Atypical congenital atrial flutter unmasked by noncontact mapping

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Introduction

Identification of atrial tachycardia mechanisms on the basis of 12-lead electrocardiogram can be misleading, particularly in patients with previous atrial ablation or congenital cardiac anomalies. Even in cases of electrocardiogram appearance of typical cavotricuspid isthmus (CTI)–dependent atrial flutter, it is important to keep an open mind about other possible mechanisms. The AcQMap combined imaging and electrophysiological mapping system (Acutus Medical, Carlsbad, CA) is an emerging noncontact charge density mapping system. Its dedicated AcQMap mapping catheter (Acutus Medical) has a deployable spheroid shape formed by 6 splines, each one containing 8 electrodes and 8 ultrasound transducers. The Acutus system reconstructs 3-dimensional endocardial anatomy from reflection points marked by the ultrasound transducers and inversely derives charge density data from unipolar cavitary electrograms recorded by the noncontact electrodes. A key concept in biophysics, namely the relationship between voltage and charge, is then exploited to facilitate the visualization of high-resolution maps of arrhythmia propagation.[1–3]

Case report

A 54-year-old man presented with a history of palpitations and exertional dyspnea on a background of morbid obesity, obstructive sleep apnea, and diabetes mellitus type 2. Appearances on electrocardiogram were in keeping with typical CTI-dependent atrial flutter. Transthoracic echocardiography demonstrated elevated estimated right ventricular systolic pressures presumed to be related to obesity and sleep apnea. Following direct current cardioversion, sinus rhythm was maintained for only 1 month but was associated with significant symptomatic improvement. He therefore elected to undergo catheter ablation.

KEYWORDS Anomalous pulmonary vein drainage; Focal firing from anomalous vein; Noncontact mapping system; Typical atrial flutter; Upper loop atrial flutter
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KEY TEACHING POINTS

- Identification of atrial tachycardia mechanisms on the basis of electrocardiography can be challenging, especially in the presence of congenital heart disease.
- Noncontact mapping systems can unmask complex tachycardia mechanisms.
- Owing to the combination of highly accurate ultrasound-guided imaging and high-resolution mapping, the Acutus noncontact mapping system (Acutus Medical, Carlsbad, CA) can be particularly beneficial for detailed characterization of atrial tachyarrhythmias and choice of tailored ablation strategies.

On the day of the procedure the patient was in his clinical tachycardia (Figure 1A). Right venous femoral access was achieved. A decapolar catheter was placed to the coronary sinus via right venous femoral access and it showed a regular atrial tachycardia, with midline atrial coronary sinus activation and tachycardia cycle length of 234 ms. Atrial entrainment from the CTI was negative, suggesting an atypical atrial flutter (Figure 1B). At that time the Acutus noncontact mapping system was under trial in our center and it was fortunately used for mapping, combined with Precision mapping system, for early evaluation of the system. Ultrasound generation of the right atrial (RA) anatomy using the AcQMap catheter combined with the Acutus mapping system showed a "bulge" on the RA posterior wall that was suspicious for the antrum of an anomalous pulmonary vein draining into the RA (Figure 1C). The vein was cannulated by the ablation catheter under fluoroscopic and Acutus guidance, with fluoroscopic appearance of an anomalous right superior pulmonary vein (Figure 1D). The Acutus propagation map of the clinical tachycardia showed a complex tachycardia mechanism, consisting of a clockwise "upper loop" reentrant activity around the superior vena cava (SVC), repetitively reset every 4–6 beats by focal firing from the antrum of the anomalous right superior pulmonary vein (Figure 2A,

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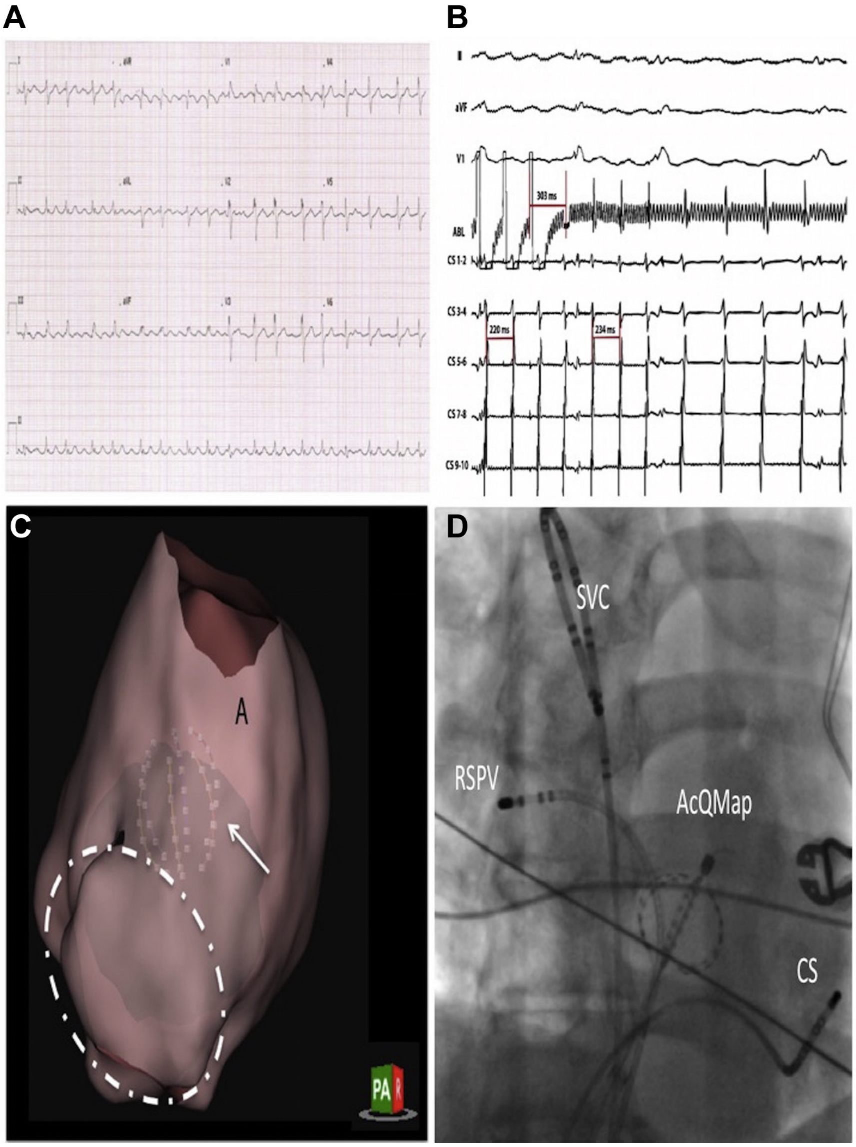

Figure 1 **A:** Electrocardiogram of clinical tachycardia. **B:** Atrial entrainment of clinical tachycardia from cavotricuspid isthmus (CTI). Intracardiac electrograms recorded in the coronary sinus (CS) demonstrated an atrial flutter with cycle length of 234 ms. Atrial entrainment from ablation catheter at the CTI showed a long postpacing interval in keeping with atypical atrial flutter. **C:** Acutus (Acutus Medical, Carlsbad, CA) ultrasound-generated 3-dimensional anatomy of the right atrium (RA). Suggestion, on the RA posterior wall, of antrum of anomalous pulmonary vein draining into the RA (*circled bulge*). AcQMap mapping catheter (Acutus Medical; *white arrow*) in RA. **D:** Confirmation of anomalous right superior pulmonary vein (RSPV) drainage. Fluoroscopic image, right anterior oblique view. Ablation catheter in the anomalous vein (RSPV), decapolar catheter in superior vena cava (SVC), quadripolar catheter in the coronary sinus (CS), AcQMap mapping catheter in the right atrial chamber.

Supplementary Video). The critical isthmus of the upper loop flutter was identified as a slow-conducting area on the posterior wall between the SVC and the inferior vena cava. After ruling out phrenic nerve capture with high output pacing, linear ablation was performed on the posterior wall through this area of slow conduction to connect the SVC to the inferior vena cava and also in correspondence with the area of firing. After the ablation, the tachycardia changed to typical clockwise atrial flutter, as proven by cycle length prolongation and now positive entrainment from the CTI (postpacing interval I identical to tachycardia cycle length; Figure 2B). CTI ablation was performed, with termination of the tachycardia to sinus rhythm.

Following discharge, cardiac magnetic resonance imaging confirmed a superior sinus venosus defect with partial anomalous pulmonary venous drainage (Figure 2C) for which he underwent a porcine patch closure with redirection of 2 pulmonary veins. On follow-up 29 months post procedure, there have been no documented arrhythmias.

Conclusions

This case shows the added value of noncontact mapping and specifically of the Acutus mapping system in diagnosis and treatment of complex arrhythmias in patients with congenital heart disease. The highly accurate ultrasound-guided imaging and the high-resolution mapping capabilities of the Acutus

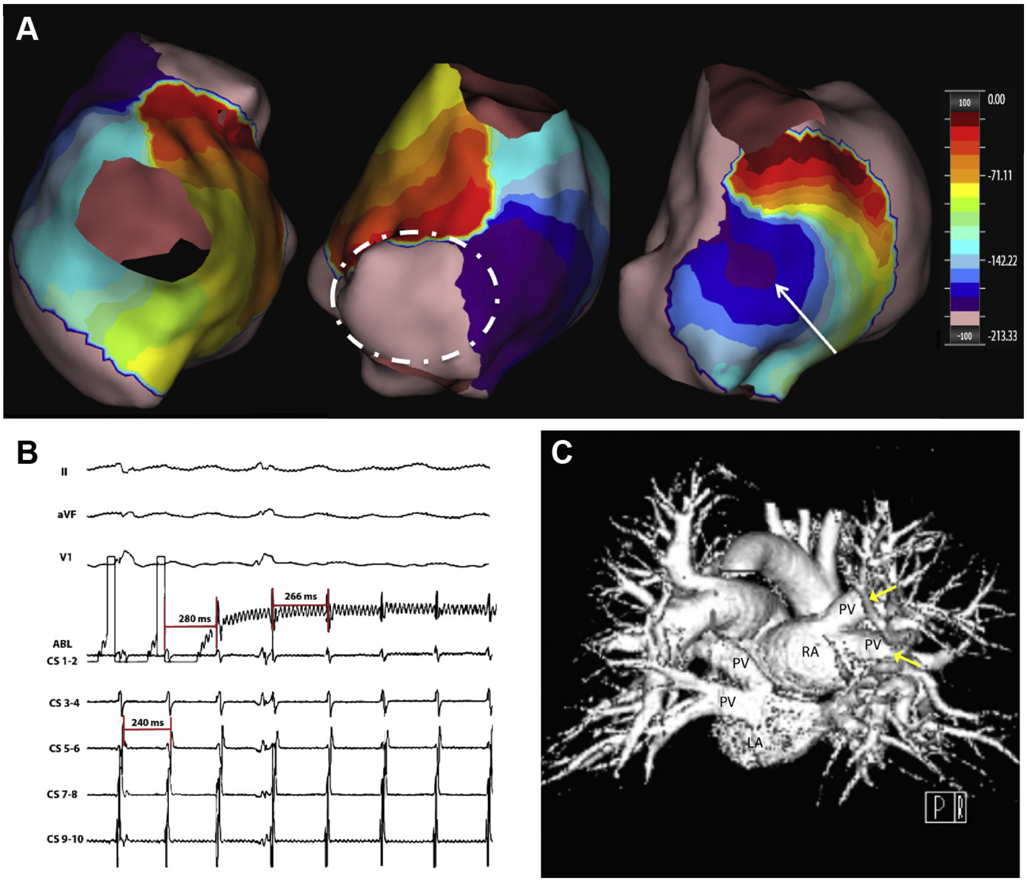

Figure 2 **A:** Acutus (Acutus Medical, Carlsbad, CA) isochronal propagation maps of clinical tachycardia. Left image: Superior view. Clockwise rotation around the superior vena cava covering 90% of the tachycardia cycle length, suggestive of upper loop atrial flutter. Middle image: Right posterior oblique view. Activation of right atrium posterior wall in absence of focal firing from the anomalous pulmonary vein. Antrum of the anomalous pulmonary vein is evident on the posterior wall (*encircled bulge*). Right image: Right posterior oblique view. Focal firing from the antrum of the anomalous pulmonary vein, with reset of the upper loop flutter. **B:** Atrial entrainment from the cavotricuspid isthmus (CTI) after intercaval ablation and suppression of focal firing. Postablation coronary sinus intracardiac electrograms showed a prolongation of the tachycardia cycle length to 266 ms. Atrial entrainment from the CTI now showed a short postpacing interval, in keeping with typical clockwise atrial flutter. ABL = ablation; CS = coronary sinus. **C:** Cardiac magnetic resonance reconstruction of the right atrium (RA), posterior view. Two anomalous pulmonary veins (*yellow arrows*) enter the posterior wall of the RA. LA = left atrium; PV = pulmonary valve; RA = right atrium.

mapping system can allow for detailed characterization of complex arrhythmia mechanisms, with tailored ablation strategies.

Appendix

Supplementary data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrcr.2020.05.007.

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