Several studies have suggested that the dyssynchronous contraction associated with right ventricular (RV) apical pacing can have deleterious effects on left ventricular (LV) function resulting in myocardial perfusion defects and heart failure.1–3 These observations have led to an increased interest in alternative pacing sites (ie, pacing of the interventricular septum) with less deleterious effect on LV contraction.4,5 These alternative pacing (RV nonapical pacing) sites include the septum (midseptum or upper-septum) and the RV outflow tract (RVOT). However, the effect of pacing from RV nonapical pacing remains questionable; some randomized and nonrandomized trials have shown beneficial effects with RV nonapical pacing compared with RV apical pacing, whereas other studies have shown no differences between them.6 Two criteria have been established on correct assessment of the pacing site in the septum. The first is the position of the RV lead in the 40° left anterior oblique (LAO40) fluoroscopic view: RV lead should have typical shape, facing toward the spine with angle between the horizontal plane and the lead between 0° and 60°.7 The other is the characteristic ECG pattern (ie, especially negative QRS complexes in lead I; the presence of q wave in lead I).8

**Background**—The aim of the study was to verify the correct anchoring location for the tip of the right ventricular lead using cardiac computed tomography and to assess the best fluoroscopic and ECG criteria associated with the correct location of the electrode into the midseptum.

**Methods and Results**—Patients indicated to pacemaker implantation were prospectively enrolled. The right ventricular lead was implanted into the midseptum according to standard criteria in left anterior oblique 40 view. The cardiac shadow on the right anterior oblique 30 was divided into 4 quadrants perpendicular to the lateral cardiac silhouette and the position of the lead tip was analyzed. The exact position of the lead tip was assessed using computed tomography. Of 51 patients, the right ventricular lead was anchored midseptum in 21 (41.2%; MS group). In 30 patients (58.8%; non-MS group), the lead was anchored in the adjacent anterior wall. The angle between the lead and horizontal axis on the left anterior oblique was similar in both groups. The non-MS group was associated with shorter distances between the tip and the cardiac contours in the right anterior oblique 30 (96.7% of leads in the non-MS group were in the outer quadrant versus 9.6% in the MS group; P<0.001). The presence of the lead in the middle or inferior quadrants was independently associated with correct midseptum placement with positive predictive value of 94.7%.

**Conclusions**—Despite the optimal shape of the left anterior oblique, substantial numbers of leads were not anchored in the midseptum. Knowing the right anterior oblique 30 lead position can ensure proper midseptal placement.

(Circ Arrhythm Electrophysiol. 2013;6:719-725.)

Key Words: cardiac pacing | fluoroscopy | pacemaker implantation | right ventricular apex | ventricular septum
Cardiac computed tomography (CT) presents an exact tool for assessing the exact location of the RV lead. The assessment of the anchoring (tip) of RV lead is quite easy; even the perforation of small screw of the lead can be visible on a cardiac CT. The aim of the study was (1) to assess the success rate of the LAO criterion (ie, to assess how many RV leads that fulfilled LAO40 criterion are in fact anchored in midseptum) and (2) to find other fluoroscopic or ECG criteria, which are better associated with the location of the RV lead relative to the midseptum.

Methods

Study Population
Study participants were prospectively enrolled in the Cardiocenter, Charles University and University Hospital Královské Vinohrady, Prague. Written informed consent was obtained from all patients, and the study protocol was approved by the Ethics Committee of the University Hospital Královské Vinohrady, Prague, Czech Republic. Inclusion criteria were standard indication for pacemaker implantation according to current European and Czech national guidelines, written informed consent, and successful implantation of RV lead into the midseptum (according to the LAO40 criterion). Exclusion criteria were iodine allergy, absence of informed content, high creatinine levels (>130 μmol/L in men or >120 μmol/L in women). Because of the possible delayed side effect of radiation, patients aged <60 years were not included. Patients, in whom RV lead was impossible to implant in the midseptum according LAO40 criteria, were not analyzed. Patient follow-up was done in the outpatient clinic of the Department of Cardiac Arrhythmias.

Implantation Procedure
Pacemaker implantations were performed by experienced operators (each with >1000 procedures; P.O., D.H., P.S.) or performed by a fellow (K.C.) under a supervision. Pacemaker implantation was done under local anesthesia, mild sedation, and prophylactic intravenous antibiotics. The RV lead was inserted via the right cephalic or subclavian venous approach. Commercially available 58-cm or 60-cm bipolar active fixation (Biotronik Siello S 60, Vitatron ICQ09B) leads with steroid-eluting electrodes were used for RV septal implants. The main goal of implantation was to ensure midseptal pacing on the basis of currently accepted standards. The LAO40 view was retained as the key criterion for septal placement in our study. After this position was achieved, a standard measurement of the amplitude of the QRS complex and threshold were carried out. Only in cases of substantially insufficient pacing parameters (pacing threshold >1.5 V) was the lead repositioned to a different (midseptal) location.

First, a lead with J-shaped angulated stylet was inserted into pulmonary trunk. The positioning of the ventricular leads into the pulmonary trunk was guided by the posterior–anterior fluoroscopic view. The other stylet (Figure 1) was hand prepared for correct placement into the midseptum. First, a generous curve was created using the distal 5 to 6 cm of wire. Then, the last 2 cm was slightly bent posteriorly to create a swan neck deformity similar to the design suggested by Vlay. On the LAO40 view, the lead was withdrawn across the pulmonary valve back into the mid-RV until the desired LAO40 position was achieved (ie, the tip of the lead faced toward the spine and the angulation between horizontal plane and the axis of the distal part of the lead was between 0° and 60°). The lead was then screwed at this location. After that, the amplitude of QRS complex, threshold, and impedance were measured. After all procedures, recordings from the final lead position were made at a frame rate of 10 per second at the LAO40, posterior–anterior, right anterior oblique 30° (RAO30) and left lateral (LL) projections. All projections were printed out at diastole for analysis.

ECG
The 12-lead ECG was done at speeds of 25 and 50 mm/seconds on the day of implantation, and before cardiac CT. Parameters for septal pacing were analyzed: (1) QRS duration (measured manually), (2) QRS axis; QRS axis was calculated using net QRS amplitude in leads I, II, and III, (3) net amplitudes of QRS in limb leads, (4) presence of QRS notch in limb leads (pacing of free wall sites has been reported to result in notching in inferior leads), (5) the presence of q wave or negative QRS complex in lead I, and (6) QRS transition zone in the precordial leads. The transition zone was defined as the first precordial lead, where the R was higher than the S.

Cardiac CT
CT was done 1 month after implantation, but after the first outpatient check-up. Because lead dislodgement typically happens during the first days or weeks after implantation, we did not want to expose our patients to the additional radiation burden of a CT until after this risk-of-displacement period had passed. Moreover, some of our patients drink less on the day of implantation and we did not want to inject contrast dye into older patients while in a possibly dehydrated condition.

Image Acquisition
CT was performed using a 256-detector-row CT scanner (Brilliance iCT 256; Philips, Best, The Netherlands) with a tube voltage of 100 kV, a tube current of 200 to 300 mAs (depending on body mass index), collimation of 2x128x0.625 mm, a pitch of 0.18, a rotation time of 0.27 seconds, and a slice thickness of 0.9 mm. A triphasic injection of 60 mL of contrast media (Ultravist 370; Bayer Healthcare Pharmaceuticals, Montville, NJ) was applied. First, 50 mL of contrast agent was administered at a flow rate of 4.0 mL/second, followed by 20 mL of 50% contrast/saline. Subsequently, a saline flush of 30 mL was administered at a flow rate of 3.0 mL/second. Bolus tracking was used for synchronization of the contrast medium injection with scanning. The region of interest was positioned at the descending aorta. After enhancement reached 140 HU, there was 3-second post-threshold delay before the scan commenced. Prospective ECG-triggered dose modulation (mode step and shoot) was used, scanning 70% to 80% of the RR interval. After examination, the displayed dose–length product was recorded to evaluate the radiation dose. The mean dose–length product was 216±46.8 miliGray·cm. The mean effective dose was calculated using a weighting factor of 0.14 and was 3.0±0.7 miliSievert.
Image Postprocessing
Data sets were transferred to an external workstation (Comprehensive Cardiac Analyses, Brilliance Workspace v. 4.0; Philips Healthcare, Cleveland, OH) for offline analysis. Axial slices, oblique reconstructions, and maximum-intensity projection images were used for precise localization of the RV lead. In addition, we assessed the RV lead angle using 3-dimensional maximum-intensity projection images in the angiographic LAO40, RAO30, LL, and posterior–anterior projections. All evaluations were carried out by 2 experienced readers, who were blinded to the other’s results. Disagreement between readers was resolved by consensus. According to the location of RV lead, patients were divided into 2 groups: MS group (midseptum group), lead in the septum and non-MS group, lead outside the septum.

Fluoroscopic Electrode Assessment
The assessment of the end of the lead was done in the LAO40, RAO30, and LL projections. In the LAO40, the angle between the end of the lead and horizontal plane was measured by hand using a protractor (Figure 2A). In the RAO30, the heart was divided into 4 quadrants perpendicular to the cardiac silhouette at the spot, where the tip of the lead was anchored (Figure 2B). The quadrant, with the end of the lead, was analyzed. In the LL, the angle between the lead and vertical axis (parallel with the sternum) was measured. All analyzed measurements were done from projections obtained at the end of the implantation during diastole. Moreover, the LAO40 and RAO30 projections were reconstructed from cardiac CT scans and the position of the lead on these reconstructed images was compared with fluoroscopic images.

Statistical Analysis
Statistical analysis was performed using SPSS v. 12 (SPSS, College Station, TX) and Stata Software (StataCor LP, College Station, TX). P values <0.05 were considered to be statistically significant. Categorical variables were tested using the Fisher exact test or $\chi^2$ analysis, as appropriate. The comparison of distribution of all leads in different quadrants was tested using the generalized Fisher exact test. Continuous variables were analyzed using the Student t test. Multivariate analysis used a stepwise backward logistic regression model. Initially, a univariate logistic regression analysis was performed using various measured fluoroscopic and ECG variables. ECG variables entered into the model were QRS duration, QRS axis, the presence of q wave or a negative QRS complex in lead I, the presence of notching in lead I or inferior leads (II, III, aVF), sum amplitude of QRS complexes in leads I, II, III, aVL, and the transition zone in V6. Fluoroscopic variables entered into the model were the angle between the end of RV lead with the horizontal plane in LAO40, the quadrant where the end of RV lead was anchored in RAO30, and the angle of the lead in the LL projection of the vertical axis. All univariate predictors with P values <0.1 were included in the multiple logistic regression model to identify those that were independently related to correct location of the lead relative to the midseptum.

Results
Clinical and Implantation Results
Fifty-one patients were enrolled in the analysis. Initially, 56 patients were enrolled. However, in 5 patients, the final LAO40 position did not meet the criteria for midseptal placement (in all 5 cases, the angle between the horizontal plane and the tip of the lead was >60°). These patients were considered to have a low probability of the lead being in the midseptum and were excluded from the remainder of the study (CT was not done). From the 51 analyzed patients, the initial lead placement in 48 patients produced pacing parameters that were considered appropriate. In 3 patients, the pacing parameters were inappropriate and the leads were repositioned to a different midseptal site. Finally, in all 51 cases, the final shapes of the leads fulfilled the LAO40 criteria and final pacing parameters were appropriate, thus these patients were able to remain in the study. According to the cardiac CT scan, the tip of the lead was anchored in the septum in 21 patients (41.2%; MS group). Further analysis of the MS group showed 12 leads (57.1%) were in the middle of septum, 7 leads (33.3%) were on the border between mid- and low-septum, and 2 leads (9.6%) were inserted on the border between midseptum and RVOT septum. The leads in remaining 30 patients, that is, the non-MS group (58.8%), were outside the septum. Additional analysis of this group revealed that these leads were anchored in the anteroseptal groove (6 leads; 20%), in the anterior free wall (16 leads; 53.3%), or in the in superior (almost RVOT) anterior wall (8 leads; 26.7%). Basic clinical, echocardiographic, and other important characteristics of patients, indication for pacemaker implantation and type of implanted pacemaker are summarized in Table 1.

Regarding complications, there were 2 dislodgements (one in each group) that were observed during outpatient follow-up; these were successfully repositioned. One patient required surgical revision because of a pocket hematoma. In the non-MS group, there was 1 case of cardiac tamponade with need for puncture. In addition, in 1 patient in the non-MS group, the end of the tip of the lead touched the left anterior descending artery but without clinical consequences. The short-term outcomes for all patients were good at the 6-week follow-up in the outpatient department.

Fluoroscopy
The measured characteristics of the LAO40, RAO30, and LL projections are shown in Table 2. There was no difference in

Figure 2. Example of left anterior oblique (LAO40) and right anterior oblique (RAO30) with description of measurements. In the LAO40, the angle between the horizontal axis and the end of the lead was measured. In the RAO30, cardiac silhouette (at the end of the tip of the lead) was divided perpendicular to its contour into 4 quadrants. The location of the tip of the lead was assessed.
the angle between the end of the lead and horizontal plane between both groups in LAO40. However, in the RAO view, the majority of leads, which were not anchored in the septum, were in the upper left quadrant, near the LL cardiac contour (N=29; 96.7%). This was in contrast to the MS group, where tips of only 2 leads (9.5%) were anchored in this quadrant on the RAO30 projection. The majority of leads that actually anchored into the septum were in the middle (either in the second or the third) quadrants of the cardiac silhouette viewed on the RAO30 (18 [85.9%] in the MS group versus 1 [3.3%] in the non-MS group; \( P<0.001 \)). There was no difference in the angle between the tip of the lead and the vertical axis in LL view, between groups.

The location of the lead in particular quadrant on fluoroscopy image on the RAO30 was verified with the location on the CT-reconstruction of RAO30 (with an agreement of 100%). Similarly, the shape and orientation of the lead on the LAO40 were compared with CT-reconstructions of LAO40 with complete agreement. For analysis, the angles at LAO40 obtained with fluoroscopy were used. Examples of 2 patients, one with the lead in the septum and the other with the lead in the anterior wall, are shown in Figure 3.

### ECG Characteristics

The measured ECG characteristics are shown in Table 3. Septal pacing was associated with shorter QRS duration and more pronounced leftward axis. There was no difference in the presence of q waves in lead I or notching of QRS complex in inferior leads. Transition zone in precordial leads was slightly later in the non-MS group.

### Multiple Logistic Regression

In the univariate logistic regression model, the following variables had a \( P \) value <0.1: QRS duration (odds ratio [OR] 0.97; \( P=0.050 \)), QRS axis (OR, 0.99; \( P=0.043 \)), the presence of q in I (OR, 0.27; \( P=0.03 \)), notching in III (OR, 0.29; \( P=0.088 \)), transition zone (OR, 0.48; \( P=0.033 \)), and the presence of the lead in middle or inferior quadrants (OR, 276; \( P<0.001 \)). All these parameters were next tested in multiple logistic regression models: the only significant predictor of correct location of the RV lead in the septum was the location of the lead in middle or inferior quadrants on RAO30 (OR, 245 [95% confidence interval, 18–3357]; \( P<0.001 \)). The presence of the lead in the middle or inferior quadrants on the RAO30 had a specificity of 96.7%, sensitivity of 85.7%, positive predictive value of 94.7%, and negative predictive value of 90.6% for correct location of the lead in the septum.

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**Table 1. Basic Clinical, Echocardiographic, and Other Important Patient Characteristics**

<table>
<thead>
<tr>
<th></th>
<th>MS (N=21)</th>
<th>Non-MS (N=30)</th>
<th>( P ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>76.8±8.7</td>
<td>74.8±7.9</td>
<td>0.39</td>
</tr>
<tr>
<td>Male sex (%)</td>
<td>13 (62)</td>
<td>11 (37)</td>
<td>0.09</td>
</tr>
<tr>
<td>BMI</td>
<td>26.7±4.5</td>
<td>27.4±3.5</td>
<td>0.54</td>
</tr>
<tr>
<td>LVEDd, mm</td>
<td>51.1±4.8</td>
<td>50.6±5.5</td>
<td>0.77</td>
</tr>
<tr>
<td>LA diameter, mm</td>
<td>43.7±6.8</td>
<td>40.9±5.0</td>
<td>0.09</td>
</tr>
<tr>
<td>RVEdd, mm</td>
<td>28.1±3.8</td>
<td>27.8±4.7</td>
<td>0.81</td>
</tr>
<tr>
<td>LV EF, %</td>
<td>57.4±6.5</td>
<td>59.0±5.8</td>
<td>0.35</td>
</tr>
<tr>
<td>Tri reg (moderate or severe)</td>
<td>7 (33)</td>
<td>7 (10)</td>
<td>0.53</td>
</tr>
<tr>
<td>Indication 1 (%)/2 (%)/3 (%)</td>
<td>9 (43)/3 (14)/9 (43)</td>
<td>9 (30)/14 (47)/7 (23)</td>
<td>0.05</td>
</tr>
<tr>
<td>Single/dual (%)</td>
<td>11 (52)/10 (48)</td>
<td>10 (33)/20 (67)</td>
<td>0.25</td>
</tr>
<tr>
<td>Ventricular threshold, V</td>
<td>0.71±0.18</td>
<td>0.62±0.17</td>
<td>0.07</td>
</tr>
<tr>
<td>QRS amplitude, mV</td>
<td>10.7±7.1</td>
<td>10.5±6.3</td>
<td>0.91</td>
</tr>
<tr>
<td>Impedance, ( \Omega )</td>
<td>648±134</td>
<td>696±172</td>
<td>0.30</td>
</tr>
</tbody>
</table>

**Table 2. Fluoroscopic Characteristics of Patients**

<table>
<thead>
<tr>
<th></th>
<th>MS (N=21)</th>
<th>Non-MS (N=30)</th>
<th>( P ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAO40 angle</td>
<td>41.67±19.73</td>
<td>47.53±14.34</td>
<td>0.23</td>
</tr>
<tr>
<td>RAO30 first quadrant</td>
<td>2 (9.5)</td>
<td>29 (96.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>RAO30 second quadrant</td>
<td>14 (66.7)</td>
<td>1 (3.3)</td>
<td></td>
</tr>
<tr>
<td>RAO30 third quadrant</td>
<td>4 (19.0)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>RAO30 fourth quadrant</td>
<td>1 (4.7)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>LL angle</td>
<td>80.38±95.42</td>
<td>81.57±105.39</td>
<td>0.96</td>
</tr>
</tbody>
</table>

Continuous data are presented as mean±SD, categorical data as count and percentages. Indication is the indication for pacemaker implantation; single/dual is the single- or dual-chamber device. 1=sick sinus syndrome, 2=atrioventricular block, 3=atrial fibrillation and significant bradycardia. BMI indicates body mass index; EF, ejection fraction of left ventricle; LVEDd, left ventricular end-diastolic dimension; LA, left atrium; MS, midseptum; RVEdd, right ventricular end-diastolic dimension; and Tri reg, tricuspid regurgitation.
Discussion
The major finding is that only 41% of the RV leads, which fulfilled standard fluoroscopic criteria on the LAO40 for septal placement, were in fact placed into the septum. In addition, the RAO view can be very helpful for correct assessment of septal lead placement.

The placement success rate in the septum has been addressed in several studies. However, the absolute majority of them considered septal position if the lead fulfilled a characteristic shape in the LAO40, which was in most studies, the only verification of septal position.6,7 The exact location of the RV lead using more precious anatomic methods has only been verified in a few recent studies (all by echocardiography).6,13,14 Domenichini et al8 randomized 59 patients in apical or septal pacing. The exact location of the RV lead position was verified using echocardiography. A true midseptal position was observed in 54% of patients, the anterior position was found in the remaining 46% of patients. Ng et al13 compared apical and septal pacing in a nonrandomized study. Septal pacing was based on LAO40 in 17 patients, and the exact location of the lead was also confirmed by echocardiography. RV septal pacing consisted of a heterogeneous group of pacing sites. The preferred pacing site was reported to have been achieved in 12 patients (70.6%); however, the anteroparietal trabeculation was considered a valid septal position for the RV lead (which is in fact adjacent to the anterior wall near the septum or the anteroseptal groove) and cannot be considered as the true septal area.15 Therefore, the placement of RV lead into the true midseptum was, in this study, achieved in only 1 patient from 17 (ie, 5.9%).13

Several ECG criteria were found to be attributed to septal pacing. The most often established was the presence of q wave or negative QRS complex in lead I.16,17 Most of the studies describing this criterion as a characteristic for septal position, confirmed the location of the lead by fluoroscopy only and studied RVOT but not midseptal pacing.

There are only a few studies which have addressed the ECG characteristics of midseptal lead placement and verified the correct location of the lead exactly using techniques other than LAO40. Burri et al9 performed an anatomic reconstruction of the RV using the NavX system and studied ECG criteria characteristic of midseptal and anterior (free) wall pacing in 31 patients. In the study, the presence of q wave in lead I was not different between anterior and septal pacing (even though, q waves or negative QRS in lead I were more frequently present in anterior pacing, although the difference was not statistically significant). Notching of QRS in lead I or the inferior lead was

<table>
<thead>
<tr>
<th>Table 3. ECG Characteristics of Patients</th>
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<tbody>
<tr>
<td>MS Group (N=21)</td>
</tr>
<tr>
<td>QRS duration, ms</td>
</tr>
<tr>
<td>QRS axis, °</td>
</tr>
<tr>
<td>Q in I (%)</td>
</tr>
<tr>
<td>QRS amplitude in I, mV</td>
</tr>
<tr>
<td>QRS amplitude in II, mV</td>
</tr>
<tr>
<td>QRS amplitude in III, mV</td>
</tr>
<tr>
<td>Notching in inferior leads</td>
</tr>
<tr>
<td>Transition zone</td>
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</tbody>
</table>

Continuous data are presented as mean±SD, categorical data as count and percentages. The “R” transition zone was defined as the first precordial lead where the R was higher than the S. MS indicates midseptum.
only marginally more frequent in septal compared with anterior free wall pacing; only the QRS axis was more leftward leaning in septal pacing compared with anterior pacing. In the study by Domenichini et al., paced QRS duration in true septal pacing was significantly shorter with less leftward leaning axes compared with apical pacing. However, a negative QRS complex in lead I was not an accurate marker of true septal pacing, being present only in 1 of 14 patients with a midseptal lead and in 12 of 12 patients with an anterior lead. In the study by Ng et al., there was a significant difference in QRS duration, axis, and presence of q waves in lead I between (by fluoroscopy) septal versus apical pacing. However, when analyzed septal paced group separately, there was only a modest agreement between different places on echocardiography and ECG, or echocardiography and fluoroscopy.

These above-mentioned findings are in agreement with our result. In our study, the presence of q waves or negative QRS in lead I, which is the most common characteristic ascribed to septal pacing, was also more (although not significant) frequent in pacing from the anterior wall and the axis was more leftward leaning in true septal pacing. Also the transition was earlier and the amplitude of QRS in lead I was higher in the septally paced patients. This may be explained by more leftward position of the anterior pacing site because of the orientation of the heart and a rightward bulge of the midseptum.

It is important to realize that, in our study, we compared true midseptal pacing with pacing on the adjacent anterior wall. We did not compare ECGs between septal and apical pacing because it has been done in most randomized trials. Moreover, we also did not compare anterior versus septal RVOT pacing. Therefore, the comparisons of our finding with findings of studies of RVOT pacing should be viewed cautiously. Studies from Domenichini et al. and Burri et al. were carried out from a similar point of view.

Regarding fluoroscopy, the absolute majority of studies followed LAO40 as the only landmark of septal position and this criterion is probably the most commonly used in clinical practice. Surprisingly, only 1 study (very recent) addressed any criterion other than the LAO40. This criterion was the position of the RV lead in the middle of the cardiac silhouette at the RAO, which was similar to our study. Burri et al. calculated the success rate of septal pacing (location in septum was verified by echocardiography) with 2D (J-curved) and 3D (J-curved with terminal posterior angulation) styles and, with or without use of the RAO view. Leads, which were at RAO30 located in the middle of cardiac silhouette, were considered to be placed in the septum, which was also similar to our study. The success rate of septal placement increased from 45% (2D stylet without RAO) to 97% (3D stylet with RAO).

True septal pacing resulted in smaller intraventricular dyssynchrony and better LV ejection fraction compared with apical pacing. However, pacing of the anterior wall resulted in intraventricular dyssynchrony similar or worse compared with apical pacing. Thus, the inconsistent results of studies comparing apical and only apparently septal pacing might have been because of variable positioning of the RV leads in patients randomized for septal pacing. Moreover, pacing of the anterior free wall should be avoided because it may result in adverse effects, such as reduced LV ejection fraction, or cardiac tamponade, or might present a risk for damage of the left anterior descending artery. Although our study was not aimed toward assessing the risk of cardiac tamponade or damage to the coronary artery, 1 tamponade event, in the non-MS group, is worth mentioning. In the only study comparing true septal (verified by echocardiography) versus apical pacing, septal pacing was associated with better LV ejection fraction and less dyssynchrony. Further studies, which examine true septal pacing, are needed to confirm less dyssynchrony and better outcomes associated with septal pacing.

In conclusion, correct positioning of the lead into midseptum, in our study, occurred in only 41% of patients, in whom the LAO40 criteria for midseptum placement were met. No ECG criteria were able clearly to distinguish between septal lead placement and anterior wall lead placement. We found that the RAO30 projection can ensure proper midseptal placement.

**Study Limitation**

Patients with severe LV dysfunction were not included in the study because of LV dilation in this patient group. Limited patient group size represents another study limitation, which could have led to broader confidence intervals in the statistical analysis.

**Acknowledgments**

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**Disclosures**

None.

**References**


**CLINICAL PERSPECTIVE**

Dyssynchronous contraction associated with right ventricular apical pacing can have deleterious effects on left ventricular function; however, pacing from the right ventricular septum should reduce this risk. The most frequently used criterion for septal lead placement is the shape of the lead, as seen in the 40° left anterior oblique 40 view: the angle between the horizontal plane and the lead should be between 0° and 60°. However, the actual reliability of this criterion has never been tested. The aim of the study was to verify this criterion using cardiac computed tomography and to find the best criteria for insuring correct placement of the electrode during septal implantation. Fifty-one patients were analyzed; all had septal lead implantation based on the left anterior oblique 40 criterion. A postimplantation computed tomography scan showed that the right ventricular lead was anchored in the septum of only 21 (41.2%; MS group) patients. In 30 patients (58.8%; non-MS group), the lead was anchored in the adjacent anterior wall. The main difference between the 2 groups was the shape of the lead in the 30° right anterior oblique view. The cardiac shadow on the 30° right anterior oblique was divided into 4 quadrants that were perpendicular to the lateral cardiac silhouette. In the MS group, most leads were anchored in the middle quadrants. In the non-MS group, most lead tips were found in the outer quadrants. The presence of the lead in the middle quadrants, on the RAO projection, was independently associated with correct midseptum lead placement.
The Insufficiency of Left Anterior Oblique and the Usefulness of Right Anterior Oblique Projection for Correct Localization of a Computed Tomography–Verified Right Ventricular Lead Into the Midseptum
Pavel Osmancik, Petr Stros, Dalibor Herman, Karol Curila and Robert Petr

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