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Three-Dimensional Nonfluoroscopic Mapping and Ablation of Inappropriate Sinus Tachycardia

Procedural Strategies and Long-Term Outcome

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OBJECTIVES We conducted this study to assess long-term results of three-dimensional (3-D) mapping-guided radiofrequency ablation (RFA) of inappropriate sinus tachycardia (IST). Change in activation after the administration of esmolol was also assessed and compared to the shift documented with successful sinus node (SN) modification.

BACKGROUND The long-term results after RFA of IST have been reported to vary between 27% and 66%.

METHODS Thirty-nine patients (35 women, mean age 31 ± 9 years) with debilitating IST were included in the study. The area around the earliest site of activation recorded using the 3-D mapping system was targeted for ablation. The shift in the earliest activation site after administration of esmolol was compared with the shift after RFA.

RESULTS The heart rate at rest and in drug-free state ranged between 95 and 125 beats/min (mean 99 ± 14 beats/min). Sinus node was successfully modified in all patients. Following ablation, the mean heart rate dropped to 72 ± 8 beats/min, $p < 0.01$. The extent of the 3-D shift in caudal activation along the crista terminalis was more pronounced after RFA than during esmolol administration (23 ± 11 mm vs. 7 ± 5 mm, respectively, $p < 0.05$). No patient required pacemaker implantation after a mean follow-up time of 32 ± 9 months; 21% of patients experienced recurrence of IST and were successfully re-ablated.

CONCLUSIONS Three-dimensional electroanatomical mapping seems to facilitate and improve the ablation results of IST. The difference in caudal shift seen after esmolol administration and following SN modification suggests that adrenergic hypersensitivity is not the only mechanism responsible for the inappropriate behavior of the SN. (J Am Coll Cardiol 2002;39:1046–54) © 2002 by the American College of Cardiology Foundation

Inappropriate sinus tachycardia (IST) is an uncommon disorder that is associated with severe disability. Usually patients with this rhythm problem have either an abnormally high resting heart rate or a disproportionate increase in heart rate in response to minimal activity (1,2). This condition is predominantly encountered in women and is clinically characterized by the occurrence of palpitation, dizziness, shortness of breath, chest discomfort and occasionally near syncope (3). It is generally differentiated from atrial tachycardia, sinus node (SN) re-entry, compensatory sinus tachycardia secondary to orthostatic hypotension or other reversible conditions on the basis of the clinical and electrocardiographic (ECG) findings, the electrophysiologic study (EPS) and the absence of partial blood pressure drop during tilt-table test (2,4,5).

Medical management of these patients includes beta-blocker as the mainstay of therapy, and in patients refractory to these drugs, catheter ablation aiming at either total exclusion and obliteration or modification of the SN has been described and performed (1,2). The initial experience with a catheter-based approach was associated with low success rate and a significant occurrence of complete destruction of the SN, necessitating permanent pacemaker implantation (6–8). In this respect, a clear definition and identification of the anatomic target to avoid complete destruction of the SN is needed. Recently, a more accurate electrophysiologic and anatomic localization of SN has been obtained combining endocardial mapping of the earliest site of activation with intracardiac echocardiography (9–11). But this approach, as reported by Shinbane and Scheinman (12), is associated with a recurrence rate of 77%. This could be explained by the inability to combine the global activation of the SN with the anatomic localization of this structure.

The purpose of this study was to evaluate the long-term efficacy and safety of the three-dimensional (3-D) nonfluoroscopic mapping and navigation system in the treatment of IST. We also assessed the effect of beta-receptor blockers on the IST during the ablation procedure. Moreover, we compared the psychological status of the patients before and after successful IST ablation.

METHODS

Patient population. Thirty-nine patients diagnosed with IST were included in this study. All patients had documentation of their arrhythmia, either by Holter monitor or loop recorder, during which correlations between symptoms and

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Abbreviations and Acronyms

CT = crista terminalis
ECG = electrocardiogram/electrocardiographic
EPS = electrophysiologic study
ICE = intracardiac echocardiography
IST = inappropriate sinus tachycardia
RFA = radiofrequency ablation
SN = sinus node
3-D = three-dimensional

the arrhythmia were documented. Thirty-three of these patients were previously treated with beta-blockers alone or in combination with calcium antagonists without any successful control of their arrhythmia. The remaining six patients elected to consider this procedure as an alternative to long-term antiarrhythmic treatment. Each patient underwent exercise treadmill test before and one month after the procedure. Twenty patients underwent daily monitored aerobic exercise for two months before being considered for this procedure. Both the definition and the diagnosis of IST were based on standard criteria. Patients were excluded from this series if they had previous ablation of the SN in other centers, or if their follow-up was shorter than two years, and if they experienced postural orthostatic tachycardia associated with the IST symptoms.

Electrophysiologic study. Each patient signed a written informed consent. Antiarrhythmic medication was discontinued at least 5 half-lives before the EPS. Patients were studied in the postassortative state. Sedation with intravenous fentanyl and midazolam was achieved. Instrumentation consisted of multielectrode catheters placed in the right atrium and His-bundle position via the right femoral vein. Coronary sinus recordings were performed from a 6F decapolar catheter (2–5–2-mm interelectrode spacing; Daig, Minnetonka, Minnesota) advanced through the right internal jugular vein. A 7F deflectable 4-mm tip quadripolar catheter (Biosense Webster, Diamond Bar, California) was used for atrial mapping and ablation.

Mapping of the right atrial activation was performed in a drug-free state during isoproterenol infusion at 2 μg/min. If isoproterenol was unable to reproduce the tachycardia, intravenous aminophylline was given at a dose of 6 mg/kg/20 min followed by maintenance infusion of 0.5 mg/kg per min. Programmed electrical simulation was performed before and after the ablation procedure to verify the mechanism of the arrhythmia and to exclude the coexistence of other arrhythmias.

Autonomic testing. In 10 patients with a resting heart rate faster that 100 beats/min the response to esmolol infusion was assessed before ablation. In addition, the shift of the earliest SN activation site during esmolol infusion and after successful ablation was compared. Esmolol was administered at an infusion rate of 500 μg/kg per min for 5 min followed by 300 μg/kg per min. After 15 min of esmolol maintenance infusion rate, 3-D right atrial mapping was repeated.

Exercise treadmill test and pre-procedure aerobic training. An exercise treadmill test using the Bruce protocol was performed in all patients before and one month after successful ablation. In the first 20 patients, a regimen of two months of intensive monitored aerobic exercise, including 20 to 40 min of vigorous activity five days/week, was prescribed before the ablation.

Intracardiac echocardiography. In eight patients intracardiac echocardiography (ICE) was obtained to verify the ability of the nonfluoroscopic mapping system to identify the crista terminalis (CT). A 10-MHz ultrasound transducer mounted on the tip of an 8.5F catheter (Boston Scientific, Sunnyvale, California) was used to visualize the CT. The ICE catheter was advanced in the right atrium using a long sheath (8.7F inner diameter/11F outer diameter) with a preshaped curve chosen based on the patient's right atrial anatomy so as to facilitate advancement of the intracardiac probe in the proximity of the CT. The CT points were initially identified and tagged on the electroanatomical map obtained with the CARTO system (Fig. 1); the validity of those sites was then verified by correlation with the information obtained using the ICE probe.

Intracardiac 3-D nonfluoroscopic mapping system. The 3-D electroanatomical mapping system has been described previously (13). Briefly, it consists of an electromagnetic location pad positioned under the patient's back, a CARTO processor unit (Biosense Webster), a Silicon Graphics workstation and an electromagnetic sensor-equipped catheter. This catheter was used for navigation mapping and ablation.

A 3-D electroanatomical map was created during sinus rhythm in the drug-free state, after administration of esmolol, during infusion of isoproterenol and/or aminophylline and after ablation resulted in change of heart rate. To reduce the risk of phrenic nerve damage on each map, the sites where phrenic nerve stimulation was demonstrated were tagged (Fig. 1). Ablation was performed starting at the earliest site of activation and extended for about 5 mm in each direction. Any drop in heart rate was followed by acquisition of a new right atrial 3-D map. Energy delivery was discontinued if no SN acceleration was seen within 10 s. If SN acceleration was not seen during ablation at the earliest activation site, the catheter was moved cranially first and subsequently caudally, looking for the sites where ablation would result in SN acceleration. When shift in the earliest site of activation was observed, and if further ablation was required owing to insufficient drop of the heart rate, ablation was performed at the superior edge of the new earliest activation site before moving to caudal locations. Ablation was terminated if the heart rate dropped below 120 beats/min during isoproterenol infusion at 2 μg/min alone or in combination with aminophylline infusion. This heart rate end point was established based on the upper heart rate observed in 15 normal volunteers receiving the

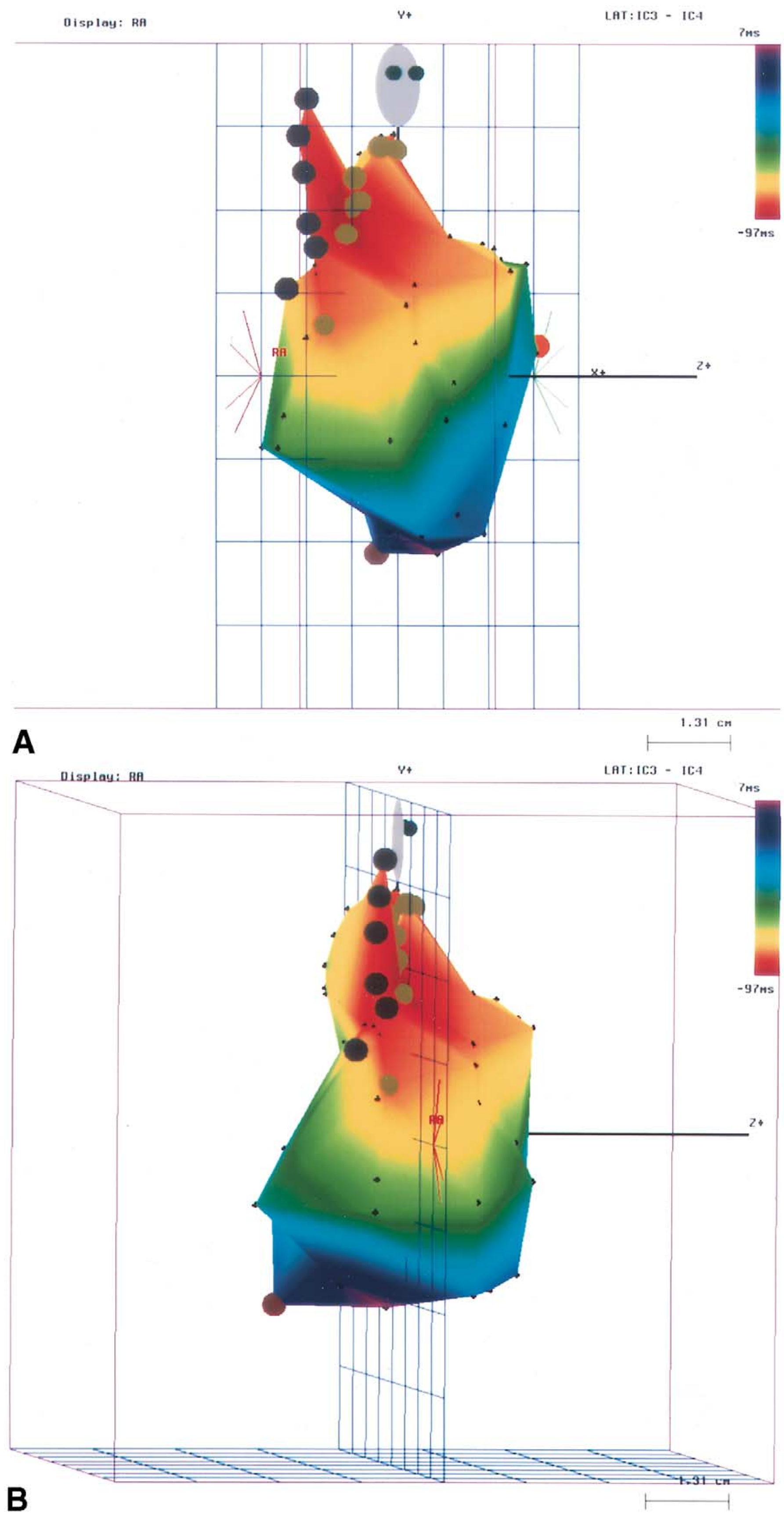
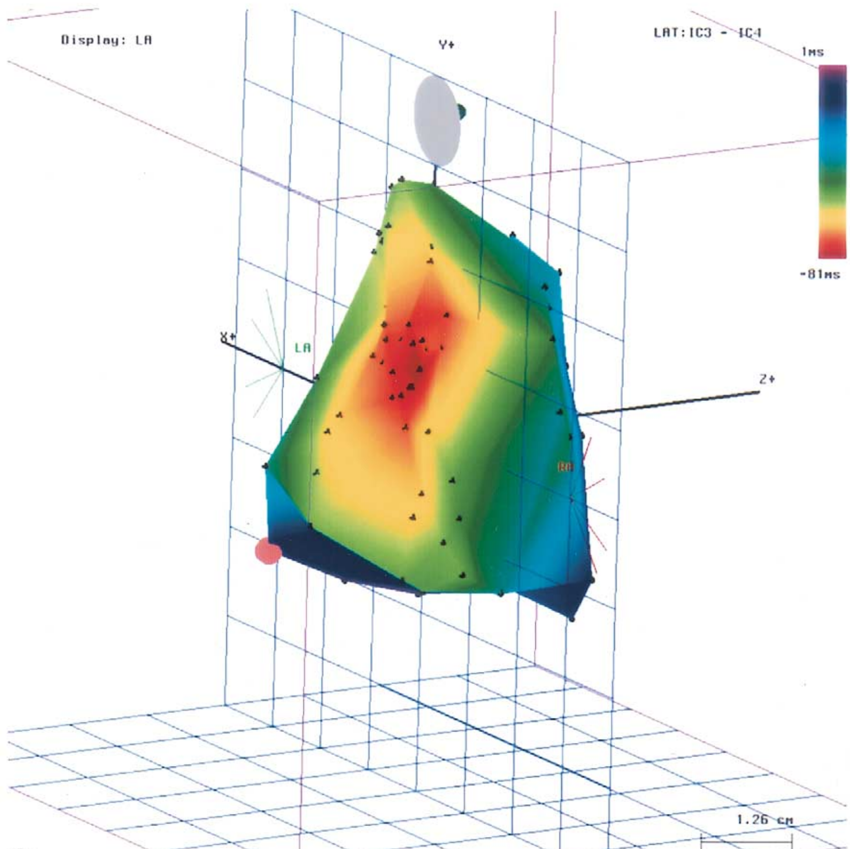


Figure 1. Three-dimensional electroanatomic activation map (CARTO) of the right atrium showing the ability to tag anatomical structure relevant to the ablation procedure. **(A)** Right anterior oblique view of the right atrium during inappropriate sinus tachycardia. The **gray tags** represent sites where pacing was able to stimulate the phrenic nerve. **Green tags** reproduce the course of the crista terminalis. **(B)** The same activation map as in **A**, but in a more posteriorly rotated view. *Continued on next page.*



C

Figure 1. **(continued). (C)** The caudal shift of the earliest activation site following sinus node modification.

same dose of isoproterenol. When the end point was achieved, a 3-D map of the right atrium was re-created. If no recovery of the heart was observed 45 to 60 min after last radiofrequency application was delivered, the procedure was then terminated.

Follow-up. After ablation, all patients were seen in the outpatient clinic at one month and every four months thereafter. In addition to a 24-h Holter monitoring, at each follow-up a 12-lead ECG was obtained. In case of recurrence of symptoms, the patient was monitored with a loop recorder for four weeks.

Twenty-four patients had direct access to medical personal 24 h a day and were encouraged to contact them should symptoms recur. The remaining 15 patients were seen in the outpatient clinic based on the schedule previously mentioned. At one-year follow-up, each patient was asked to assess the benefit of the ablation on a scale from 0 (absent) to 5 (very good).

Statistical analysis. Data are presented as mean ± SD. Paired and unpaired *t*-tests were used to compare the pre- and postablation categorical variables. The chi-square test was used to compare noncategorical variables. A p value <0.05 was considered statistically significant.

RESULTS

Patient population. Thirty-nine patients were included in this study (35 women, 4 men; mean age 31 ± 9 years; range, 22 to 44 years). All patients had debilitating IST with no evidence of other identifiable causes for this arrhythmia, including postural orthostatic tachycardia syndrome. Symptoms associated with sinus tachycardia were present in all patients for at least three months. Two patients had undergone previous atrioventricular junctional ablation and placement of a permanent VVIR pacemaker without improvement of their symptoms. Both patients subsequently developed pacemaker syndrome. Of the 39 patients, 18 had persistent sinus tachycardia with a rate >100 beats/min (mean 125 ± 10 beats/min) and 21 patients had daily multiple paroxysmal episodes. None of the patients had evidence of structural heart disease. The heart rate at rest and in a drug-free state ranged between 95 and 125 beats/min (mean 99 ± 14 beats/min).

In the 20 patients undergoing aggressive aerobic exercise for two months before the procedure, the resting heart rate significantly dropped (108 ± 12 beats/min, vs. 96 ± 14 beats/min, $p < 0.05$), but the multiple daily episodes of

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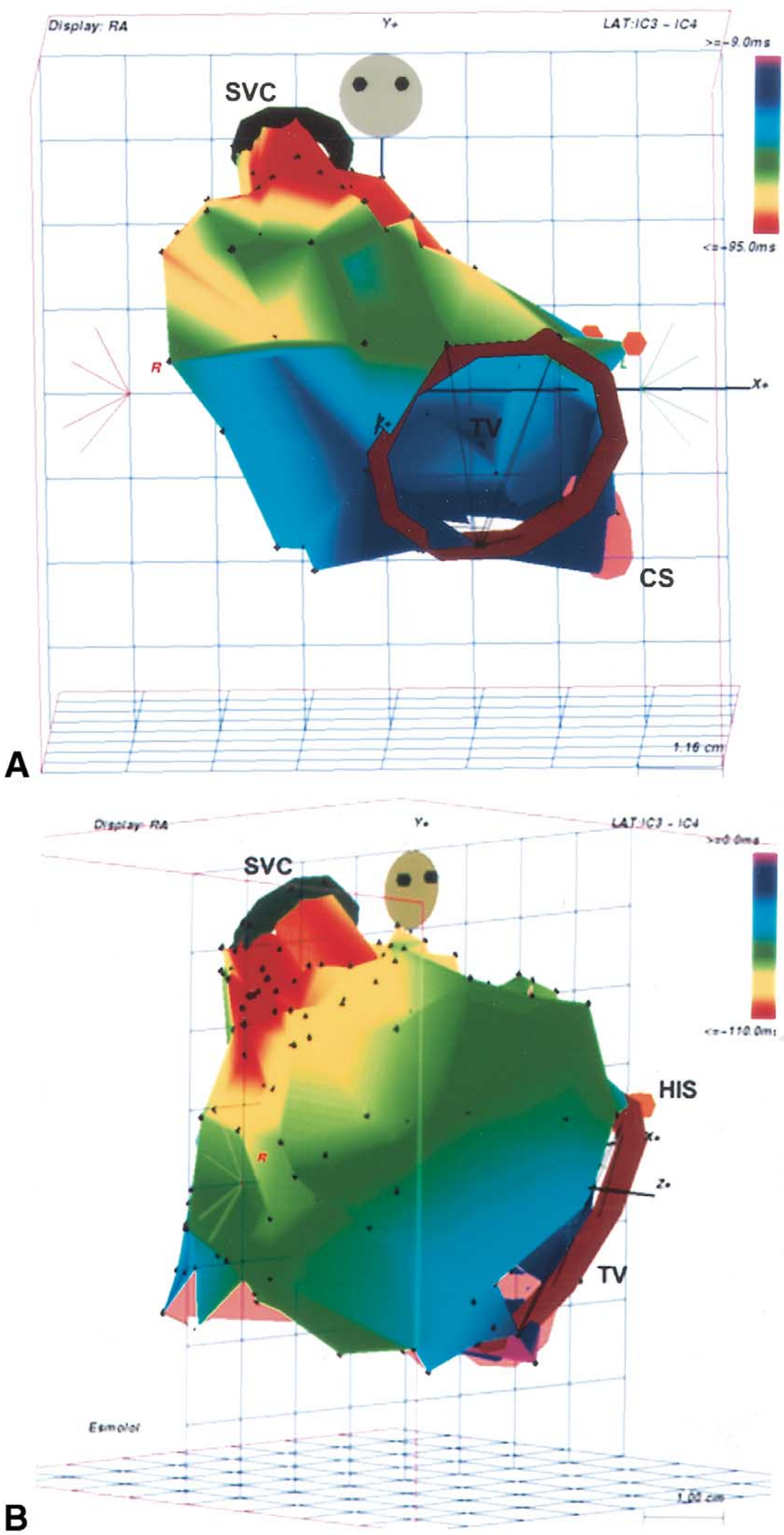

Figure 2. Three-dimensional electroanatomic activation map (CARTO) of the right atrium. Spontaneous sinus tachycardia is shown after administration of esmolol **(B)** and following successful sinus node modification **(C)**. *Continued on next page.*

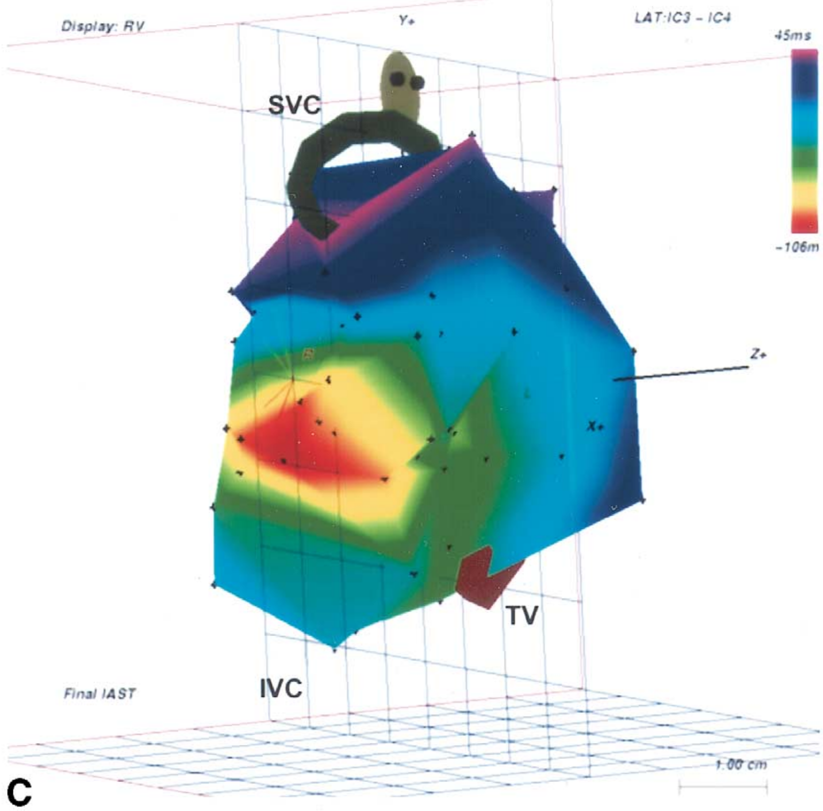

Figure 2. **(continued) Red** represents early and **purple** represents late electrical atrial activation. **(A)** The earliest site of activation during inappropriate sinus tachycardia (IST) to be in the vicinity of the atrium-SVC junction. **(B)** A 3.5-cm caudal shift of the earliest activation site after administration of intravenous esmolol. A CARTO map after sinus node modification shows a 2.5-cm caudal shift in the earliest activation site along the crista terminalis. CS = coronary sinus; HIS = His-Bundle potential; SVC = superior vena cava; IVC = inferior vena cava; TV = tricuspid annulus.

paroxysmal sinus tachycardia were still present and unresponsive to drugs.

Electrophysiologic findings. Inappropriate sinus tachycardia occurred spontaneously after administration of 2 μg/min isoproterenol infusion in 35 patients and 6 mg/kg per 20 min of aminophylline in 4 patients. Before ablation of IST, different types of atrial arrhythmias were excluded. During infusion of 2 μg/min of isoproterenol and/or aminophylline, the heart rate increased to a mean of 160 ± 28 beats/min (range, 145 to 190 beats/min) and 150 ± 25 beats/min (range, 130 to 180 beats/min), respectively.

Mapping and ablation results. In all patients the 3-D electroanatomical map during isoproterenol and aminophylline infusion showed a cranial shift as compared to the drug-free state, ranging from 5 mm to 14 mm (mean 9 ± 4 mm). Administration of esmolol in 10 patients with heart rate faster than 100 beats/min, in drug-free state, showed a caudal shift of the earliest activation site ranging between 5 and 20 mm (mean 7 ± 5 mm). In all 10 patients the extent of the 3-D–documented shift in caudal activation along the CT was more pronounced after radiofrequency ablation (RFA) compared to the shift in activation during esmolol administration (23 ± 11 mm; range, 20 to 45 mm, $p < 0.05$) (Fig. 2).

The caudal shift of the right atrial activation seen with the procedural end point was associated with flattening of the P-wave in the inferior lead and occasionally (three patients) with slightly negative initial component of the P-wave in the same ECG recordings. In none of the patients were asystole or sinus pauses observed during ablation. To achieve successful SN modification in 10 of 39 patients, an 8-mm tip ablation catheter (EP Technologies, Sunnyvale, California) was required. In two additional patients a cooled-tip catheter (Cardiac Pathways, Sunnyvale, California) was used to achieve successful modification of the SN. When either the 8-mm tip or the cooled-tip catheter was used for delivery of energy, the CARTO 4-mm tip catheter was used as a guide to the earliest ablation site of activation. The mean intracardiac ECGs amplitude recorded in the SN area was similar among patients requiring ablation with cooled-tip and 8-mm tip catheters, and patients ablated with a 4-mm tip electrode (4-mm 1.6 ± 0.4 mV vs. cooled/8-mm 1.7 ± 0.6 mV, p = NS). In eight patients (21%) the ablation site resulting in drop of the heart rate was away from the earliest activation site by a mean of 7 ± 3 mm. The successful site was indeed caudal to the earliest site in six of the eight patients and cranial to the earliest site in two of the eight patients.

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Table 1. Changes in Heart Rate Before and After Ablation

	Preablation HR (beats/min)	Postablation HR (beats/min)	p Value
Holter monitor			
Mean HR	108 ± 5	85 ± 5	< 0.001
Maximum HR	182 ± 6	120 ± 4.2	< 0.0001
Minimum HR	88 ± 5	61 ± 4.3	< 0.01
Exercise test			
Resting HR	99 ± 4	72 ± 4.1	< 0.001
Mean HR after 1.5 min	157 ± 11	96 ± 7	< 0.001
Maximum HR	178 ± 15	125 ± 9	< 0.001

HR = heart rate.

In two patients, to achieve rate drop, lesions had to be delivered at sites showing capture of the phrenic nerve. In one patient, the pacing threshold was 9 mA, and ablation did not damage the nerve. In the second patient, the pacing threshold was 4 mA, and ablation induced diaphragm paralysis, which recovered seven months after the procedure. After successful SN modification, the mean heart rate was 72 ± 8 beats/min (range, 65 to 87 beats/min) in drug-free state, and 105 ± 12 beats/min (range, 99 to 115 beats/min) on 2 μg/min of isoproterenol infusion.

The mean number of lesions and fluoroscopy times were 29 ± 11 min and 21 ± 6 min, respectively. The mean length of the area covered by ablation lesions at the end of the procedure was 12 ± 4 mm times 19 ± 5 mm.

Associated arrhythmias. In 12 of 39 patients (31%) other tachyarrhythmias were induced either at the end of the initial study or were observed at follow-up in association with recurrence of palpitation. In nine patients following ablation of IST, the AV node re-entry (three patients), right atrial tachycardia (four patients) and left atrial tachycardia (two patients) were documented and successfully ablated. In three patients, symptoms recurring 3 ± 1 months after follow-up were associated with documented tachycardia, which revealed a P-wave morphology different from the sinus rhythm P-wave. Left atrial tachycardia originating along the anterosuperior aspect of the mitral annulus was mapped in all three patients and successfully ablated. Of these three patients, only one patient has sustained repetitive episodes of atrial tachycardia at the time of the EPS and ablation, whereas in the other two patients, mapping of frequent isolated beats (one patient) and nonsustained short episodes of this tachycardia (one patient) were mapped and ablated.

Follow-up findings. At follow-up, ambulatory ECG monitoring and exercise stress test showed a significant reduction of the sinus rate as compared to the procedure before assessment. As shown in Table 1, the mean heart rate at 1.5 min of exercise dropped to 96 ± 7 beats/min after ablation from a mean of 157 ± 11 beats/min before ablation ($p < 0.001$). Similarly, following ablation, the mean maximal heart rate with exercise dropped to 125 ± 9 beats/min from 178 ± 15 beats/min before ablation ($p < 0.001$). All Holter monitoring variables before ablation were altered and significantly reduced in the postablation assessment (Table 1). Eight patients (21%) had recurrence of IST and required repeat ablation. Inappropriate sinus tachycardia recurred within one to three weeks after the initial ablation (18 ± 10 days). As mentioned previously, three additional patients had recurrence of symptoms after successful SN modification, and repeat EPS demonstrated left atrial tachycardia that was successfully ablated. Therefore, 28% of the patients (11 of 39 patients) required a second procedure. Two of the patients undergoing SN modification had a pacemaker previously implanted, which was upgraded after the initial procedure to a dual-chamber device. One of these two patients experienced symptoms compatible with superior vena cava syndrome four months after the procedure. Further investigations including transesophageal echocardiography and a venous angiogram showed the presence of a stricture with a gradient at the junction between the superior vena cava and the right atrium. Balloon dilation in this patient resulted in complete resolution of her symptoms.

After a successful procedure, 17 patients (44%) reported persistence of symptoms of palpitation, shortness of breath, chest pain and near syncope. Monitoring with a loop recorder did not show any recurrence of IST. In 7 of 17 patients, premature ventricular (5 patients) or atrial (2 patients) contractions were documented with symptoms. After counseling for several months, 10 of these 17 patients had improvement of their symptoms. Near syncope consistent with neurocardiogenic episodes was present in seven patients and was pre-existent to the ablation.

At the one-year follow-up, patients scored the overall impact of the ablation as poor (2 patients), fair (12 patients), good (17 patients) and very good (8 patients). Complete resolution of symptoms was more likely to occur in patients with a shorter history of tachycardia (median duration of 3 months [range 3 to 7 months] vs. 24 months [range 14 to 70 months], $p < 0.05$). In addition, the percentage of patients reporting presence of syncope or near syncope, severe chest pain or shortness of breath before ablation was higher among those perceiving the procedure as poor or fair, versus good or very good (poor/fair group, 12 of 14 [86%] vs. good/very good group, 5 of 25 [20%], $p < 0.01$).

After ablation, 15 of 39 (38%) patients were followed with clinic visits scheduled as per routine postablation protocol (group 1). The remaining 24 (61%) patients instead had direct access to allied professionals 24 h a day for counseling and medical advice (group 2). In the group with direct access to allied professionals the median monthly number of emergency room admissions or clinic visits was drastically reduced after ablation, whereas no difference was seen in the group undergoing conventional follow-up in the outpatient clinic. In the group with direct access to allied professionals, the median number of phone contacts during the first months of postablation was four (between two and six) and appeared to drop over time, with the median number three months after ablation equal to zero (from zero

Table 2. Patients' Characteristics and Hospitalization or Clinic Visits During Follow-Up

	Group 1 (15 patients)	Group 2 (24 patients)	p Value
Age	29 ± 16	25 ± 11	NS
Gender (F/M)	23/2	22/2	NS
Psychiatric diagnosis	100% (15/15)	100% (24/24)	NS
Mean duration of symptoms (months)	20 ± 5	22 ± 5	NS
Median monthly number of ER or clinic visits preablation (range)	3 (2–6)	3 (1–5)	NS
Median number of ER or clinic admissions 1-month postablation (range)	0 (0–2)	3 (2–5)	< 0.05
Median number of phone contacts 1-month postablation (range)	4 (2–6)	1 (1–2)	< 0.05
Median number of phone contacts during the third month postablation (range)	0 (0–1)	None	< 0.05

ER = emergency room.

to one). Only two of the patients followed by direct access to an allied professional required unscheduled visit postsuccessful ablation. In contrast, in the group undergoing conventional follow-up, the number of clinic visits or emergency room admissions during the first month after ablation was similar to the number observed before ablation (Table 2). A psychiatrist assessed all patients before and at least six months after successful ablation. Before ablation, 2 patients were diagnosed with schizophrenia, 3 with depression, 21 with panic disorder and 13 with somatoform disorders.

Following ablation, 18 of 21 patients (81%) with panic disorder did not continue their follow-up in the psychiatric clinic. Four of the patients with panic disorder continued to take antianxiety medications intermittently, and 10 experienced sporadic episodes of shortness of breath and chest pain. In addition, 8 of the 13 patients (61%) with a diagnosis of somatoform disorder also discontinued their psychiatric clinic follow-up and did not require any further psychiatric care.

After a mean follow-up of 32 ± 9 months all patients remained in sinus rhythm without any evidence of inappropriate behavior of the SN response during exercise and daily activity.

DISCUSSION

Main findings. We demonstrated that 3-D electroanatomical mapping of the right atrium provides an effective tool to monitor and guide ablation for IST. This approach seems to eliminate the occurrence of excessive destruction of the SN and to reduce and perhaps eliminate the risk of complete SN ablation. Moreover, we could demonstrate that IST is frequently associated with other entities of atrial tachyarrhythmias.

Previous studies. Previously, studies on radiofrequency catheter ablation of IST have reported a wide range of long-term success rates (from 23% to 66%) and a sizable risk of complete abolition of the SN (1,2,7,8,14). Recently, Man et al. (1) have shown modification of the SN using conventional mapping technique to be modestly effective in managing patients with IST. As reported by Man et al. (1), one of the factors contributing to the limited long-term cure was the inability to target with precision the sites of impulse origin using conventional mapping. Recently, RFA guided by ICE has also appeared to reduce the risk of inadvertent SN damage (9–12). However, this technique seems to be associated with a poor success rate (23%) at the long-term follow-up (12). One must realize that SN modification is not a focal ablation, but requires complete abolition of the cranial portion of the SN complex, which seems to show automatic behavior. With the 3-D electroanatomic mapping system we could define the sites of earliest activation with accuracy, and a more systematic ablation around the area of the cranial portion of the SN was easy to achieve by using the real-time electroanatomic mapping and navigation features. This may have been responsible for the better follow-up results observed in our series compared to those reported by Man et al. (1) and Shinbane and Scheinman (12).

Conversely, in about 20% of the patients the site where ablation resulted in successful SN modification did not correspond to the area of earliest activation. This suggests that at times the earliest activation represents the endocardial exit point into the right atrium of SN firing cells located deeper within the SN structure. It is also important to appreciate the proximity between the ablation sites and the SN exit point after the ablation. This supports the need of an accurate, continuous and real-time monitoring of the ablation location to avoid inadvertent damage to the area of the SN relevant for the long-term physiologic SN function.

Association with other arrhythmias. Of importance is the recognition of the relatively frequent association with other atrial tachycardias, which required ablation to maximize procedural success. Several of these tachycardias, although clinically sustained, appeared nonsustained in the electrophysiology laboratory.

Response to beta-blockade. Of interest is the response to beta-blockade before ablation. Morillo et al. (15) suggested that the mechanism leading to IST is related to a primary SN abnormality characterized by a high intrinsic heart rate, depressed efferent cardiovagal reflex and beta-adrenergic hypersensitivity. Our data are consistent with a combined mechanism involving both an increased sympathetic hypersensitivity and an intrinsic automatic behavior. Indeed, the caudal shift observed after beta-blockade with esmolol was less drastic than the shift seen after successful ablation. This supports the concept that adrenergic hypersensitivity is not the only mechanism responsible for the inappropriate behavior of the SN in these patients.

Similarly, monitored aerobic exercise despite reducing the resting heart rate did not abolish inappropriate paroxysms of sinus tachycardia, suggesting again that both increased adrenergic response and automatic behavior coexist in the majority of patients with IST. Previously, preliminary results from our laboratory have shown that teenagers represent a selected group of subjects with IST who may respond to the aerobic exercise program (16). It is conceivable that very young patients share a different mechanism with a predominant hyperactivity of the sympathoadrenergic system. In eight patients (21%) of our series to achieve persistent SN modification, the use of an 8-mm tip or a cooled-tip catheter was required. It is possible that in a small number of patients the thickness of the area of interest may prevent successful ablation with conventional approaches and thus require the need of ablation techniques allowing for larger and deeper lesions.

Psychological impact of ablation. The personality of patients with IST is complex, and it is therefore important to discuss thoroughly the realistic expectations and beneficial effects of the procedure. Many of our study patients had associated psychiatric disorders, which improved following ablation in about 66% of them.

In contrast, in the majority of patients symptoms of shortness of breath and chest pain persisted after successful elimination of the rhythm problem. In this respect, patients more likely to experience a complete resolution of their symptoms are those with a shorter history of the arrhythmia. Conversely, patients reporting near syncope, syncope, and with a longer history of IST had a higher probability of recurrent complaints after the procedure. Because of the high incidence of associated symptoms, in these patients easy access to medical personnel appeared to be beneficial after ablation in reducing the utilization of health-care resources. In fact, direct access to allied health professionals in a group of the patients included in this series reduced the need for emergency room visits and unscheduled clinic visits after the ablation procedure.

Conclusions. Finally, 3-D electroanatomic-mapping–guided SN modification is effective and safe. Moreover, adrenergic hypersensitivity does not appear to be the only mechanism responsible for IST. In addition, our study provides information that is relevant to counsel patients considered for SN modification regarding the realistic expectations from the procedure. As it appeared from our results, patients with absence of symptoms other than palpitation and early ablation after presentation of the rhythm disorder were more likely to perceive the procedure as beneficial and to experience complete symptom resolution. After ablation, counseling and easy access to experienced allied professionals increase the positive impact of this procedure on the use of health-care resources.

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