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Case Report

An unusual propagation pattern along the tricuspid annulus after cavo-tricuspid isthmus ablation: Insights into posterior transverse conduction revealed by an ultra-high-resolution 3-dimensional mapping system

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ABSTRACT

Cavo-tricuspid isthmus (CTI) ablation is a cornerstone of atrial flutter ablation. The goal of CTI-dependent flutter ablation is achievement of bidirectional CTI block. Usually bidirectional CTI block is confirmed by atrial activation during septal and lateral atrial pacing or the use of differential pacing maneuvers. According to the pathological findings, the transmural muscle fibers connect the endo- and epicardium. An epicardial-endocardial breakthrough (EEB) sometimes interferes with the confirmation of bidirectional block. Recently, a new ultra-high-resolution 3-dimentional mapping systems (Rhythmia®, Boston Scientific, Marlborough [Cambridge] MA, USA) that allows rapid ultra-high-resolution electroanatomical mapping was introduced. A 64-year-old man with a sustained atrial flutter (AFL) was referred to us. Catheter ablation was performed using an ultra-high-resolution 3-dimensional mapping system. Here, we report the case of a patient with an EEB visualized by ultra-high-resolution 3-dimensional mapping.

<**Learning objective:** The crista terminalis are recognized as the anatomic structure responsible for line of conduction block at the posterior right atrial wall. This block line is mainly functional, and transverse conduction across the posterior wall can be observed. This is the first report to visualize the EEB and examine its influence on the conventional electrophysiological findings.>

Introduction

Transverse conduction disturbance in the right atrial posterior wall has been considered to be an essential arrhythmogenic substrate for sustaining macroreentrant tachycardia around the tricuspid annulus. The goal of cavo-tricuspid isthmus (CTI)-dependent flutter ablation is achievement of bidirectional CTI block. Atrial activation during septal and lateral atrial pacing, or the use of differential pacing maneuvers, is useful in demonstrating a bidirectional block; however, epicardial-endocardial breakthrough (EEB) sometimes interferes with the confirmation of bidirectional block. Here, we report the case of a patient with an EEB visualized by ultra-high-resolution 3-dimensional mapping.

Case report

A 64-year-old man with an asymptomatic sustained atrial flutter (AFL) was referred to us. He had a history of hypertension and hyperuricemia. His blood pressure was 139/80 mmHg; heart rate was 92 bpm; oxygen saturation was 98% on room air; and body temperature was 36.3 °C. Chest X-ray revealed no evidence of cardiomegaly or pulmonary congestion. The plasma brain natriuretic peptide level was elevated at 337.7 ng/L and the estimated glomerular filtration rate was decreased at 35 mL/min/1.73 m^2. Oral drug therapy included metoprolol (3.75 mg/d) and edoxiaban (30 mg/d). An electrocardiogram showed AFL (3:1 conduction) with a sawtooth pattern in the inferior leads and a

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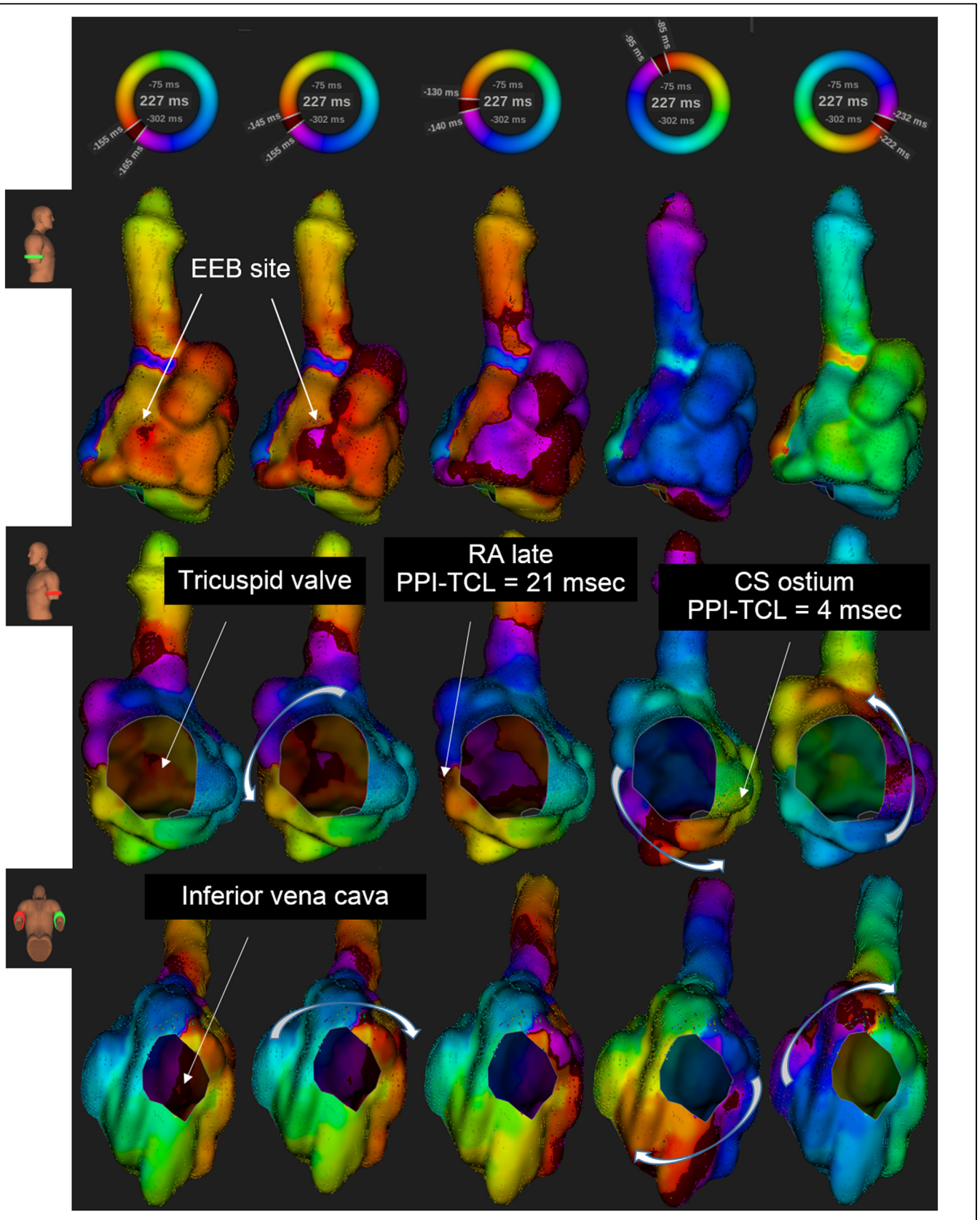

Fig. 1. Propagation maps of clinical atrial flutter: a lower loop reentry is noted to coexist with typical atrial flutter around the tricuspid annulus. A lower loop circuit contains an epicardial-endocardial breakthrough across the posterior wall.
The number of mapping points = 9051 points.
EEB, epicardial-endocardial breakthrough; RA, right atrium; CS, coronary sinus; PPI, post pacing interval; TCL, tachycardia cycle length

tachycardia cycle length of 227 msec. Transthoracic echocardiography revealed no structural abnormality. Catheter ablation to treat the AFL was initiated. A multipolar electrode catheter (BeeAT®; Japan Lifeline, Tokyo, Japan) was inserted into the coronary sinus (CS). Another multipolar "halo" electrode catheter (Livewire®, Abbott, St. Paul, MN, USA) was placed in contact with the tricuspid annulus (TA) (Fig. S1a in Supplementary material). An open-irrigated ablation catheter with a 3.5-mm tip (Thermocool®; Biosense Webster, Diamond Bar, CA, USA) was inserted via a steerable long sheath (Agilis®, Abbott). The right atrium was mapped during AFL using an ultra-high-resolution 3-dimensional (3-D) mapping system (RHYTHMIA®, Boston Scientific, Natick MA, USA) with a 64-pole mini-basket catheter (ORION®, Boston Scientific).

The propagation map revealed a double tachycardia propagating around the inferior vena cava (lower loop reentry) and the TA (typical AFL) (Fig. 1). Notably, the lower loop circuit demonstrated an epicardial-endocardial breakthrough (EEB) across the posterior wall.

Burst pacing was performed to entrain the tachycardia at multiple atrial sites (distal CS, CS ostium, and lateral right atrium (RA)) at 10–20 ms below the tachycardia cycle length. The post pacing interval was 316 ms at the distal CS, 231 ms at the CS ostium, and 248 ms at the lateral RA (Fig. 1 and Fig. S1b–d in Supplementary material). We decided to perform a cavo-tricuspid isthmus (CTI) linear ablation to eliminate both of the reentrant circuits. The tachycardia was replaced by sinus rhythm during the ablation. After completion of the linear ablation lesion, we examined if electrical conduction along the CTI line was blocked, and found that the propagation sequence around the TA under constant pacing from the CS ostium (pacing cycle length, 600 ms) demonstrated incomplete septal-to-lateral RA conduction block, with the signal recorded at the lower lateral portion of the TA (7 o'clock) being earlier than that at the mid-lateral portion (9 o'clock) (Fig. 2). Differential atrial pacing (pacing cycle length, 600 ms) from the lateral TA also showed incomplete lateral-to-septal block, with conduction time from the lateral pacing sites to the CS ostium being similar (Fig. S1e in Supplementary material). We created a right atrial map twice during CS ostium pacing and during lateral TA pacing at 600 ms. These revealed bidirectional EEB across the posterior RA wall, and bidirectional complete CTI

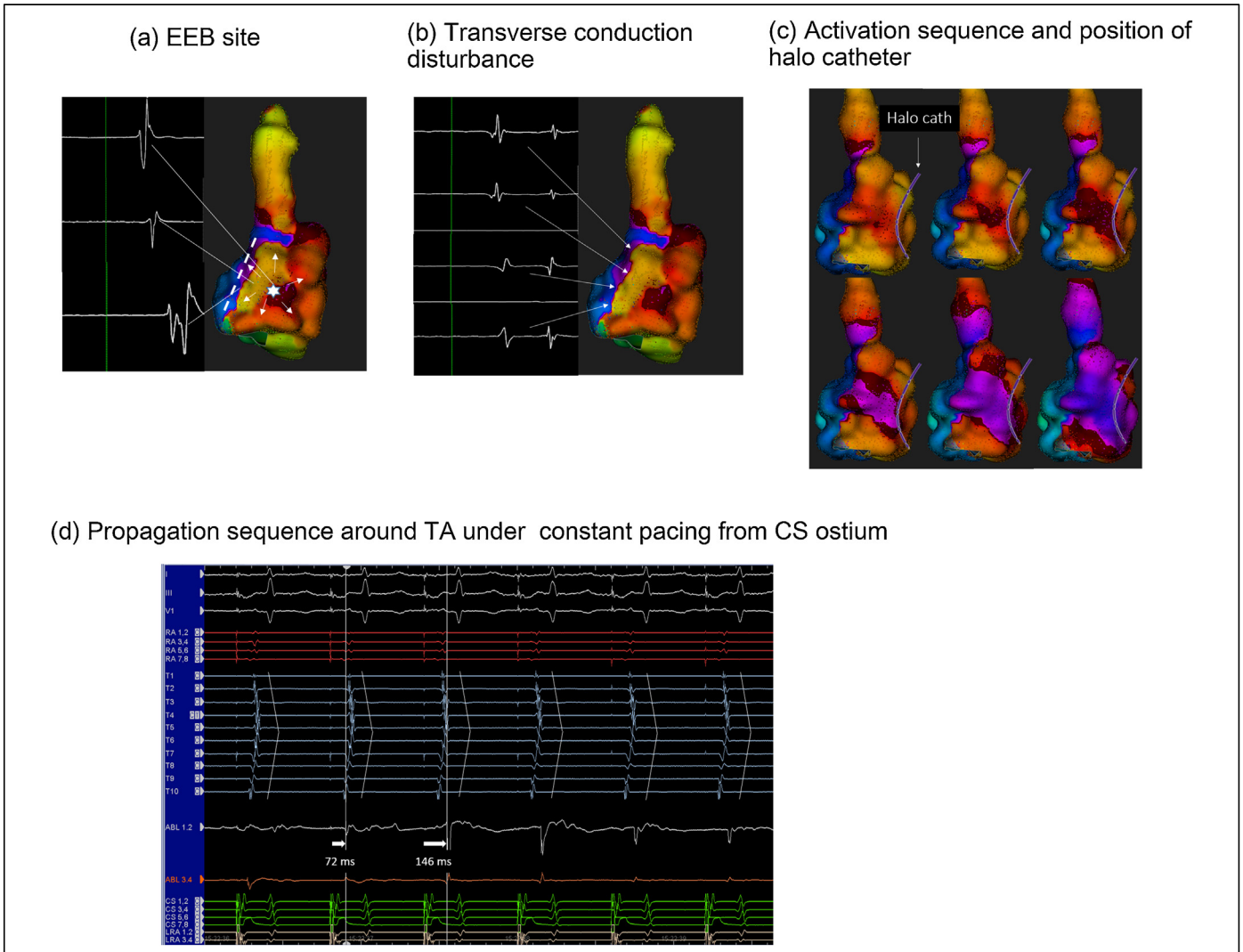

Fig. 2. Propagation maps during coronary sinus (CS) ostium pacing: (a) epicardial-endocardial breakthrough site in the posterior wall, (b) transverse conduction disturbance in the posterior wall, (c) activation sequence and position of halo catheter, and (d) propagation sequence around the tricuspid annulus under constant pacing from the CS ostium during radiofrequency application. Although the potential of the ablation catheter was delayed due to radiofrequency application, the signal recorded at lower lateral portion of the tricuspid annulus (7 o'clock) was earlier than that at the midlateral portion (9 o'clock).
The number of mapping points = 8933 points.
EEB, epicardial-endocardial breakthrough; TA, tricuspid annulus; CS, coronary sinus

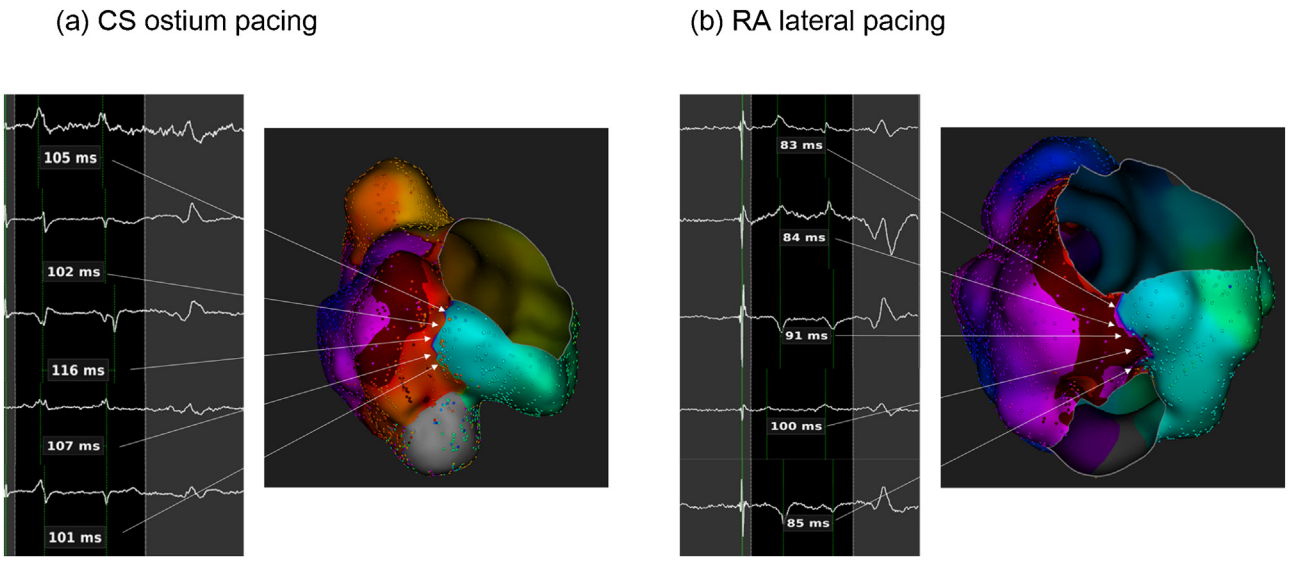

Fig. 3. Propagation maps during coronary sinus ostium pacing (a) and RA lateral pacing (b): confirmation of complete bidirectional cavo-tricuspid isthmus block. CS, coronary sinus; RA right atrium

block was confirmed (Fig. 3). In this case, posterior transverse conduction through an epicardial-endocardial connection explained the lower loop reentrant circuit of clinical AFL with an unusual propagation pattern around the TA after completion of the CTI block line.

Discussion

To our knowledge, this is the first case of a posterior transverse propagation pattern that made it difficult to confirm the bidirectional conduction block of a CTI line using conventional methodology with a TA propagation sequence.

CTI linear ablation is superior to antiarrhythmic drugs in the treatment of CTI-dependent flutter, with higher rates of maintenance of sinus rhythm and reduction in the recurrence of future atrial fibrillation [1,2]. The demonstration of bidirectional CTI block is the key goal in CTI-dependent AFL ablation. A transverse conduction disturbance in the right atrial posterior wall has been considered the critical arrhythmogenic substrate for sustaining macroreentrant tachycardia around the TA (common AFL). Bidirectional conduction block along the CTI line is usually confirmed using an approaching propagation wave toward the block line around the TA under pacing at the opposite side of the line [3]. However, a previous report suggested that transverse conduction across the crista terminalis influences the atrial activation sequence during CS ostium pacing to such an extent that it incorrectly suggests incomplete isthmus block [4].

The crista terminalis has been recognized as the anatomic structure responsible for the line of conduction block at the posterior right atrial wall [5]. It is now established that this block line is mainly functional, and transverse conduction across the posterior wall can be observed at long pacing cycle lengths or during some atrial arrhythmias, such as lower loop reentrant tachycardia [4,6,7]. Schuessler et al. demonstrated that differences in epicardial and endocardial activation patterns can occur because of the underlying anatomic architectures [8]. The transmural muscle fibers connect the endo- and epicardium. Pathik et al. reported an EEB in the right atrium using ultra-high-resolution 3-D mapping [9]. They demonstrated that EEBs could be demonstrated in 54% of 26 patients with stable right atrial macroreentry (typical AFL = 47%, lower loop reentry = 35%). The occurrence of transverse conduction across the posterior may vary depending on the type of macroreentrant mechanism.

In our case, the activation sequence around the TA during pacing at each side of the CTI line did not demonstrate the usual activation pattern with the propagation wave approaching the block line. Instead, the ultra-high-resolution 3-D mapping which contained around 9000 points visualized the transverse conduction across the posterior wall incorporating an epicardial pathway during CS ostium pacing and lateral RA pacing, suggesting that this mapping would be helpful in confirming the block line after CTI linear ablation.

Conclusions

Ultra-high-resolution 3-D mapping is useful in confirming a bidirectional block in the CTI even in the presence of transverse conduction in the posterior RA incorporating an epicardial pathway.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jccase.2018.12.006.

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