Selective Site Pacing: Defining and Reaching the Selected Site

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LIEBERMAN, R., ET AL.: Selective Site Pacing: Defining and Reaching the Selected Site. Selective site right ventricular pacing has been suggested as an approach to reduce the incidence of ventricular dysfunction and hopefully influence the morbidity resulting from traditional right ventricular apical pacing. Pacing from the right ventricular apex allows a stable ventricular rate, and together with atrial pacing and sensing, helps maintain atrioventricular synchrony but does not allow physiological activation of the left ventricle. Traditional atrial pacing sites like the right atrial appendage may encourage atrial tachyarrhythmias, whereas lead placement in right atrial septal sites may reduce the frequency of symptomatic atrial tachyarrhythmia episodes, especially when combined with prevention algorithms. Researchers attempting to pace the heart from these selective sites have been hindered by the lack of uniform definitions of where these sites actually lie and the inadequacy of tools to consistently reach these locations and verify correct placement. This lack of definition consensus may have contributed to the apparent conflict of data, particularly in the right ventricle. There is an urgent need for a standardization of terms and identifying measures for selective pacing sites. (PACE 2004; 27[Pt. II]:883–886)

selective site pacing

Traditional and Selective Pacing Sites

The traditional pacing sites, the right atrial appendage and right ventricular apex, allow easy endocardial placement of leads while providing stable and reliable chronic pacing parameters. Although these sites maintain heart rates and atrioventricular synchrony, right ventricular apical pacing is associated with increased morbidity and mortality compared with subjects having normal atrioventricular conduction.1−4 Right ventricular apical pacing initiates an abnormal asynchronous electrical activation pattern, resulting in asynchronous left ventricular contraction and relaxation.5−8 Consequently, right ventricular apical pacing may lead to asymmetric septal hypertrophy,9,10 inhomogeneous left ventricular wall strain,9 myofibrillar disarray,11−13 and perfusion defects.7 These changes, in turn, may be responsible for an increased morbidity and mortality in this group of patients.

The term, alternate site pacing, refers to pacing sites other than the right atrial appendage and ventricular apex. Implicit with alternative site pacing is the false notion that a site is being chosen, other than a proven standard pacing site and is, hence, inferior. For this reason, the term selective site pacing has been suggested as it more accurately reflects the physician rationale as to where to implant pacing leads. The physician selects a specific pacing site for a variety of potential benefits. In the atria, the septum is chosen to improve intraatrial conduction and minimize dispersion of refractoriness. This in turn may improve atrial hemodynamics and reduce the incidence of paroxysmal atrial tachyarrhythmias like atrial fibrillation.14

In the ventricles, the expected improvements from a more physiological depolarization pattern include better hemodynamics,15 less mitral valve regurgitation, less detrimental remodeling,16 and delaying, reducing, or eliminating long-term negative changes like perfusion defects and heart failure.17

The Clinical Definition of Selective Pacing Sites

When defining pacing sites in the heart, the literature has traditionally defined broad anatomic positions. However, outside the traditional sites, it is difficult to visualize and verify selective sites using electrophysiology laboratory tools. Despite this, there is an urgent need to carefully correlate anatomic sites with readily available tools like fluoroscopy and standard electrocardiographic (ECG) leads. Figures 1 and 2 illustrate the areas currently being considered for selective site pacing in the atrium and ventricle for the hemodynamic and arrhythmic reasons already defined. However, using selective site pacing, a variety of additional implantation sites in the atria or ventricles could also be considered for a variety of yet to be defined potential benefits.
Right Atrial Selective Sites

Right Atrial High Septum (Fig. 1)

Pacing the high septum of the right atrium will improve intraatrial conduction and minimize dispersion of refractoriness. This in turn may improve atrial hemodynamics and perhaps prevent atrial fibrillation. This area of the right atrial septum involves the crista terminalis and Bachmann’s bundle and is particularly difficult to pace using standard pacing tools. The atrial muscle tissue in this area has high conduction velocity, but lacks distinct electrophysiological properties. The atrial paced ECG criteria for this area demonstrate a positive or isoelectric P wave in leads II and III.

Coronary Sinus Ostium (COS) (Fig. 1)

The selective site on the low septum of the right atrium is the mouth or COS. Pacing in this area shortens the duration of atrial activation, which may decrease the propensity to acquire atrial fibrillation. The target for attachment of the atrial lead is just superior to the COS and inferior to the fossa ovalis and is best approached in the left anterior oblique 40-degree fluoroscopic view. If viewed as a clock face, the ostium is at the 6 o’clock position and the lead tip, when appropriately advanced, will be at the 12 o’clock position. The atrial paced ECG shows a negative P wave in leads II, III, and aVF.

Right Ventricular Selective Sites

The selective site for right ventricular pacing lies in the right ventricular outflow tract (RVOT) and refers to a poorly defined broad area of the right ventricle, which encompasses all areas except the apex. In the anteroposterior view, the lower border of the RVOT is a line extending from the apex of the tricuspid valve to the border of the right ventricle (Fig. 2). The pulmonary valve represents the anatomic RVOT upper border. These boundaries create a trapezoid-shaped area, whose remaining borders are the interventricular septum and right ventricular free wall. Using standard fluoroscopy, the RVOT landmarks provided by the described anatomic model cannot be accurately visualized. Therefore, it is necessary to create fluoroscopic images and ECG patterns that best reflect the areas defined by the anatomic model. The RVOT fluoroscopic lower border is demarcated by extending a pacing catheter parallel to the right ventricular inferior border from the tricuspid valve apex to the lateral right ventricular border in the anteroposterior or right anterior oblique views (Fig. 3). The upper border of the anatomic RVOT is determined on a fluoroscopic image by positioning a pacing catheter through the pulmonary valve (noted by the loss of R wave on the intracardiac electrogram). The actual junction of the RVOT and pulmonary artery can then be identified by the appearance of
**Figure 3.** Right anterior oblique (RAO) fluoroscopic image of the heart with two catheters in the right ventricle to define the upper and lower limits of the right ventricular outflow tract.

**Figure 4.** Left anterior oblique (LAO) views of the heart. (Left) Anatomic diagram to show the position of the right ventricle and septum. (Right) Fluoroscopic image to show the pacing lead in the low septum.
dominant R waves as the catheter is withdrawn into the right ventricle.

Once the boundaries of the RVOT have been defined, it is necessary to define the actual pacing positions within this area. For simplicity, the RVOT can be divided into four quadrants. The RVOT is divided horizontally by a line midway between the pulmonary valve and the lower border, forming an upper and lower half. These two halves can be divided vertically by a line that connects the pulmonary valve to the RVOT lower border and in this way dividing the RVOT into the right ventricular septal and free wall. The quadrants created define high (infundibular) and low (outflow) septal RVOT and high (infundibular) and low (outflow) free-wall RVOT positions.

In determining high and low positions, it is useful to use the right anterior oblique fluoroscopic view (Fig. 3). However, to help differentiate the RVOT septum and free wall, the left anterior oblique 40-degree fluoroscopic view is used (Fig. 4). The ECG confirmation of pacing in the right ventricular septum is manifested by a positive QRS morphology in lead I, whereas pacing in the right ventricular free wall manifests as a positive QRS morphology in lead I. As well, ventricular pacing in a high position will result in an upright QRS in aVF, whereas a lower position will have a less positive QRS deflection in aVF. The Table I summarizes the ventricular paced ECG findings for these positions.

### Conclusion

The right atrial septum and RVOT have been suggested as more physiological sites for cardiac pacing. However, there has been much confusion among investigators defining these selective pacing sites. This article defined the septal sites in the right heart and the characteristic fluoroscopic and ECG findings.

### Table I

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<thead>
<tr>
<th>Right Ventricular Selective Site</th>
<th>Lead I</th>
<th>aVF</th>
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<tbody>
<tr>
<td>High septal</td>
<td>–</td>
<td>+</td>
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<tr>
<td>Low septal</td>
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<td>±</td>
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<tr>
<td>High free wall</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Low free wall</td>
<td>+</td>
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### References

18. Bennett DH, Comparison of the acute effects of pacing the atrial septum, right atrial appendage coronary sinus os and the latter two sites simultaneously on the duration of atrial activation. *Heart* 2000; 84:193–196.