

# The influence of right ventricular apical pacing on left atrial volume in patients with normal left ventricular function

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**Background:** Right ventricular apical (RVA) pacing has been reported to induce several deleterious effects particularly in the presence of structural heart disease but can also involve patients with normal left ventricular (LV) function. Left atrial (LA) enlargement is one of these effects, but the majority of studies have measured LA dimension rather than volume.

**Objective:** The present prospective study was designed to assess the effect of RVA pacing on LA volume in patients with normal LV function.

**Patients and Methods:** The study comprised 41 consecutive patients with LV ejection fraction  $\geq 45\%$  and LV end diastolic dimension  $\leq 56$  mm who underwent single-or dual- chamber pacemaker implantation in RVA and followed for LA volume measurement and pacemaker analysis at least during the ensuing 4.2 months.

**Results:** In all, 21 patients were excluded from the study due to five spontaneous wide QRS complex ( $\geq 120$  msec), one recent acute coronary syndrome, one significant valvular heart disease, three pacing frequency  $< 90\%$ , eight death or losing follow up in three cases. In remaining 20 patients, LA volume ranged from 21 to 54 mm<sup>3</sup> with mean of  $37.3 \pm 9.7$  mm<sup>3</sup> prior to pacemaker implantation that increased to 31 to 103 mm<sup>3</sup> ( $54.3 \pm 17.0$ ) during follow-up ( $P < 0.001$ ).

**Conclusion:** RVA pacing might lead to an increase in LA volume even in patients with normal LV function.

**Keywords:** Right ventricular apical pacing, left atrial volume, left ventricular function.

## Introduction

The right ventricular apex (RVA) is the preferred site for cardiac stimulation in the management of symptomatic Brady arrhythmias<sup>1</sup> and remains the most widely used in standard indications<sup>2</sup>.

Chronic RVA pacing has been reported to induce several deleterious effects such as impairment of diastolic function<sup>3-5</sup> and reduction in systolic contraction, promotion of ventricu-

lar remodeling and arrhythmias as well as left atrial (LA) enlargement<sup>6</sup>. These side effects particularly occur in the presence of structural heart disease but can also involve patients with normal left ventricular function<sup>6</sup>. In this manner, LA enlargement has been taken into consideration less than other echocardiographic parameters and the majority of relative studies have measured LA dimension rather than LA volume, which is a better measurement of LA size and provides a favorable prognostic value. In addition, in some studies, LA volume expressed the severity of diastolic dysfunction and correlated with left ventricular end-diastolic dimension (LVEDD), left ventricular

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end-systolic dimension (LVESD) and left ventricular ejection fraction (LVEF)<sup>7</sup>. Therefore this prospective study was undertaken to assess the influence of RVA pacing on LA volume in the presence of normal LV function.

### Patients and Methods

**Study population:** This study included 41 consecutive patients with LVEF  $\geq$  45% and LVEDD  $\leq$  56 mm that underwent single- or dual- chamber pacemaker implantation in RVA. They were then subjected to follow-up (FU) echocardiography by the same cardiologist and pace analysis after at least 4.2 months.

### Echocardiographic Measurement

2-Dimensional (2D) transthoracic echocardiography (TTE) was performed using a commercially available ultrasound system (Acuson CV 70, Siemens), according to American Society of Echocardiography Guidelines (9,10), and LA volume was measured at end-systole from the apical 4-and 2-chamber views (discs methods).

### Exclusion Criteria

These involved spontaneous wide QRS complex ( $\geq$  120 msec) in 5 ,acute coronary syndrome (ACS) occurring recently or during FU in one, significant valvular heart disease (VHD) in one , pacing frequency  $<$ 90% in three, cardiac or non- cardiac death in eight, and losing FU in three patients.

### Statistical Analysis

Data are presented as mean  $\pm$  standard deviation. Patients were used as their own controls and comparison was performed using paired t-test. A p-value  $<$ 0.05 was considered statistically significant.

## Results

### Patients characteristics

**Table 1.** Demographic and echocardiographic data prior to pacemaker implantation

Parameter	Value
Age (years)	66.1 $\pm$ 10.8
Female	13 (65%)
Follow up (month)	7.9 $\pm$ 2.4
Pacing indication	
CAVB	17 (85%)
SSS	3 (15%)
Pacing mode	
VVIR	11 (55%)
DDDR	9 (45%)
LVEF (%)	70.3 $\pm$ 11.2
LA volume (mm <sup>3</sup> )	37.3 $\pm$ 9.2
LVEDD (mm)	46.1 $\pm$ 6.616

CAVB= Complete Atrio Ventricular Block, LA volume=Left Atrial volume, LVEDD= Left Ventricular End-Diastolic Dimension, LVESD= Left Ventricular End-Systolic Dimension, SSS= Sick Sinus Syndrome.

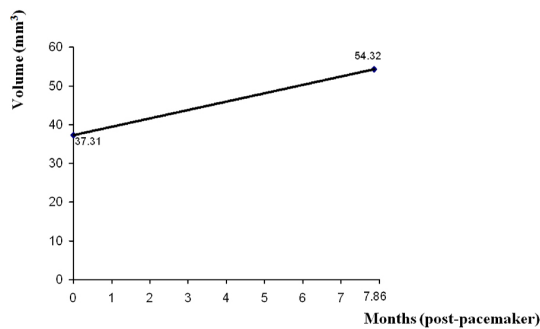
The study comprised 20 patients whose demographic and echocardiographic characteristics prior to pacemaker implantation are described in Table 1.

The patients aged from 35-83 (66.1 $\pm$ 10.8 years); and 65% were female. They were followed for 7.9 months (4.2-12.3 months)?. Indication for pacemaker implantation was complete atrioventricular block (CAVB) in 17 patients and sick sinus syndrome (SSS) in 3 cases. Pacemakers were single-chamber (VVIR) in 13 patients and dual- chamber (DDDR) and in the others.

**Echocardiographic parameters:** As shown in Fig. 1, LA volume (mm<sup>3</sup>) prior to pacemaker implantation ranged from 21 to 54 (37.3 $\pm$ 9.7) and in FU echocardiography became 31 to 103 (54.3 $\pm$ 17.0), and the differences were statistically significant (P $<$ 0.001).

## Discussion

Over the last decade several studies have demonstrated the deleterious consequences



**Fig 1.** Variation of Left atrial volume, pre- and post-pacemaker implantation.

of RVA pacing<sup>10-22</sup>. In this connection, a longitudinal controlled study was carried out that included 24 young patients (with mean FU of 9.5 years), whose RVA pacing led to irreversible LV systolic and diastolic dysfunction<sup>10</sup>. However a few investigations have evaluated LA enlargement as a side effect. Nielsen et al followed, in a randomized trial, 177 patients with SSS and normal atrioventricular conduction with AAIR or DDDR pacemaker for  $2.9 \pm 1.1$  years and found that LA diameter increased significantly in DDDR but not in AAIR group<sup>21</sup>. However, contrary to our study, comparing LA volume before and at least during FU of pacemaker implantation, no significant changes were found in any of the patients and LA dilation was possibly caused by the abnormal activation sequence and mechanical contraction

#### References

- 1 Tse HF, Lau CP. Long-term effect of right ventricular pacing on myocardial perfusion and function. *J Am Coll Cardiol.* 1997; **29**: 744-9.
- 2 Cock CC, Giudici MC, Twisk JW. Comparison of the hemodynamic effects of right ventricular outflow-tract pacing with right ventricular apex pacing. *Europace.* 2003; **5**: 275-8.
- 3 Bedotto JB, Grayburn PA, Black WH, et al. Alterations in left ventricular relaxation during atrioventricular pacing in humans. *J Am Coll Cardiol* 1990; **15**:658-64.
- 4 Betocchi S, Piscione F, Villari B, et al. Effects of induced asynchrony on left ventricular diastolic function in patients with coronary artery disease. *J Am Coll Cardiol* 1993; **21**: 1124-31.
- 5 Stojnic B, Stojanov P, Angelkov L, et al. Evaluation of asynchronous left ventricular relaxation by doppler echocardiography during ventricular pacing with AV synchrony (VDD): Comparison with atrial pacing (AAI). *PACE* 1996; **19**: 940-4.
- 6 Antonis SM. The deleterious consequences of Right ventricular Apical pacing: Time to Seek Alternate Site pacing. *PACE* 2006; **29**: 298-315.
- 7 Teresa SM. Left Atrial volume as a Morph physiologic Expression of left Ventricular diastolic Dysfunction and Relation to Cardiovascular Risk Burden. *Am J Cardiol* 2002; **90**: 1284-1289.
- 8 Quinones MA, Otto CM, Stoddard M, et al. Recommendations for quantification of Doppler echocardiography: A report from the Doppler Quantification Task Force of the Nomenclature and Standards Committee of the American Society of Echocardiography. *J Am Soc Echocardiogr* 2002; **15**:167-184.
- 9 Schiller NB, Shah PM, Crawford M, et al. Recommendations for quantitation of the left ventricle by two-dimensional echocardiography. American Society of Echocardiography Committee on Standards, Subcommittee on Quantitation of Two-Dimensional Echocardiograms. *J Am Soc Echocardiogr* 1989; **2**: 358-367.
- 10 Tantengco MVT, Thomas RL, Karpawich PP. Left ventricular dysfunction after long-term right ventricular apical pacing in the young. *J Am Coll Cardiol* 2001; **37**: 2093.

pattern of ventricles induced by RVA pacing<sup>24-27</sup> which was associated with a decrease in the LV systolic<sup>22, 23</sup> and diastolic dysfunction<sup>24</sup>.

Teresa SMT et al.<sup>7</sup> in a study on 140 adults referred for a clinically-indicated echocardiogram, demonstrated that LA volume correlated positively with age, body surface area, cardiovascular risk score, LVEDD and LVESD and negatively with LVEF. Also, LA volume expressed the severity of diastolic dysfunction and provided an index of cardiovascular risk and disease burden in patients without a history of atrial arrhythmias or valvular heart diseases.

#### Conclusion

RVA pacing can lead to an increase in LA volume even in patients with normal LV function. However, the study was limited in that our patients who had no evidence of ACS, may have had clinically silent coronary artery disease that contributed to LA volume increase, with additional limitation imposed by FU duration.

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- 11 Karpawich PP, Rabah R, Haas JE. Altered cardiac histology following apical right ventricular pacing in patients with congenital atrioventricular block. *Pacing Clin Electrophysiol* 1999; **22**:1372-1377.
- 12 Thambo J-B, Bordachar P, Garrigue S, et al. Detrimental ventricular remodeling in patients with congenital complete heart block and chronic right ventricular apical pacing. *Circulation* 2004; **110**: 3766-3772.
- 13 Tse H-F, Yu C, Wong K-K, et al. **Functional abnormalities with permanent right ventricular pacing.** *JAmColl Cardiol* 2002; **40**: 1451-1458.
- 14 Hamdan MH, Zagrodzky JD, Joglar JA, et al. **Biventricular pacing decreases sympathetic activity compared with right ventricular pacing in patients with depressed ejection fraction.** *Circulation* 2000; **102**: 1027-1032.
- 15 The DAVID Trial Investigators. Dual-chamber pacing or ventricular backup pacing in patients with an implantable defibrillator : The dual chamber and VVI implantable defibrillator (DAVID) trial. *JAMA* 2002; **285**: 3115-3123.
- 16 Moss AJ. Findings from MADIT II substudies. *Eur Heart J* 2003; **5(Suppl. I)**: 134-138.
- 17 Steinberg JS, Fischer A, Wang P, et al., for the MADIT II Investigators. The clinical implications of cumulative right ventricular pacing in the multicenter automatic defibrillator trial II. *J Cardiovasc Electrophysiol* 2005; **16**: 359-365.
- 18 Wonisch M, Lercher P, Scherr D, et al. **Influence of permanent right ventricular pacing on cardiorespiratory exercise parameters in chronic heart failure patients with implanted cardioverter defibrillators.** *Chest* 2005; **127**: 787-793.
- 19 Thackray SDR, Witte KKA, Nikitin NP, et al. The prevalence of heart failure and asymptomatic left ventricular dysfunction in a typical regional pacemaker population. *Eur Heart J* 2003; **24**: 1143-1152.
- 20 Sweeney MO, Hellkamp AS, Ellenbogen KA, et al. for the MOST Investigators. Adverse effect of ventricular pacing on heart failure and atrial fibrillation among patients with normal baseline QRS duration in a clinical trial of pacemaker therapy for sinus node dysfunction. *Circulation* 2003; **107**: 2932-2937.
- 21 Nielsen JC, Kristensen L, Andersen HR, et al. **A randomized comparison of atrial and dual chamber pacing in 177 consecutive patients with sick sinus syndrome.** *J Am Coll Cardiol* 2003; **42**: 614-623.
- 22 O'Keefe JH, Abuissa H, Jones PG, et al. Effect of chronic right ventricular apical pacing on left ventricular function. *Am J Cardiol* 2005; **95**: 771-773.
- 23 Leclercq C, Gras D, Le Hellocq A, Nicol L, Mabo P, Daubert C. Hemodynamic importance of preserving the normal sequence of ventricular activation in permanent cardiac pacing. *Am Heart J* 1995; **129**: 1133-1141.
- 24 Rosenqvist M, Isaaq K, Botvinick EH, et al. Relative importance of activation sequence compared to atrioventricular synchrony in left ventricular function. *Am J Cardiol* 1991; **67**: 148-156.