Migration of the breakthrough: the advantage of noncontact mapping in targeting inappropriate sinus tachycardia

Çıkış noktasının taşınması: Uygunsuz sinüs taşikardisinde hedefin belirlenmesinde temassız haritalamanın avantajı

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We report on a 42-year-old female patient with inappropriate sinus tachycardia (IST), in whom an effective sinus node modification was made by using the noncontact mapping system. The patient was admitted with palpitations and a heart rate between 90-110 beats per minute (bpm). Her heart rate increased to 150 bpm during minimal exercise. After confirming the diagnosis of IST by an electrophysiological study, radiofrequency catheter ablation was performed. A color-coded isopotential map was created when the heart rate was 95 bpm and the initial breakthrough of the sinus node (SNB) was labeled. After administration of isoproterenol, a new color-coded map recording was created when the heart rate reached 160 bpm, showing a new breakthrough 24 mm away from the SNB. Radiofrequency was delivered to this region and the heart rate decreased to 120 bpm. After another infusion of isoproterenol, the maximum heart rate reached 140 bpm and another isopotential map recording was created, which demonstrated migration of the breakthrough 16 mm away from the SNB. Radiofrequency was delivered to the second site and the heart rate decreased to 90 bpm and increased to a maximum of 120 bpm after a new isoproterenol infusion. A subsequent infusion caused no increase in the heart rate, and the ablation procedure was terminated. During a follow-up of one year, the patient was in sinus rhythm with a mean heart rate of 80 bpm.

Key words: Catheter ablation; electrophysiologic techniques, cardiac; heart conduction system; heart rate; sinoatrial node; tachycardia, sinus/therapy.

Bu yazıda, uygunsuz sinüs taşikardisi (UST) nedeniyle temassız haritalama sistemi kullanarak başarılı sinüs nod takibi yaptığımız ve radyofrekans ablasyon uyguladığımız 42 yaşında bir kadın hasta sunuldu. Hasta, çarpıntı yakınması ve 90-100 atım/dk arasında olan kalp hızı ile yatırıldı. Kalp hızı hafif egzersiz sırasında 150 atım/dk ölçüldü. Elektrofizyolojik çalışmada UST tanısının doğrulanmasından sonra, hastaya radyofrekans kateter ablasyonu uygulandı. Kalp hızının 95 atım/dk olduğu anda renkli izopotansiyel harita çıkarıldı ve sinüs nodunun ilk çıkış noktası (SNÇ) işaretlendi. İsoproterenol infüzyonundan sonra kalp hızı 160 atım/dk'ya yükseldi ve yeni bir renkli izopotansiyel harita çıkarılarak, yeni çıkış noktasının SNÇ'den 24 mm uzağa taşındığı gözlendi. Bu bölgeye radyofrekans uygulamasından sonra kalp hızı 120 atım/dk'ya düştü. Tekrarlayan isoproterenol infüzyonuyla kalp hızı bu kez 140 atım/dk'ya yükseldi ve yeni bir izopotansiyel harita çıkarıldı. Bu kez de çıkış noktasının SNÇ'den 16 mm uzağa taşındığı gözlendi. İkinci bölgeye de radyofrekans ablasyon uygulaması sonucunda kalp hızı 90 atım/dk'ya geriledi ve tekrarlayan isoproterenol infüzyonuyla en çok 120 atım/dk'ya çıktı. İsoproterenol infüzyonunun tekrarının kalp hızında başka artışa yol açmaması üzerine ablasyon işlemi sonlandırıldı. Bir yıllık takibi sırasında hasta sinüs ritminde kaldı ve ortalama kalp hızı 80 atım/dk idi.

Anahtar sözcükler: Kateter ablasyonu; elektrofizyolojik teknik, kardiyak; kalp iletim sistemi; kalp hızı; sinoatriyal düğüm; taşikardi, sinüs/tedavi.

Inappropriate sinus tachycardia (IST) is a clinical syndrome characterized by high intrinsic heart rate and hypersensitivity to beta-adrenergic stimulation.[1] The most proposed mechanisms include increased sympathetic tone, increased sympathetic receptor sensitivity, blunted parasympathetic tone, and enhanced automaticity due to regional autonomic neuropathy.[2] Previously, ablation of IST by conventional mapping

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and three-dimensional nonfluoroscopic mapping have been reported.[3-7] However, migration site of the earliest atrial activation just after radiofrequency energy application reduces the success rate of intervention and increases the rate of recurrences.[4,5] In this case report, migration of the breakthrough after radiofrequency catheter ablation by noncontact mapping is presented.

CASE REPORT

A 42-year-old female patient was admitted with perplexing palpitations. The resting 12-lead surface electrocardiogram (ECG) showed the heart rate between 90-110 beats per minute (bpm), P wave axis and morphology similar to those in sinus rhythm. Her heart rate increased up to 150 bpm during minimal exercise. Secondary causes of sinus tachycardia were excluded. During 24-hour ECG Holter monitoring, the heart rate was between 90-110 bpm at rest and increased up to 150 bpm during daily activities.

An electrophysiological study was performed, during which no other tachycardia was induced by programmed atrial and ventricular stimulation. Three minutes after the infusion of isoproterenol, the heart rate exceeded 150 bpm. It was also confirmed by pacing maneuvers that this stepwise fasting tachycardia was not a re-entrant tachycardia. P wave axis and morphology did not change during tachycardia induction. After confirming the diagnosis, we terminated the electrophysiological study and decided to perform radiofrequency catheter ablation for IST at another session.

In the second session, a noncontact catheter (EnSite Array, St. Jude Medical Inc, Minnesota, USA) was placed in the right atrium via the right femoral vein. The balloon was inflated with radiocontrast-saline mixture of 7 ml. The right atrial anatomy was created with a radiofrequency ablation-mapping catheter (Mariner, Medtronic Inc, Minneapolis, USA). The junction of the superior vena cava and right atrium was labeled as the region in which the right atrial local electrocardiogram recordings vanished in maximal gain. The superior vena cava, inferior vena cava, right atrial appendage, His area, and coronary sinus ostium were marked as the anatomic landmarks. A color-coded isopotential map was created while the basal heart rate was 95 bpm (Fig. 1a). The earliest breakthrough was labeled as the breakthrough of the sinus node (SNB). Thereafter, 1 μg/min isoproterenol was administrated. A new color-coded map recording was created when the heart rate reached 160 bpm during the isoproterenol infusion. The new breakthrough at a distance of 24 mm away from the SNB was labeled as STB1 (Fig. 1b). Fourteen radiofrequency current applications were delivered to this region

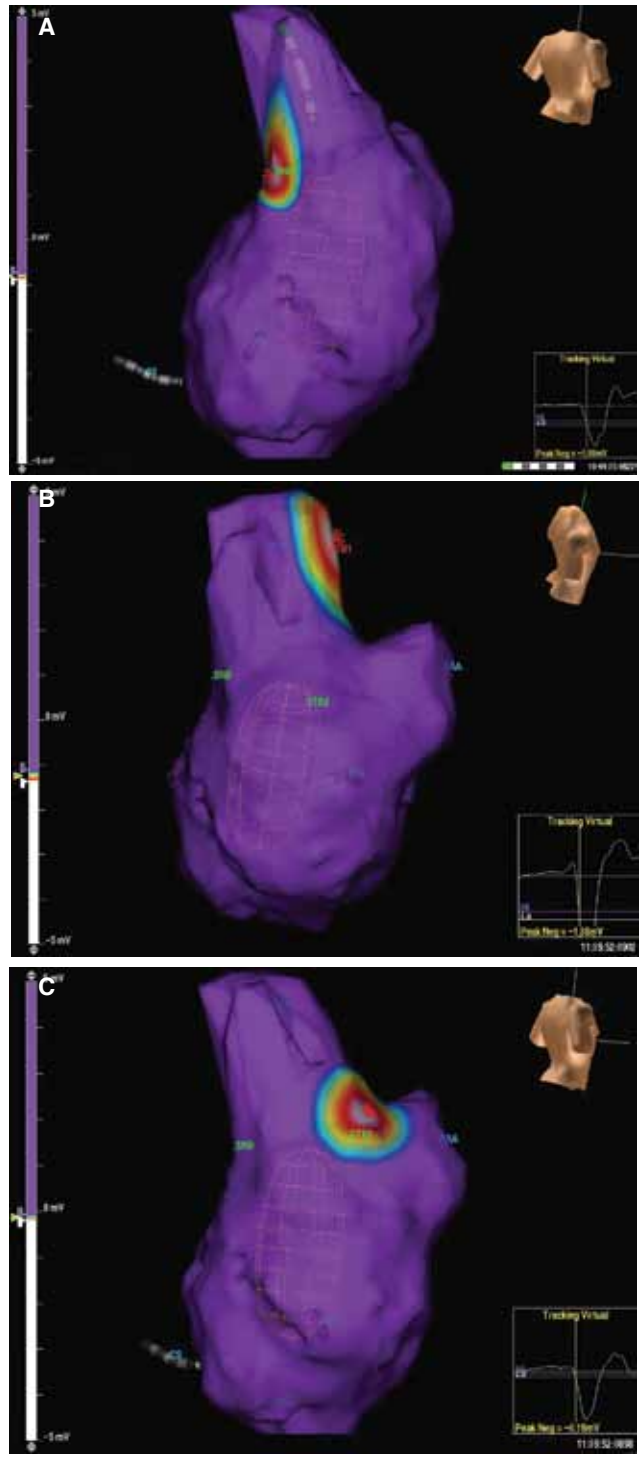

Figure 1. (A) SNB shows the breaktrough point during the basal heart rate. **(B)** STB1 shows the breaktrough point when the heart rate reached 160 bpm. **(C)** STB2 shows the breaktrough point after radiofrequency ablation (heart rate was 140 bpm).

using a 4-mm tip Mariner ablation catheter with a maximum power of 30 W and temperature of 60 °C. After the radiofrequency current application, the heart rate decreased to 120 bpm and infusion of 1 μg/min was restarted. At that time, the maximum heart rate reached 140 bpm and another isopotential map recording was created, which demonstrated migration of the breakthrough. This region was labeled as STB2 (Fig. 1c). Twenty radiofrequency current applications were delivered to the second site at a distance of 16 mm away from the SNB with the same ablation settings. After this radiofrequency application, the heart rate decreased to 90 bpm without isoproterenol infusion, and after an infusion of 1 μg/min, it increased to a maximum of 120 bpm, then the infusion dose was doubled to 2 μg/min. Since there was no increase in the heart rate, the ablation procedure was terminated. Thereafter, the patient was followed-up at three-month intervals with 24-hour ECG Holter monitoring, during which she was free of symptoms and the mean heart rate was about 80 bpm. She remained in sinus rhythm without any episodes of arrhythmia for one year.

DISCUSSION

Long-term success rates of radiofrequency ablation of IST vary between 23% and 66%.[3-5] The reason for this wide range is that the ablation of IST is a modification procedure of the sinus node rather than a focal ablation. Careful observations of ablation showed that, during tachycardia, the earliest activation site migrated to a cranial location and, after successful ablation, it moved to a caudal location.[3-5] This kind of migration of the early activation point may reflect differences in the number and/or multicentricity of subsidiary sites of impulse generation in the right atrium.[4] Ablation performed with three-dimensional nonfluoroscopic mapping demonstrated that, after isoproterenol administration, the breakthrough migrated to an anterosuperior location of up to 24 mm[6] and, after radiofrequency current application, the earliest activation site showed a caudal shift between 18 and 23 mm.[7]

In our case, the baseline SNB was on the posterosuperior of the right atrium, near the junction of the vena cava superior and right atrium, and at the site of the expected sinus node localization. After isoproterenol administration, the activation point showed an anterosuperior migration of 24 mm, as was observed by Bonhomme et al.[6] The R wave prior to Q-S morphology on the virtual electrogram recordings of the STB1 showed that the firing point was located deeply but exited the endocardium from the targeted point. After radiofrequency current application to this area, the breakthrough migrated to a more caudal location. The second region, which was labeled as STB2, was located with a distance of 16 mm anterior to the SNB. After the second set of radiofrequency current applications to the new area, the sinus rate decreased and increases in the heart rate was blunted despite isoproterenol infusion.

One advantage of noncontact mapping is the determination of the endocardial breakthrough accurately. Thus, it makes possible to determine the shift of the breakthrough and to ablate the endocardial exit points easily. Moreover, complications requiring pacemaker implantation will be avoided by being far away from the baseline sinus breakout point.

Complications may develop due to repetitive procedures of radiofrequency application and the cardiac tissue factors in this area. One of these complications is pericarditis, and the other is phrenic nerve damage. It is advocated that contraction of the diaphragm should be checked with high-output pacing pulses from the ablation catheter to avoid phrenic nerve damage. Pericarditis usually undergoes spontaneous regression. However, close follow-up is important for detecting pericardial effusion.

This case showed that radiofrequency current application of a large area might be necessary in the ablation of IST due to a wide shift of the breakthrough. With the use of the noncontact mapping system and by working far away from the sinus node, it is possible to determine the target areas of ablation more accurately and to prevent inadvertent complications such as excessive sinus slowing and sinus arrest.

REFERENCES

1. Morillo CA, Klein GJ, Thakur RK, Li H, Zardini M, Yee R. Mechanism of 'inappropriate' sinus tachycardia. Role of sympathovagal balance. Circulation 1994; 90:873-7.
2. Shen WK. How to manage patients with inappropriate sinus tachycardia. Heart Rhythm 2005;2:1015-9.
3. Lee RJ, Kalman JM, Fitzpatrick AP, Epstein LM, Fisher WG, Olgin JE, et al. Radiofrequency catheter modification of the sinus node for "inappropriate" sinus tachycardia. Circulation 1995;92:2919-28.
4. Man KC, Knight B, Tse HF, Pelosi F, Michaud GF, Flemming M, et al. Radiofrequency catheter ablation of inappropriate sinus tachycardia guided by activation mapping. J Am Coll Cardiol 2000;35:451-7.

5. Marrouche NF, Beheiry S, Tomassoni G, Cole C, Bash D, Dresing T, et al. Three-dimensional nonfluoroscopic mapping and ablation of inappropriate sinus tachycardia. Procedural strategies and long-term outcome. J Am Coll Cardiol 2002;39:1046-54.
6. Bonhomme CE, Deger FT, Schultz J, Hsu SS. Radiofrequency catheter ablation using non-contact mapping for inappropriate sinus tachycardia. J Interv Card Electrophysiol 2004;10:159-63.
7. Leonelli F, Richey M, Beheiry S, Rajkovich K, Natale A. Tridimensional mapping: guided modification of the sinus node. J Cardiovasc Electrophysiol 1998;9:1214-7.