Three-dimensional electroanatomical mapping for non-pulmonary vein foci in a patient with complete situs inversus and dextrocardia

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ABSTRACT

In patients with atrial fibrillation (AF) having congenital anatomical abnormalities, such as complete situs inversus and dextrocardia, pulmonary vein isolation (PVI) ablation can be performed safety using a three-dimensional electroanatomical mapping system. However, it is not clear whether a three-dimensional electroanatomical mapping system can be used to detect non-PV ectopic beats initiating AF in patients with complete situs inversus and dextrocardia. Here, we report a 21-year-old man with complete situs inversus and dextrocardia, who showed AF caused by non-PV ectopic beats. We successfully detected the origin of the triggered activity from the non-PV foci using three-dimensional electroanatomical mapping.

1. Introduction

Pulmonary vein isolation (PVI) is a cornerstone procedure in ablation treatment for atrial fibrillation (AF). In AF patients with anatomical abnormality, such as complete situs inversus and dextrocardia, a three-dimensional electroanatomical mapping system has been shown to be useful for performing the PVI procedure [1]. Recently, several studies have addressed the importance of non-PV ectopic beats initiating AF [2]. However, there have been no reports about the effectiveness of 12-lead electrocardiography (ECG) and a three-dimensional electroanatomical mapping system for detecting non-PV ectopic beats initiating AF in patients with complete situs inversus and dextrocardia. Here, we report a rare case of AF initiated by non-PV ectopic beats in a patient with complete situs inversus and dextrocardia and present the usefulness of three-dimensional electroanatomical mapping for detecting the origin of the triggered activity from non-PV foci.

2. Case report

A 21-year-old man with complete situs inversus and dextrocardia, but without any disease linked to the disorder, was admitted to our institution for an ablation procedure to resolve persistent AF. Three-dimensional reconstruction of the right atrium (RA) and left atrium (LA) with computed tomography images was performed using an electroanatomical mapping system (EnSite*). A 5-French deflectable multipolar catheter was positioned in the coronary sinus, and a mapping catheter and probe for intracardiac echocardiography were inserted via the left femoral vein. Transseptal catheterization was guided using fluoroscopy and intracardiac echocardiography (ViewFlex™ Xtra ICE Catheter, St. Jude Medical, Inc., St. Paul, MN, USA), and contrast medium was injected into the LA through the transseptal sheath (SL0 and Agilis™, St. Jude Medical) (Fig. 2). Even after performing bilateral PVI and electrocardioversion to terminate the AF, premature atrial contractions (PACs) emerged incessantly and initiated AF.

On 12-lead ECG (standard limb and left-sided precordial lead positions), the P-wave morphology during sinus rhythm was negative in leads I and aVL, positive in leads III, aVR, and V1, and isoelectric in leads II and aVF. The PACs triggered AF exhibited positive P waves in leads III and V1, negative waves in leads I and II, and isoelectric waves in leads aVL (Fig. 3A). On opposite 12-lead ECG (left-right reversal limb and right-sided precordial lead positions), the PACs exhibited positive P-waves in leads I, II, and V1, isoelectric waves in lead aVL, and negative waves in lead III. (Fig. 3B). A biaxial standard local activation time map of the PACs was created with an electroanatomical mapping system (EnSite

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Velocity™, St Jude Medical) that indicated a centrifugal activation pattern from the atrial septum (Fig. 4A). An irrigated ablation catheter, positioned at the mid-septum of the RA (left-sided), demonstrated the earliest electrical potentials of the PACs which proceeded the potentials observed on the surface electrocardiogram by 63 msec (Fig. 4B), and radiofrequency application at that point resulted in immediate disappearance of the PACs (Fig. 5). No atrial tachyarrhythmias recurred over 24 months of follow-up.

3. Discussion

Several cases of catheter ablation for paroxysmal AF in patients with complete situs inversus and dextrocardia have been reported [1,3]. However, to the best of our knowledge, this is the first report of AF initiated by non-PV ectopic beats in a patient with complete situs inversus and dextrocardia, who successfully underwent ablation using an electroanatomical mapping system. We identified two important clinical characteristics.

First, identification of the site of PAC origin using 12-lead ECG was challenging in patients with dextrocardia and situs inversus. Yamada et al. [4] reported that the P-wave morphology of PACs triggering AF might have limited information for predicting where the PACs originate in patients with dextrocardia. In the present case, on standard 12-lead ECG (standard limb and left-sided precordial lead positions), PACs triggering AF exhibited positive P waves in leads V1 and III, negative waves in leads I and II, and isoelectric waves in lead aVL. On opposite 12-lead ECG (left-right reversal limb and right-sided precordial lead positions), the PACs exhibited positive P waves in leads I, II, and V1, isoelectric waves in lead aVL, and negative waves in lead III. Kistler et al. [5] provided a detailed analysis of the utility of the P-wave configuration for localization of atrial tachycardia origins in patents with normal heart. They stated that either a negative or biphasic (positive, and then negative) P wave in lead V1 was associated with a specificity of 100% for right atrial tachycardia and a positive or biphasic (negative, and then positive) P-wave in lead V1 was associated with a sensitivity of 100% for atrial tachycardia originating in the LA. In this case, the P waves of PACs initiating AF were completely positive in both left and right-sided V1 leads, which raised suspicion of PAC origin in the LA. According to their P-wave morphology algorithm, the crista terminalis or right pulmonary vein was considered to be suspicious for PAC origin on standard 12-lead ECG, and the left pulmonary vein was considered to be suspicious on opposite 12-lead ECG. Tang et al. [6] proposed an algorithm for predicting atrial tachycardia foci according to the P-wave configuration in lead aVL, distinguishing right from left atrial tachycardia. They stated that a negative or isoelectric P wave in lead aVL indicates left atrial

![Fig. 1.](image-url) A: Chest radiography and 64-slice multidetector computed tomography (CT) show mirror-image dextrocardia. B: Three-dimensional reconstruction of the RA and LA according to CT images.
Fig. 2. A: Direct contrast injection into the LA and PV through the transseptal sheath in left posterior oblique (35°) and right anterior oblique (45°) views. B: Three-dimensional reconstruction of the RA and LA according to CT images from the same oblique views.
LA = left atrium; RA = right atrium; PV = pulmonary vein; LAA = left atrial appendage; CS = coronary sinus; RSPV = right superior pulmonary vein; RAO = right anterior oblique; LAO = left anterior oblique.

Fig. 3. A: Sinus rhythm and premature atrial contractions (PACs) on standard 12-lead electrocardiography (ECG) (standard limb and left-sided precordial lead positions). The P-wave morphology of the PACs is positive in leads III and V1, negative in leads I and II, isoelectric in lead aVL.
B: Sinus rhythm and PACs on opposite 12-lead ECG (left-right reversal limb and right-sided precordial lead positions). The P-wave morphology of the PACs is positive in leads I, II, and V1, isoelectric in lead aVL, and negative in lead III (* PAC).
Fig. 4. A: Bidirectional standard local activation time mapping during premature atrial contractions (PACs) in left posterior oblique (30°) and right anterior oblique (45°) views. The color-coded activation sequence is shown in white to blue, demonstrating the earliest to latest excitation sites. A single area showing the earliest activation is located at the middle of the RA septal region (left-sided).

B: Catheter position at the successful ablation site in the left posterior oblique view (50°). The red dots depict the ablation line of PV isolation. The orange dot depicts the successful ablation site of the PACs. The bonus radiofrequency energy application sites are shown by the green dots. The earliest activation at the left-sided mid right atrial septum preceded the onset of the surface P wave by 63 msec.

SVC = superior vena cava; RA = right atrium; LA = left atrium; CS = coronary sinus; LAA = left atrial appendage; TA = tricuspid annulus; RSPV = right superior pulmonary vein; RIPV = right inferior pulmonary vein.

Fig. 5. Incessant premature atrial contractions (PACs) were terminated 3.8 seconds after the beginning of radiofrequency current application.
foci and a positive or biphasic P wave in lead aVL indicates either right atrial or right superior pulmonary vein foci. In this case, the PACs exhibited isoelectric P waves in lead aVL on standard and opposite 12-lead ECGs, suggesting left atrial foci according to their algorithm. Thus, although we recorded the PACs on standard and left-right reversal 12-lead ECGs, the P-wave morphology of the PACs did not fit into any diagnostic algorithms for identifying PAC origin. This might be because the difference in three-dimensional excite activation sequences in patients with dextrocardia cannot be recorded on left-right reversal 12-lead ECG.

Second, the three-dimensional electroanatomical mapping system was useful for detecting the source of non-PV ectopic beats initiating AF in patients with dextrocardia and situs inversus. Such mapping allows the determination of the precise location at which an ablation procedure should be performed either by isolating the PV or treating a non-PV arrhythmogenic site. The PV is a major site of ectopic foci that initiates paroxysmal AF, and isolation of the PV from the LA reportedly cures 70% of patients with paroxysmal AF [7]. Several studies have addressed the importance of non-PV ectopic beats initiating AF [8]. Such ectopy may arise from the superior vena cava, left atrial posterior free wall, crista terminalis, coronary sinus, ligament of Marshall, or interatrial septum. Non-PV ectopic beats from the interatrial septum are extremely rare, accounting for only 0.4% of cases of AF [9]. Thus, this case is exceptional because the patient had two very rare conditions, including complete situs inversus with dextrocardia and paroxysmal AF initiated from the interatrial septum. Three-dimensional electroanatomical mapping was a valid and feasible approach to detect the non-PV ectopic beats initiating AF in patients with complete situs inversus and dextrocardia.

4. Conclusion

The electroanatomical mapping system is useful for detecting the source of arrhythmogenic non-PV ectopic beats, particularly in patients with anatomical complexities associated with complete situs inversus and dextrocardia.

Conflicts of interest

None.

References

[1] Del Greco M, Marini M, Centonze M, Disertori M. Atrial fibrillation ablation procedure using electroanatomic reconstruction of the right and left atrium in a patient affected by dextrocardia. Europace 2009;11:1399–400.
[2] Lin WS, Tai CT, Hsieh MH, Tsai CF, Lin YK, Tsao HM, et al. Catheter ablation of paroxysmal atrial fibrillation initiated by non-pulmonary vein ectopy. Circulation 2003;107:3176–83.
[3] Yamada T, McElderry HT, Doppalapudi H, Platonov M, Epstein AE, Plumb VJ, et al. Successful catheter ablation of atrial fibrillation in a patient with dextrocardia. Europace 2009;11:1118–9.
[4] Yamada T, McElderry HT, Doppalapudi H, Platonov M, Epstein AE, Plumb VJ, et al. Focal atrial fibrillation in dextrocardia. Ann Noninvasive Electrocardiol 2009;14:301–4.
[5] Kistler PM, Roberts-Thomson KC, Haqqani HM, Fynn SP, Singarayar S, Vohra JK, et al. P-wave morphology in focal atrial tachycardia: development of an algorithm to predict the anatomic site of origin. J Am Coll Cardiol 2006;48:1010–7.
[6] Tang CW, Scheinman MM, Van Hare GF, Epstein LM, Fitzpatrick AP, Lee RJ, et al. Use of P wave configuration during atrial tachycardia to predict site of origin. J Am Coll Cardiol 1995;26:1315–24.
[7] Oral H, Knight BF, Tada H, Ozaydin M, Chugh A, Hassan S, et al. Pulmonary vein isolation for paroxysmal and persistent atrial fibrillation. Circulation 2002;105:1077–81.
[8] Takigawa M, Takahashi A, Kuwahara T, Okubo K, Takahashi Y, Nakashima E, et al. Impact of non-pulmonary vein foci on the outcome of the second session of catheter ablation for paroxysmal atrial fibrillation. J Cardiovasc Electrophysiol 2015;26:739–46.
[9] Shah D, Haissaguerre M, Jais P, Hocini M. Nonpulmonary vein foci: do they exist? Pacing Clin Electrophysiol 2003;26:1631–5.