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Chapter 10

Real-time integration of intracardiac echocardiography to facilitate atrial tachycardia ablation in a patient with a Senning baffle

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Introduction

This case-report concerns a 10-year-old boy who previously underwent a Senning operation for transposition of the great arteries with an intramural course of the coronary arteries. The patient suffered from recurrent episodes of atrial tachycardia (AT) with 1:1 atrioventricular conduction which caused, in combination with dysfunction of the systemic right ventricle, hemodynamic instability. Unresponsive to antiarrhythmic drug treatment, the patient was referred to our institution for an electrophysiological study and radiofrequency catheter ablation.

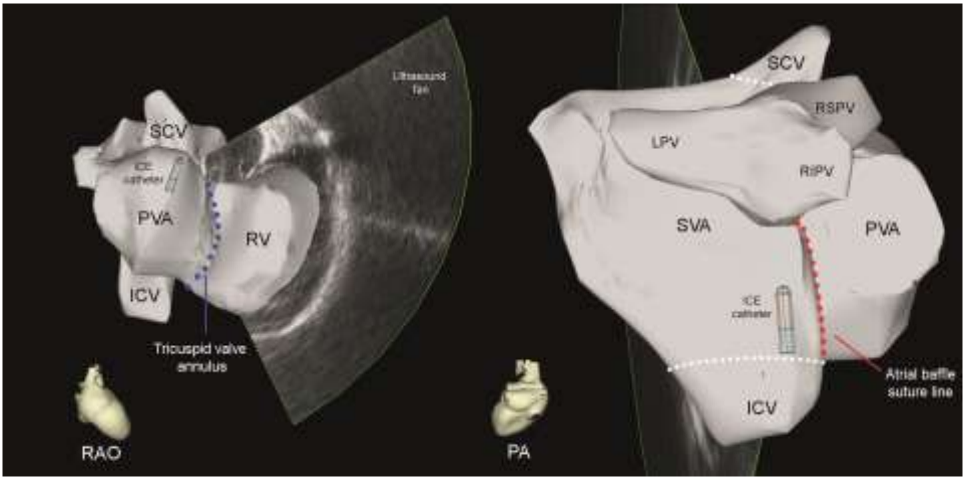

Figure 1. A three-dimensional shell of the cardiac anatomy created with intracardiac echocardiography (ICE). Positioning the ICE catheter inside the systemic venous atrium (SVA), anatomical and surgical lines of conduction block were identified such as caval veins, tricuspid valve annulus and atrial baffle suture line. ICV = inferior caval vein, LPV = left pulmonary veins, PA = posterior-anterior view, PVA = pulmonary venous atrium, RAO = right anterior oblique view, RIPV = right inferior pulmonary vein, RSPV = right superior pulmonary vein, RV = right ventricle, SCV = superior caval vein.

Electrophysiological examination and ablation

The procedure was performed under general anesthesia. Because the AT caused hemodynamic instability, the mapping procedure was aimed at identification of the arrhythmogenic substrate and critical isthmus of a presumed macro-reentrant circuit with only brief episodes of induced tachycardia. First, a registered three-dimensional (3D) shell of the cardiac anatomy was created on an electroanatomical mapping system (Cartosound, Biosense Webster, Diamond Bar, California, USA) using intracardiac echocardiography (ICE). By positioning the ICE catheter inside the systemic venous atrium, the entire cardiac anatomy could be visualized including structures that form a potential area of conduction block such as the caval veins, the tricuspid valve annulus and surgical suture lines (e.g. atrial baffle suture line)(Figure 1). Second, bipolar voltage mapping of the systemic venous atrium was performed during sinus rhythm to further evaluate the arrhythmogenic substrate and to confirm areas of conduction block caused by surgical incisions (Figure 2). An area of low voltages (>0.5 mV) and persistent double potentials was found near the inter-atrial septum, confirming the location of the atrial baffle suture line. Based on these findings and the current literature on tachycardia ablation in Senning patients,[1] a selection of potential reentry circuit isthmus sites was made (Figure 2). Subsequently, the AT was induced and reentry was confirmed as the underlying mechanism by entrainment mapping at the selected sites. The responses to entrainment are given in figure 2. Pacing near the cavotricuspid isthmus (CTI) from inside the pulmonary venous atrium resulted in identical flutter-wave (F-wave) morphology in all 12 electrocardiogram leads and a post-pacing interval similar to the intraatrial reentrant tachycardia (IART) cycle length (Figure 2), indicating a CTI dependent flutter. Most likely, the reentrant circuit involved the posterior wall of the systemic venous atrium with the atrial baffle suture line acting as the posterior barrier, the anterior septal remnant and the CTI. A linear lesion was created between the tricuspid valve annulus and inferior caval vein (Figure 3). During ablation, the IART cycle length progressively prolonged until finally the IART terminated. Importantly, in Senning patients the CTI is divided into a systemic venous part and a pulmonary venous part by the atrial baffle. To assure a complete line of block, applications were delivered on both sides of the CTI. At the end of the procedure the IART was no longer inducible. During the 5-month follow-up period no recurrences have been observed.

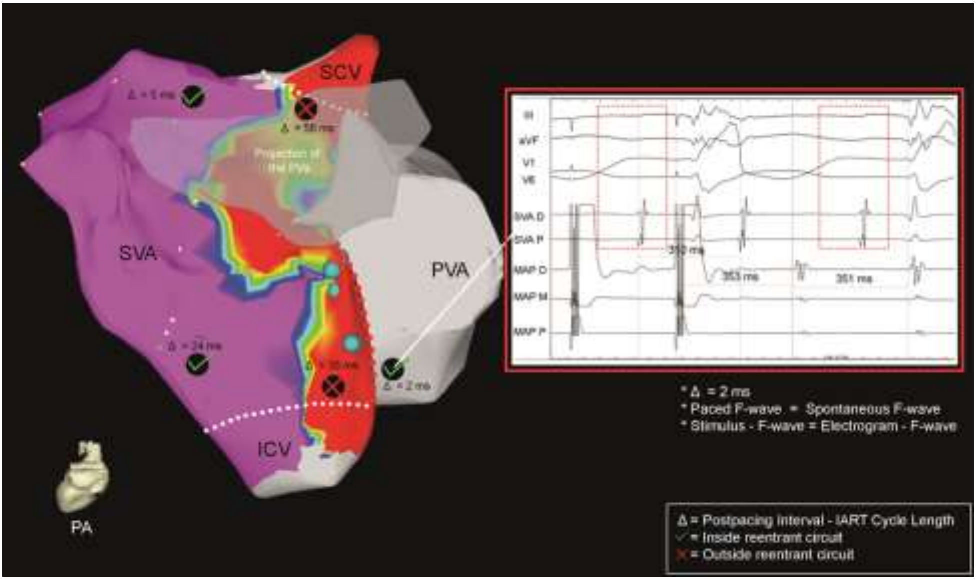

Figure 2. Bipolar voltage map of the systemic venous atrium (SVA) integrated with the three-dimensional shell of the cardiac anatomy created with intracardiac echocardiography in a posterior view. Bipolar voltages are color coded: low voltages (arbitrarily defined as <0.5 mV) are displayed in red, high voltages (≥0.5 mV) are displayed in pink. Green dots represent sites with double potentials. Black dots represent sites selected for entrainment pacing during intraatrial reentrant tachycardia (IART). For each selected site the difference between post-pacing interval and tachycardia cycle length (Δ) is given. Additionally, a tracing of the response to entrainment pacing at the cavotricuspid isthmus is given (white box). The tracing includes surface electrocardiogram leads III, aVF, V1, V6 and intracardiac recordings from the reference catheter inside the SVA and the mapping catheter (p = proximal, m = mid and d = distal). Pacing was performed from the distal electrodes of the mapping catheter (first two beats on each tracing). ICV = inferior caval vein, MAP = mapping catheter, PA = posterior-anterior view, PVs = pulmonary veins, SCV = superior caval vein.

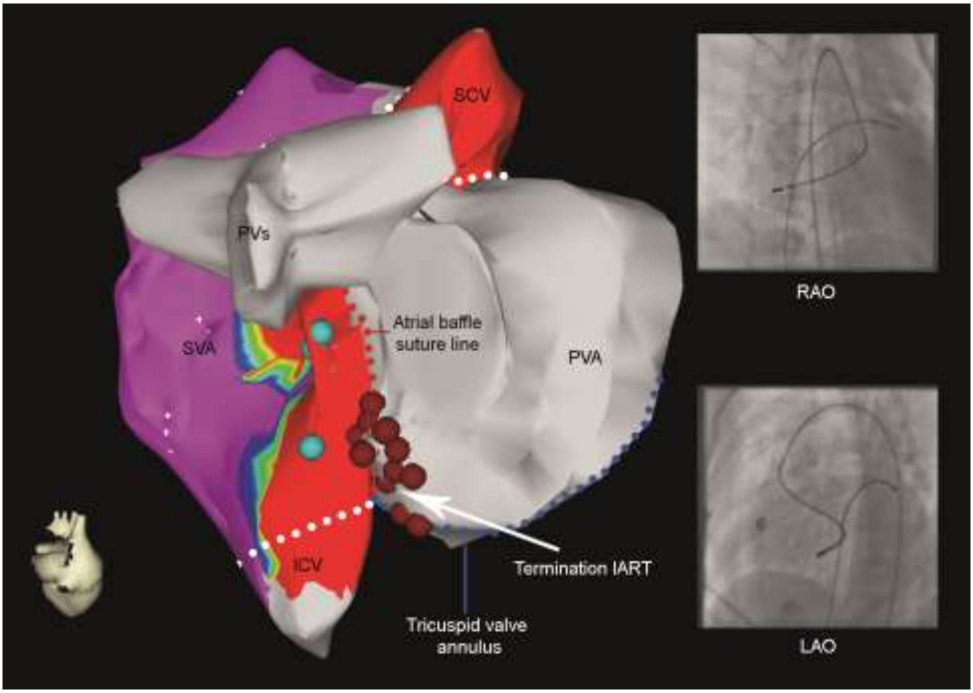

Figure 3. Map containing voltage data of the systemic venous atrium (SVA) and anatomical data acquired with intracardiac echocardiography (seen from a right posterior oblique view; color coding similar as in figure 2). The ablation catheter was positioned inside the pulmonary venous atrium using a retrograde approach. A linear radiofrequency (RF) lesion connecting the tricuspid valve annulus and inferior caval vein resulted in prolongation of the intraatrial reentrant tachycardia (IART) cycle length and eventually in IART termination (red dots represent RF ablation sites, white arrow indicates site of termination). Insets: catheter position during termination of the tachycardia on a fluoroscopic right anterior oblique (RAO) and left anterior oblique (LAO) view.

Discussion

Intra-atrial reentry is the most common mechanism for supraventricular tachycardia in patients with a Mustard or Senning baffle.[1,2] Image integration (e.g. Multi-Slice Computed Tomography and electroanatomical mapping) can facilitate the ablation of these tachycardias by visualizing the complex cardiac anatomy and its relation to the position of the ablation catheter.[3] However, the accuracy of image integration is limited by the quality of the registration process.[4] Differences in heart rate, heart rhythm and fluid status can negatively influence this process. In the present report, a new anatomical mapping technique is used to create a 3D anatomical map of the cardiac anatomy with ICE. This technique does not require a registration process and allows visualization of landmark structures with minimal radiation exposure. The anatomical information acquired with ICE in combination with rough voltage mapping enabled us to identify and confirm the critical isthmus by limited entrainment mapping at selected sites during only brief episodes of the tachycardia.

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