Selective Site Pacing From the Right Ventricular Mid-Septum

Follow-up of Lead Performance and Procedure Technique

Satoru YUSU,¹ MD, Hisaaki MERA,¹ MD, Kyoko HOSHIDA,¹ MD, Mutsumi MIYAKOSHI,¹ MD, Yosuke MIWA,¹ MD, Takehiro TSUKADA,¹ MD, Hideaki YOSHINO,¹ MD, and Takanori IKEDA,² MD

SUMMARY

Pacing from the right ventricular (RV) apex is associated with adverse effects such as heart failure and atrial fibrillation. We attempted pacing from the RV mid-septum, which is theoretically a more physiological pacing site. A total of 172 consecutive patients with indications for permanent pacemaker implantation were studied. A screw-in lead and a curved stylet were used for lead positioning on the RV mid-septum. Pacemaker indices were evaluated at implantation and one year later. As an electrocardiographic parameter, QRS duration was measured in lead II. These data were compared to those of 66 patients subjected to conventional RV apical pacing. Lead placement was successful in all patients of RV mid-septal pacing. There were no technical problems during or after the procedure. The cumulative percentage of ventricular pacing at one year postimplantation was $85 \pm 24\%$ in the SSP group. Sensing, pacing threshold, and lead impedance in the SSP group remained clinically stable over one year. When these measurements were compared between the SSP and AP groups, the pacing threshold and the lead impedance at one year postimplantation in the SSP group were higher ($P < 0.05$) and lower ($P < 0.01$), respectively, than those of the AP group. The mean QRS duration was markedly shorter (123 ± 16 versus 150 ± 18 msec, $P < 0.0001$). Selective site pacing from the RV mid-septum is feasible and results in less conduction delay compared to conventional RV apical pacing, and its procedure seems to be more physiological in permanent pacemaker implantation. (Int Heart J 2012; 53: 113-116)

Key words: Pacing procedure, Selective site pacing, Physiological pacing, Right ventricular mid-septal pacing, Pacemaker implantation

The mainstream of pacing treatment for bradyarrhythmia has been pacing from the right ventricular (RV) apex, which has been regarded as physiological pacing, to maintain atrioventricular synchrony. However, with conventional RV apex pacing, the impulse is conducted from the apex to the base of the heart and from the right to the left ventricles, and therefore the time for impulse conduction in the ventricles is significantly prolonged.^{1,2)} This procedure is reported to cause ventricular dyssynchrony,^{3,4)} resulting in an increased risk for occurrence of heart failure⁵⁻⁷⁾ or atrial fibrillation.^{7,8)} Recently, selective site pacing (SSP), where alternate sites for ventricular pacing are used, has come into use to improve ventricular dyssynchrony.⁹⁻¹¹⁾

In SSP, His-bundle or para-His pacing^{12,13)} and a procedure where a ventricular lead is positioned in the RV outflow tract have been used.¹⁴⁻¹⁶⁾ The former involves technical difficulties, whereas the latter has produced unsatisfactory long-term effects and also poses a high risk of complications such as pericardial effusion.¹⁷⁾

In this study, we evaluated the efficacy and safety of SSP in patients in whom RV leads were positioned in the middle of the RV septum (mid-septum) and compared it with conven-

tional RV apex pacing. We also examined points to obtain fluoroscopic images and electrocardiographic parameters when the leads were positioned in the RV mid-septum.

METHODS

Patients: Since February 2007, we have performed SSP from RV mid-septum pacing in all patients with bradyarrhythmia requiring pacemaker treatment and with an estimated ventricular pacing rate of over 20%.

In this study, of the 199 consecutive patients subjected to SSP, 172 who were followed up for one year after implantation (SSP group: 76 ± 10 years old, male: 51%), and 66 consecutive patients followed up for one year after undergoing apex pacing (AP group: 75 ± 9 years old, male: 55%) were included. The indications included sick sinus syndrome in 134 patients and atrioventricular (AV) block in 104.

Study protocol: DDD pacemakers were implanted in all the patients. In both groups, changes in pacing threshold, sensing, and lead impedance from immediately after implantation to one year postimplantation, lead dislodgement, and the QRS

From the ¹ Second Department of Internal Medicine, Kyorin University School of Medicine and ² Department of Cardiovascular Medicine, Toho University Medical Center, Tokyo, Japan.

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Address for correspondence: Takanori Ikeda, MD, Department of Cardiovascular Medicine, Toho University Medical Center, 6-11-1 Omorinishi, Ota-ku, Tokyo 143-8541, Japan.

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width as an electrocardiographic parameter during ventricular pacing at one year postimplantation were determined. The QRS width was determined on the computer screen with enlargement of 400% using lead II of standard 12-lead electrocardiography that is capable of computer acquisition.

Implantation procedure: The right subclavian vein was punctured using a venipuncture technique under local anesthesia and then the pacing leads were implanted first in the right ventricle and then in the right atrium under fluoroscopic guidance.

In the SSP group, a screw-in lead was used for both the atrium and ventricle in all patients. The RV lead was positioned in the mid-septum and the right atrial (RA) lead in the right auricle. The actual site targeted for RV mid-septal pacing in this study is shown in Figure 1. First, the RV lead was advanced through the tricuspid valve and then the tip was posi-

Figure 1. Anatomical features of the RV septum. The circular area indicates the pacing site targeted for RV mid-septal pacing; RA, right atrium; and RV, right ventricle.

Table I. Clinical Characteristics of the Study Population

	SSP group (n = 172)	AP group (n = 66)	P
Age (years)	76 ± 10	75 ± 9	NS
Gender (male)	88	36	NS
Hypertension (n)	68	36	NS
Sick sinus syndrome (n)	91	43	NS
Atrioventricular block (n)	81	23	NS
Antiarrhythmic drug (n)	30	16	NS
ACEI/ARB (n)	35	21	NS
Beta blocker (n)	36	20	NS

ACEI indicates angiotensin-converting enzyme inhibitor and ARB, angiotensin receptor blocker.

tioned directly against the interventricular septum with a manually shaped stylet, as verified by frontal and lateral fluoroscopic views with left anterior oblique 40, 45, and 50 degree projections. Next, the tip was screwed on the interventricular septum. The optimal lead position was confirmed by fluoroscopy and the limb leads of the electrocardiogram demonstrating the narrowest QRS complex available.

In the AP group, screw-in and tined leads were used for the RA and RV, respectively; the RV lead was positioned in the apex and the atrial lead in the right auricle. The leads were positioned while monitoring fluoroscopic images.

Statistical analysis: All analyses were carried out using statistical software (SPSS version 15.0 for Windows). Nondiscrete data are expressed as the mean ± standard deviation, and the paired Student's *t*-test was used. Comparative tests were all 2-sided, and differences found were considered statistically significant if $P < 0.05$.

RESULTS

Patient characteristics: The SSP and AP groups consisted of 172 and 66 patients, respectively. No significant difference in age, gender, number of patients with complicated hypertension, underlying cardiac disease, or medication was observed between the two groups (Table I).

Pacing system performance and safety: The cumulative percentage of ventricular pacing at one year postimplantation was $85 \pm 24\%$ in the SSP group and $91 \pm 8\%$ in the AP group ($P = \text{NS}$). Thus, most patients in both groups had an estimated ventricular pacing rate of over 20% (ie, one of the inclusion criteria).

In the SSP group, the pacing threshold was 0.7 ± 0.4 and 0.9 ± 1.3 V ($P = \text{NS}$), the sensing was 9.9 ± 4 and 10.0 ± 1.3 mV ($P = \text{NS}$), and the lead impedance was 679 ± 185 and 440 ± 103 ohm ($P < 0.01$) immediately and one year after implantation, respectively. In the AP group, the corresponding values were 0.6 ± 0.2 and 0.5 ± 0.3 V ($P = \text{NS}$), 12.1 ± 4.4 and 15.0 ± 5.0 V ($P < 0.05$), and 968 ± 337 and 816 ± 175 ohm ($P < 0.01$), respectively (Table II). When these measurements were compared between the SSP and AP groups, the pacing threshold and the lead impedance at one year postimplantation in the SSP group were significantly higher ($P < 0.05$) and lower ($P < 0.01$), respectively, than those of the AP group.

Neither group showed an increase in the pacing threshold for the ventricular lead or reduction of sensing. The lead impedance for the ventricular lead was significantly reduced in both groups. No clinical changes were observed. In addition,

Table II. Comparative Ventricular Lead Pacing Thresholds, R-Wave Sensing, and Bipolar Lead Impedance at Implantation and at One Year Postimplantation

	SSP group		AP group	
	at implantation	after one year	at implantation	after one year
Pacing threshold (V)	0.7 ± 0.4	$0.9 \pm 1.3^{**}$	0.6 ± 0.2	0.5 ± 0.3
Sensing (mV)	9.9 ± 4.0	10.0 ± 1.3	12.1 ± 4.4	$15.0 \pm 5.0^{**}$
Lead impedance (ohm)	679 ± 185	$440 \pm 103^{*+}$	968 ± 337	$816 \pm 175^{*}$

* $P < 0.01$ and ** $P < 0.05$ compared to "at implantation"; + $P < 0.01$ and ** $P < 0.05$ compared to the AP group.

Table III. Characteristics of the 12-Lead Electrocardiogram for RV Septal Pacing

	Positivity in this study (n = 172)
1. Characteristics of QRS complex with limb leads	
· Narrow QRS complexes (< 130 ms)	82%
a) Inferior wall leads (II, III, and aV _F)	
· Upward-directed wide QRS complexes	90%
b) Left lateral wall leads (I and aV _L)	
· Relatively high amplitudes but < 10 mm in lead I (upward direction)	88%
· Relatively low amplitudes < 5 mm in lead aV _L (either upward or downward direction)	75%
※ Predominantly upward-directed wide QRS complexes: free wall side	
※ Predominantly downward-directed wide QRS complexes: high-level septum side	
2. Characteristics of QRS complex with chest leads	
· Preferably narrow QRS (< 140 ms)	92%
· Small R-wave or QS pattern with lead V ₁	100%

Figure 2. Twelve-lead electrocardiogram of a patient who underwent right ventricular apex pacing.

no dislodgement of the atrial or ventricular leads was noted.

The total procedure time (incision to closure) for pacemaker implantation was 92 ± 14 min in the SSP group and 85 ± 20 min in the AP group ($P = \text{NS}$).

Pacing QRS width: Figure 2 shows a 12-lead electrocardiogram for the AP group. The pacing QRS width was 150 ± 18 msec. Figure 3 shows a 12-lead electrocardiogram for the SSP group. The pacing QRS width was 123 ± 16 msec. These results revealed an obviously shorter pacing QRS width in the SSP group ($P < 0.0001$).

DISCUSSION

RV mid-septal pacing used in this study was shown to involve no clinically relevant changes in pacing threshold, sensing, or lead impedance, compared to conventional RV apical pacing. These pacemaker indices of RV mid-septal pacing did not change at one year postimplantation.

As an alternative strategy, RV outflow tract pacing has been performed,⁹⁻¹¹⁾ whereas its procedure may be considered

Figure 3. Twelve-lead electrocardiogram of a patient who underwent right ventricular mid-septum pacing. **Figure 4.** Fluoroscopic images demonstrating the RV mid-septum. (A) Frontal view, (B) 40 degree LAO view, (C) 45 degree LAO view, (D) 50 degree LAO view. LAO indicates left anterior oblique.

to be associated with a high threshold and low sensing.¹⁸⁾ Additionally, the anatomical accuracy for RV outflow tract is poor and several reports have used inconsistent pacing sites: RV outflow tract free wall or septum.¹⁴⁻¹⁶⁾ This has led to procedural difficulties and a risk of complications such as pericardial fluid.¹⁹⁾

The SSP procedure that we introduce in this study enabled safe and accurate positioning of a lead in the RV mid-septum without complications that require a surgical procedure. Furthermore, using this procedure, we achieved an extremely narrow pacing QRS width in lead II of the 12-lead electrocardiogram, as shown in this study. Compared to the QRS width for RV outflow tract pacing described in several reports,^{20,21)} the QRS width for RV mid-septal pacing was shown to be obviously narrower. Narrowing of QRS width suggests a reduction in the time for ventricular conduction and easier preservation of ventricular synchrony.²¹⁾

Based on these results, the points for lead positioning that will enable narrowing of pacing QRS width are shown in Figure 4. The point where the tip of the ventricular lead is oriented posteriorly even when the projection for fluoroscopy is shifted to 40-50 degree left anterior oblique is recommended. The characteristics of a 12-lead electrocardiogram suggestive of mid-septum pacing, based on the pacing waveforms from the

leads positioned using the procedure we propose, are summarized in Table III.

Study limitations: This study may involve difficulty in predicting the long-term efficacy of SSP because of a short follow-up. Since the patients included in the study had a relatively satisfactory left ventricular ejection before RV mid-septal pacing, long-term evaluation in an increased number of patients with poor cardiac function is desirable.

As regards positioning of the ventricular lead in the AP group, we did not strive to make a narrow QRS complex during the procedure. This may have affected the results of our study.

Conclusion: RV mid-septal pacing was associated with comparable operation time (assuming the operator has received adequate training) of approximately 90 minutes, no lead dislodgement, and no change in the pacing threshold, sensing, or lead impedance, as well as RV apical pacing. Additionally, this pacing site might reflect a more physiological and synchronous form of ventricular activation.

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