success rate of the operation. With the development of three-dimensional ultrasonic image reconstruction technology and equipment, the above limitations may be overcome.

At present, nearly all radiofrequency catheter ablation (RFCA) cases are performed under X-ray fluoroscopy. Damage from the rays during the operation is unavoidable for surgeons and patients. The huge, expensive equipment and complicated operation process have made the procedure extremely unpopular (1–3). Since 1981, some scholars have used transthoracic echocardiography (TTE) to guide right ventricular pacemaker electrode orientation and labelling electrode orientation, suggesting the feasibility of TTE in the RFCA of the atrioventricular node [AVN] (4–7). However, knowledge about TTE guiding the RFCA of the AVN has been limited. In the present study, we used RFCA of AVN guided by TTE (8–11).

SUBJECTS AND METHODS

Consecutive patients who met the inclusion criteria were included in this study. This study was approved by the Institutional Review Board and Ethics Committee of the 1st Hospital Affiliated to Kunming Medical College, and all study subjects signed informed consent for participation in the study and all treatments performed. Eleven subjects were recruited: six males and five females aged 48 to 76 (average

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age 66) years. Among the subjects, five had hypertension, two had pulmonary heart disease, one had rheumatic heart disease (mitral stenosis and mitral incompetence), one had congenital heart disease and had recently come from an operation for repair of arterial septal defect, one had hyperthyroid cardiomyopathy, and one had polymyositis. All the patients agreed to accept RFCA of the AVN and implantation of VVI pacemaker (paces and senses the ventricle and is inhibited if it senses ventricular activity) because of persistent or permanent atrial fibrillation/atrial flutter, which rendered the use of three or more anti-arrhythmic drugs ineffective in controlling ventricular rate. A HP5500 coloured ultrasonic cardiograph (USA), 12-lead physiology record/stimulating/radiofrequency system (detecting head frequency of 2.5 MHz), Cordis four-pole labelling electrode and non-thermal-control common 'big tip' electrode were used. This study was conducted in accordance with the Declaration of Helsinki.

Following routine cardiac intervention, the subjects were placed in a sterilized isolation bed in the cardiac coloured ultrasonic room. Real-time simulation of two-lead electrocardiogram (ECG) was then built. A lead II ECG signal was introduced into the ultrasonic system and displayed simultaneously in the same screen with the cardiac section. A transfusion passage and an oxygen aspirator were created. The left anterior section of the chest and right inguinal region were sterilized, isolated, and anaesthetized. By puncturing the left subclavian vein, the permanent pacemaker electrode catheter was inserted to complete electrode positioning according to the previously mentioned method, hence building a protective temporary pacemaker *via* this catheter (Fig. 1).

The ablation electrode catheter was inserted into the right femoral vein 40 cm deep to examine if a 'comet-tail' image of the ablation electrode catheter 'big tip' is visualized in the superior/inferior vena cava and right atria. The "big tip" is then pressed into the cavity of the right ventricle (Figs. 2 and 3). The tricuspid ring and atrioventricular septum were clearly displayed in the subcostal four-chamber and parasternal four-chamber sections. The ablation catheter was withdrawn near the decussation formed by the atrioventricular septum and mitral-tricuspid ring and septal tricuspid under the attachment of the membranous part of the ventricular septum. The 'big tip' was adjusted to record a clear and large His bundle potential, then withdrawn slightly to make the His bundle potential decrease markedly but not disappear (Fig. 4). The ablation catheter was applied to the ventricular septum and fixed where the swing of the atrial wave was much smaller than that of the ventricular wave.

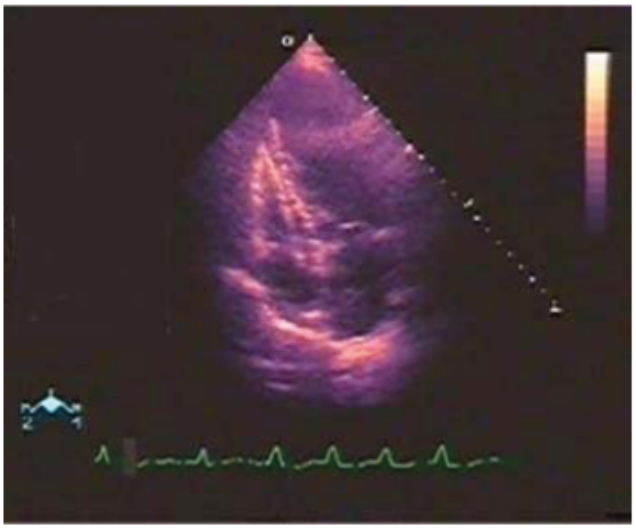

Fig. 1: Apex four-chamber view. Pacing electrode was satisfactorily positioned.

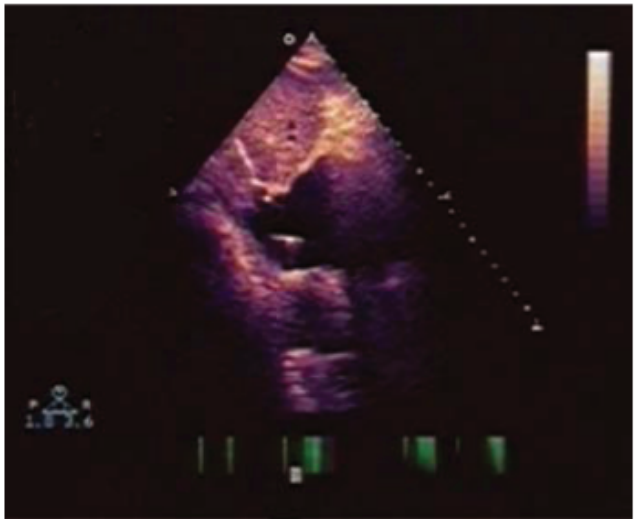

Fig. 2: Subcostal long axis view; movement of J-shaped wire from superior vena cava into the right atrium.

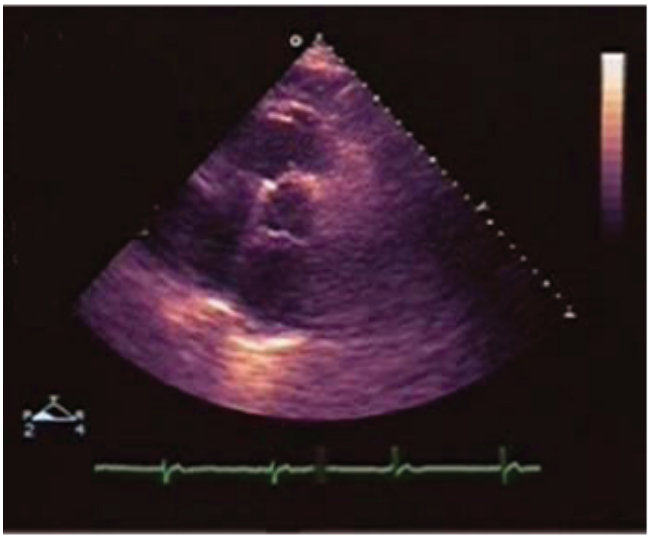

Fig. 3: Right ventricular outflow tract short axis view. Location of ablation catheter.

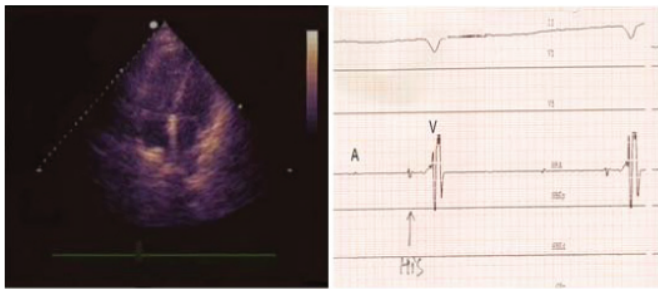

Fig. 4: Apical four-chamber views: tip of ablation catheter located closely in the membranous septum under the tricuspid leaflet. His bundle electrogram was stable.

Ablation was attempted at 15 W under successive ultrasonic monitoring. The power was increased to 40 W when the R-R wave prolonged substantially. Discharge was maintained to produce a stable lead III. Atrioventricular block (AVB) was the aim under the protection of temporary pacing, and then stabilization was attempted with a 90-second ablation performed twice. If there was no sign of R-R interval elongation after an attempt for 10 seconds, discharging was stopped and a target would be relocated. A search for a new target was conducted if no sign of R-R interval elongation could be detected.

If no satisfactory His bundle potential was traced by repeated orientation, ablation was applied where the 'big tip' was located in the septal valve zone of the tricuspid ring and pierced into the endocardium. The proximal and distal portions both showed small atrial waves and big ventricular waves. The proximal atrial wave was much bigger than the distal atrial wave, and the proximal atrial wave was more stable.

Each time before discharging, the long-axis section of the right-ventricle outflow tract was used to prevent the 'big tip' from getting into the outflow tract or pulmonary artery. During discharge, successive ultrasonic monitoring was used to assure that a smog-like echo poured out from the 'big tip' and flowed to the right-ventricle outflow tract, the 'big tip' did not shift, and the ECG kept a stable atrioventricular wave amplitude rate throughout the entire operation (Figs. 5 and 6). The patient should not experience any malaise. If one of the criteria of successful ablation failed, then discharging should be stopped and the procedure should be relocalized. Whether the ablation electrode should be sent into the right ventricle to create temporary protective pacing depends on the heart rate of the patient after the operation. In the current study, a VVI pacemaker was connected to the permanent pacing catheter and buried into a subcutaneous bag, saturated and gave proper fixation. After determining that the permanent pacing system had good responsiveness, the catheter in the right femoral vein was pulled out and pressure applied to the puncture point. All patients were prescribed bed rest and three days' intravenous antibiotic therapy. Patients without recurrence and complication were discharged with a

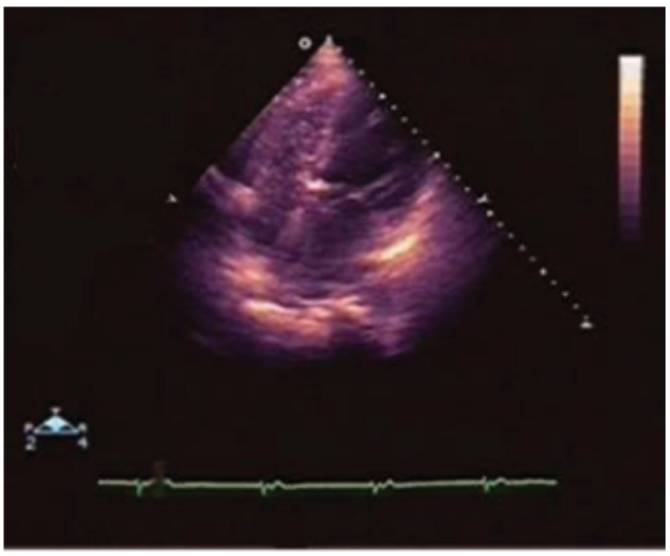

Fig. 5: Apical four-chamber view: smog-like echo ultrasound contrast in right ventricle when ablation electrode was discharging efficiently and tightly, showing the strong 'electric drying' effect.

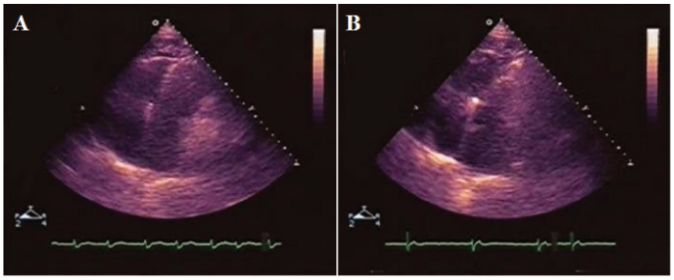

Fig. 6: Apical four-chamber view. (A) Strong echo detected in target area after successful ablation. (B) Tip of ablation catheter synchronized with cardiac motion because of thermal adhesion with myocardial tissue.

follow-up. The patients' dynamic and common ECGs were examined throughout the follow-up period (Fig. 7).

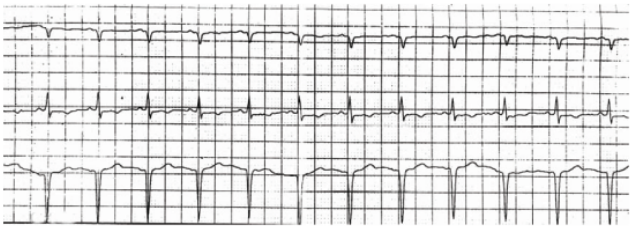

Fig. 7: Holter showed sinus rhythm after intracardiac ablation.

RESULTS

Eleven patients completed the AVN operation and VVI pacemaker implantation guided by TTE, with a 100% operation success rate. Pacemaker thresholds and impedances ranged from 1.5 V to 2.5 V and from 400 Ω to 600 Ω. Signs of power release could be seen in the ultrasonic section during discharging, that is, a smog-like echo poured out from

the apical portion of the 'big tip' and flowed into the right-ventricle outflow tract *via* the apex of the right ventricle. When the power discharge was raised, the smog-like echo increased. After successive ablation, the endocardium echo in the target zone increased significantly (Fig. 1). The duration of the operation varied from 70 to 180 minutes (mean 100 minutes), without death and other serious complications, such as pneumothorax, lead dislodgement or infection. Eleven patients presented with stable atrial fibrillation/flutter accompanied by complete or advanced AVB, with a boundary/ventricular escape beat alternating with the VVI pacing rhythm. Among the 11 patients, the rate of boundary escape beat exceeded 60 times/minute in four patients. All 11 patients were subsequently followed-up (varying from six to 20 months (mean 12 months)). Their clinical symptoms improved without recurrence, pacemaker problems, or electrode catheter shifting. Atrioventricular conduction in one 78-year old male patient resumed on the eighth day after the operation. After six months of subsequent visits, his ventricular rate reduced from 90 times/minute (average) and 160 times/minute (fastest) to 80 times/minute (average) and 100 times/minutes (fastest) without reoperation.

DISCUSSION

Electrode catheters are made of alloy core and smooth insulated material, which make a strong interface contrast between catheter and human tissue, especially blood. Ablation electrodes take on a strong, special 'comet-tail' image in an ultrasonogram. With the help of electrophysiological orientation, such as endocardiogram examination, observation of ablation effect, and so on, the use of TTE in the RFCA of AVN can be theoretically feasible. In the current research, we successfully completed AVN ablation guided by TTE in 11 patients, indicating that ultrasound could be an effective complement and substitute to X-ray to guide the orientation of the endocardiac catheter in endocardiac radiofrequency (12–14).

The effect of endocardiac radiofrequency not only depends on the power and duration of discharge, but mainly on accurate target orientation and the degree of attachment between the ablation 'big tip' and the target (15). Noninvasive transthoracic ultrasonic examination can provide a continuous survey of the degree of attachment between the ablation 'big tip' and the target and of the state of power release, which is difficult to achieve with X-ray because of considerations of harmful radiation and catheter overheating. Ultrasound also helps overcome some problems with X-ray, such as overlapped images, inability to monitor the degree of attachment of the 'big tip', the state of power release or endocardiac 'electric desiccation' effects, and so on. These advantages of ultrasonic-guided RFCA make it possible to improve treatment effects and safety. Haemopericardium, heart perforation, and other endocardiac tissue damage are easier to diagnose. Exposure to X-ray radiation is harmful for unmarried medical workers or for those without enough protection. In some cases, when the use of X-ray is not suitable, such as during malfunction of X-ray equipment, lack of enough electric power, emergencies involving children, pregnant women, or X-ray allergies, ultrasound can be used to complete the operation. Ultrasound-guided VVI pacemaker implantation has been repeatedly proven feasible. Therefore, completing AVN ablation and subsequent VVI pacemaker implantation with noninvasive ultrasonic guidance is also feasible. This method is a safer, more effective alternative to an expensive X-ray imaging system and protective equipment. Thus, surgeons need not be burdened with heavy clothes, and operation expenses would be reduced.

Due to the lack of intuitive catheter shape and form, the duration of operation is prolonged. Erroneous determination of a 'false catheter tip, anatomic target zone, or false apex of right ventricle' may occur when the detector nod or curving catheter is inserted at an improper angle. Echocardiography and electrophysiology must be considered to distinguish the differences.

Surgeons choosing to perform ultrasound-guided operations must have rich experience in endocardiac radiofrequency under X-ray and ultrasound-guided VVI pacemaker implantation, basic knowledge of cardiac ultrasonic diagnosis, and the assistance of an experienced ultrasonic specialist (16–21). Evaluating the panorama of catheter shape, especially the position of the tip combined with endocardiac multi-lead physiology recorder, is needed to avoid the diagnosis of a 'false catheter tip', 'false apex of right ventricle', 'false anatomical target', and so on. Two important principles must be maintained: multi-section imaging and dynamic observation. A stable AV connection near the 'big tip' must be assured before and during charging using TTE in RFCA of the AVN. After a clear, large His bundle potential is observed, the ablation 'big tip' should be carefully removed. The 'big tip' should directly discharge to the target with a satisfactory atrioventricular wave swing rate when the His bundle potential nearly disappears under the high-grade AVB to make the spontaneous ectopic rhythm.

In conclusion, TTE is a safe, effective and easy approach in guiding AVN ablation. This procedure could be an important supplement to X-ray fluoroscopy in some endocardiac radiofrequency operations. The success rate of ultrasound-guided endocardiac radiofrequency operation can thus be improved, and the occurrence of complications can be reduced through multi-section imaging and dynamic observation and using three-dimensional ultrasonic imaging equipment. Ultrasound is superior to X-ray fluoroscopy in estimating the degree of attachment between the electrode and target, examining power release, enhancing the efficiency of sign and ablation and discovering complications in time. Ultrasound-guided endocardiac radiofrequency prevents X-ray radiation exposure to doctors and patients, reduces the consumption of hygienic resources, enlarges the

operation scope, and popularizes endocardiac radiofrequency. The use of the proposed method is in accord with the present heart health conditions in China.

Conflict of interest: The authors declare that they have no conflict of interests.

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