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ORIGINAL ARTICLE

Assessment of left ventricular electromechanical activation during right ventricular apical and outflow tract pacing

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Abstract *Background:* Right ventricular (RV) apical pacing, induces asynchronous ventricular contraction and impairs cardiac function. Alternative sites of pacing particularly right ventricular outflow tract (RVOT) may have a more favorable hemodynamic profile, physiological left ventricular (LV) activation and normal ventricular contraction pattern. The Aim of the study was to find out the best alternative sites to RV apex for permanent pacemaker (PM) lead fixation in the RVOT, based on the width of the QRS in the surface ECG.

Patients and methods: The study included 69 patients with pacemaker-dependent complete heart block; 35 with active pacemaker lead fixation in the site which achieved narrowest max. QRS duration in the RVOT (group 1) and 34 with active pacemaker lead fixation in RV apex (group 2).

Results: High RVOT septum was the site which achieved the narrowest QRS duration on surface ECG (117.86 ± 8.43 ms) when compared with RV apex (140.29 ± 13.14) ($p < 0.001$). There was a marked LV asynchrony after 3 months in group 2; IVMD (51.67 ± 14.06 ms), LVPEP (191.55 ± 36.56 ms), RVPEP (142.45 ± 23.11 ms) and SPWMD (125.64 ± 34.15 ms) when compared to group 1; IVMD (26.93 ± 12.44 ms), LVPEP (107.32 ± 45.28 ms), RVPEP (76.11 ± 27.66 ms) and SPWMD (78.15 ± 36.45 ms) ($p < 0.001$). Tissue Doppler Imaging revealed marked difference on the opposing LV segments mainly between mid-septal and mid-lateral in group 2. The 6 MWT was much better in group 1 patients (473 ± 240 m) than in group 2 patients (308 ± 221 m) ($p < 0.001$).

Conclusion: High RVOT septum is the ideal site for PM lead implantation. Compared with RV apical pacing, it is associated with improvement in functional and hemodynamic parameters over medium-term follow-up.

1. Introduction

Right ventricular apical pacing produces abnormal and prolonged left ventricular (LV) activation with consequent mechanical dyssynchrony and dysfunction.[1] The previous

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deleterious effects led to the utilization of new pacing sites namely, the mid-RV septal and the RV outflow tract (RVOT), which showed better hemodynamic profile due to the presumed more physiologic activation pattern, in addition to the more practical approach than the His bundle pacing.[2,3]

However, due to the multiplicity of possible lead positions alternative pacing sites have yielded conflicting and controversial results.[4]

Since the septal regions normally depolarize first, RV septal pacing could achieve a more favorable ventricular contraction pattern. Such strategic sites could be found by endocardial mapping during pacemaker implantation. Based on this concept, we investigated the feasibility of RVOT endocardial mapping to identify optimal anatomical locations for lead placement.[5]

The Aim of this work was to find out alternative sites to RV apex for PM lead fixation which minimizes LV dyssynchrony and subsequent complications, and to prove the clinical benefit of RVOT pacing in increasing the patients exercise capacity.

2. Patients and methods

This prospective case-control study was conducted in Cardiology Department, Zagazig University Hospitals. We included 103 patients admitted to the cardiology department between September 2013 and September 2015 with 3rd degree AV block. Informed consent was obtained from all patients; the study was approved by the ethics and medical research committee in Zagazig University, thirty four patients were excluded during the study due to pacing percentage less than 90%, and sixty nine patients completed the study.

1. Grouping of patients:
The patients were randomly divided into two groups, and every other patient was assigned to one of two groups: group 1 (case group) included 35 patients where PM leads were inserted into any of the following RV positions (High RVOT septum, Mid RVOT septum, Low RVOT septum, High RVOT free wall and Low RVOT free wall) selected according to which site had the narrowest surface ECG QRS duration after pacing on these sites by intra-cardiac catheter and group 2 (control group) included 34 patients where PM active leads were inserted directly into RV apex.
2. Exclusion criteria:
We excluded patients with atrial fibrillation, ejection fraction less than 50%, ischemic heart disease, rheumatic valvular heart disease, any myocardial disease, congenital heart block, patients independent on the pacemaker (less than 90% dependence on the pacemaker as revealed during pacemaker programming, or the presence of indigenous rhythm in ECG during evaluation of the patient) and any patient with a comorbidity that can affect the 6 MWT result (e.g. musculo-skeletal disease, organ failure, BMI more than 30 kgm/m^2, anemia, negative inotropic medications and DM).
3. Pacemaker implantation:
   3.1. Initial pace mapping: All patients included in group 1 were submitted to RVOT pacing using quadripolar deflectable catheter with 5–5 mm electrode spacing inserted through the femoral vein into the RV, pacing was applied through the distal two pools with an amplitude of 2 V with 0.4 ms pulse width using EPS320 Cardiac Stimulator (Micropace Inc., CA, USA), and at a rate of 80/min, the simultaneous standard 12 lead surface ECG generated from the cardiac pacing was recorded using multichannel recorder cardiolab EP recording system (GE healthcare, WI, USA).
   3.2. Anatomical sites Identification: the pacing was applied to the RVOT which was identified as follows:
      3.2.1. The upper border of the RVOT was identified by passing the quadripolar catheter in the 30° RAO view to the pulmonary artery and withdrawing it gradually until a deflection appears between its distal poles (recorded on the intra-cardiac channel in the multi-channel recorder), at that point the RVOT upper border is noted. The lower border of the RVOT is identified by pushing the temporary pacing electrode in the RV apex until the shaft of the electrode can no more be advanced due to contact with the apex of the tricuspid valve, an imaginary line is passed from the highest point the shaft can reach to the lateral cardiac border, that line represents the lower border of the RVOT Fig. 1.
      3.2.2. Identification of selective anatomical sites in the RVOT:
      Once the upper and lower boundaries of the RVOT identified, the radiologic view was changed to LAO 30°, the medial aspect of

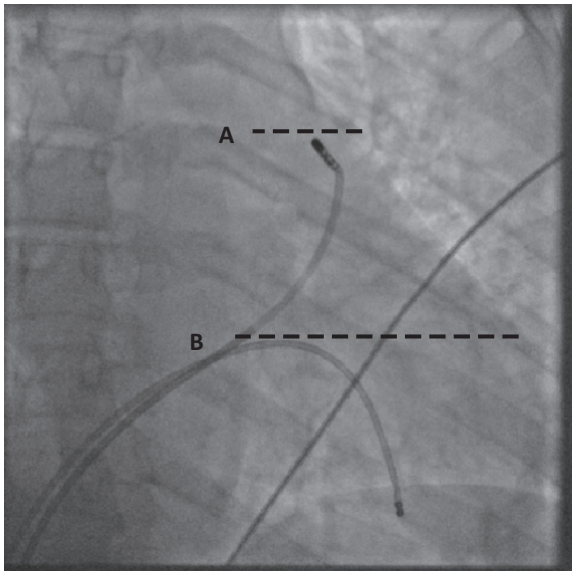

Figure 1 Fluoroscopic image of the heart in 30° RAO projection showing a quadripolar deflectable catheter just below the pulmonary valve marking the upper border of the RVOT (line A), and a bipolar pacing electrode in the RV apex with its highest point in its shaft marking the TV apex and the lower border of the RVOT (line B).