Finding the “Gold Spot” in RV Pacing: A Review Article

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Abstract

As we know that transvenous pacing has been an advancement in the management of patients with bradycardias and the most basic level ensures rate that will support to maintain the cardiac output. However as we know from a long time now that pacing right ventricle (RV) apex for a long time may lead to left ventricle (LV) dysfunction, atrial fibrillation, heart failure, and it may lead to an increased mortality as reported. So many successful pacing algorithms and designs have been developed and designed so as to minimize unnecessary ventricular pacing but it is not always possible to avoid it in a proportion of pacemaker-dependent patients. As there is an undoubted evidence that RV apical pacing has deleterious effects but there has been an emerging evidence that pacing from the RV septum is associated with a shorter duration of activation, improved hemodynamics, and less LV remodeling. In addition concerns about the stability and longevity of steroid-eluting active fixation leads have proven to be unfounded. All the implanters at present have adopted RV septal pacing so that it can minimize the likely harm to their patients although it is not very well proven that other pacing site may give much benefit. This review will talk about the alternate site pacing and its consequences.

Keywords: Right Ventricle (RV); Left Ventricle (LV)

Introduction

Right ventricle has been an established practice for decades, but the optimal site of pacing has stayed a controversy to preserve hemodynamic function. Right ventricular (RV) apical pacing has been found to have a negative impact on synchrony of left ventricular contraction. However septal pacing of RV may have an advantage with less chances of dyssynchrony and overall reduced negative impact on the left ventricular (LV) contraction and function. As per literature, the results of many large randomized studies which compared apical and septal pacing were not found to have uniform results. And overall results have been seen to be affected by so many limitations like improper implantation of the lead in the septum, with so many leads apparently being septal, were in fact, implanted off-septum.

For such a long time now, a good number of studies have suggested that RV apical pacing (RVAP) has a potential to induce or worsen left ventricle (LV) contraction with dyssynchrony, LV longitudinal shortening and twist, atrial fibrillation, and heart failure which may cause more morbidity over time [2,3]. All these pathophysiological reasons have been attributed to the violation of several electrophysiological properties of the myocardium and so a reason for myocardial dysfunction [4]. The conduction in the myocardium as we all know is slower at least four times than that in the nervous Purkinje system. The conduction process over the muscle fibers is about two times faster than the perpendicular activation [5]. But as we know the conduction characteristics between the endocardial and epicardial layers are different [6,7]. In the setting of RVAP, the activation front changes and it becomes ellipsoidal, and we are able to see the slowed conduction, particularly in the intermediate and epicardial layers [1,4]. All these have been the reasons that we have been looking for alternative pacing sites which requires a more synchronous ventricular activation pattern and all these over time have been explored [1,4].

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The described changes in LV function as mentioned above have generated a search for selective non-apical RV alternative pacing sites so as to achieve a less eccentric and more physiologic pattern of ventricular activation which will be more physiological and with less morbidity overtime [8-11]. As mentioned till date, the other sites for RV pacing which have been explored like the His bundle and parahisian tissues [12,13], the mid-septum [14], the low interventricular septum or RV inflow tract [15,16], the right ventricular outflow tract (RVOT) [17,18] and in particular, the RVOT septum [19]. But out of all these sites, the widely explored of these selective alternative sites has been the RVOT and there has been an increasing focus on the septal aspect as well.

Consequently most studies and in particular the very earlier studies had a potential flaw that the leads which were likely positioned in the mid-RV or RVOT, but not necessarily septal. In a report of RVOT pacing where a simple curved stylet was used and most probably it was similar to the tool which had been used in most of the studies and in this it was seen that only 61% of the leads which were used were shown to be actually on the septum using the LAO (Left anterior oblique) fluoroscopic projection with the remainder on the anterior and free walls [19]. So it always remained a query that why is it important to distinguish septal positioning from other RV sites? When a review of the work of Durrer., et al. was done [20], it was found that the septal regions of the LV were the first zones of the ventricle to depolarize and rightly so and it suggested that if we initiate pacing from very close to the areas on the right side of the septum, it will achieve as normal a contraction pattern as is possible. On the other side, the RV free wall will be the last zone which will get depolarized. Whenever it was tried to prove the physiologic and the hemodynamic benefits of septal pacing, it looked to be very illogical to have the RVOT pacing with a mix of both septal and free wall pacing. Thus here the likely beneficial effects of septal pacing are likely to be negated when we do free wall pacing and thus it won’t be a surprising result that we see no consistent physiologic benefit of RVOT pacing over RV apical pacing.

Zhang., et al. had a comparative study with RVOT pacing vs RVAP in elderly patients with normal LVEF [21]. Their results showed deterioration in the LVEF in patients with RVAP in contrast with those who had RVOT pacing, suggesting that RVOT pacing is better than RVAP in preventing cardiac dysfunction. However a study by Gong., et al. [22] found although RVOT pacing caused more synchronous LV contraction than RVAP, but no benefit over RVAP was shown regarding the prevention of cardiac remodeling and preservation of LV systolic function after 12 months of pacing in patients with normal cardiac function. It was shown that RVOT pacing also produced a wide QRS complex with a median QRS duration of 161 ms, a value that was very different and surprising from that in other studies concerning QRSd produced by RVOT septal pacing. So the precise pacing site might be different from others. And such a prolonged QRS duration by RVOT septal pacing may increase heart failure risk similar to long-term RVAP [23].

A latest well organized PROTECT PACE study, showed that pacing from either RV Apex or RV hiss site (RVHS) may result in a small but statistically significant reduction in overall LV function over a 2-year period, but RVHS has not conferred any much of a protective (or detrimental) effect on LV systolic function over RVA pacing. Thus, as of now there is no current indication to change the standard pacing site practice particularly in regard to RV lead placement, as it remains a safe and a very effective treatment for almost all high-degree AV blocks [24].

<table>
<thead>
<tr>
<th>Study/reference</th>
<th>Year</th>
<th>No. pts.</th>
<th>Alternate pacing site</th>
<th>Study type</th>
<th>Physiologic investigation</th>
<th>EF</th>
<th>Length study</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Victor, et al.</td>
<td>1999</td>
<td>16</td>
<td>RVOT</td>
<td>Some ablation</td>
<td>NYHA, 0 uptake, exercise time, EF radionuclide</td>
<td>Mixed</td>
<td>Cross-over 3M</td>
<td>0</td>
</tr>
<tr>
<td>Mera, et al.</td>
<td>1999</td>
<td>12</td>
<td>RVOT septal</td>
<td>All ablation</td>
<td>EF radionuclide Fractional shortening</td>
<td>Mixed</td>
<td>Cross-over 2M</td>
<td>+</td>
</tr>
<tr>
<td>Stambler, et al.</td>
<td>2002</td>
<td>80</td>
<td>RVOT</td>
<td>Some ablation</td>
<td>EF choardiograph, quality of life, 6M Hall Walk</td>
<td>LV &lt; 40%</td>
<td>Cross-over 3M</td>
<td>0</td>
</tr>
<tr>
<td>Bourke, et al.</td>
<td>2002</td>
<td>20</td>
<td>RVOT</td>
<td>All ablation</td>
<td>EF radionuclide Mixed</td>
<td>Randomized 4M</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Victor, et al.</td>
<td>2005</td>
<td>28</td>
<td>RV septum</td>
<td>All ablation</td>
<td>EF radionuclide Mixed</td>
<td>Cross-over 3M</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Muto, et al.</td>
<td>2007</td>
<td>233</td>
<td>RV mid-septum</td>
<td>Slow AF</td>
<td>EF echocardiograph LV &lt; 30%</td>
<td>Randomized 18M</td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>

**Heart Block Studies**

| Tse, et al.     | 2002 | 24      | RVOT                 | EF radionuclide | Mixed | Randomized 18M | +      |
| Vanerio., et al.| 2008 | 150     | RVOT                 | Sane ablation AF | Survival | - 9 to 2694 Days | +      |
| Kypta, et al.   | 2008 | 98      | RV septum            | EF echocardiograph, exercise time, natriuretic peptide | Mixed | Randomized 18M | 0      |
| Tse, et al.     | 2009 | 12      | RVOT septal         | Upgrade RV apex to RVOT septal also RV apex control | EF radionuclide. 6M Hall Wak | Mixed | 18M |
| Plevari., et al.| 2009 | 31      | Low mid-septum      | EF echocardiograph, dyssynchrony | Mixed | Randomized 12M | +      |

**Table 1:** Long-term studies comparing pacing from the right ventricle apex and right ventricle alternate sites.

AF: Atrial fibrillation; No. Pts: Number of Patients; M: Months; NYHA: New York Heart Association Score; EF: Ejection Fraction.

**Conclusion**

All the attempts to shift from traditional RV apical pacing to RV septal pacing will require a reluctant change in mindset for many practitioners and beginners, many of whom ironically espouse the merits of avoiding unnecessary ventricular pacing and also practice cardiac resynchronization therapy. The landmarks from anatomy and also the electrocardiographic features seen in RV septal pacing have now

been very well described and easily recognized. Now so many simple tools have been made readily available and are very reliable. In spite of all this, the issue is still controversial and will remain so for time being but more and more evidence is turning in favor of alternative pacing site in RV which is more physiological and may preserve LV function.

**Bibliography**

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