Long Term Effect of Permenant Right Ventricular Pacing on Left Ventricular Systolic Function

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ABSTRACT:

BACKGROUND:

Right ventricular apical pacing is associated with alterations of left ventricular contraction sequence and dilatation and may have a deleterious effect on left ventricular function.

OBJECTIVE:

The study investigates the correlation between left ventricular function and long term right ventricular pacing.

METHODS:

In this study, 80 patients with permanent right ventricular apical pacing (VDD and DDD) randomized to assess left ventricular systolic function particularly LVEF% .primary end point was LVEF% after 1 year of pacing.

RESULTS:

In this study, the mean LVEF% was reduced after 1year of right ventricular pacing from (67.47±2.94 to 55.89±8.41, p value 0.0001), with absolute reduction of about 12%.

Patients with LV systolic dysfunction (EF% less than or equal to 45%) which constitute 10 patients (12.5%) have mean baseline LVEF% (66.70±4.03 reduced to 37.50±6.38, P value 0.0001). Cumulative percentage of RV pacing and duration are predictors of LVEF% reduction.

CONCLUSION:

Conventional right ventricular apical pacing resulted in a significant reduction in the left ventricular ejection fraction, particularly in patients with high percentage of right ventricular pacing and should be suspected in any patients after long term pacing of right ventricular. Functional rather than topographic criterion should be considered for optimal pacing.

KEY WORD : permanent RV pacing. LV dysfunction

INTRODUCTION:

One of the most challenging tasks of modern pacing is to optimise or at least stabilize cardiac performance. This is clearly dependent on the important factors of chronotropic function, the quality of AV synchrony, the ventricular activation sequence and ventricular pacing site [(1)].

Over the last 40 years stimulation of the right ventricular apex became the standard method for pacing the ventricles because it is a stable and easily accessible site, and usually provides appropriate sensing and threshold parameters [(1,2)] Although it was quickly realised that stimulation of this site leads to an abnormal contraction pattern by bypassing the physiological conduction system, for pacing in patients with life-threatening conditions it still seemed appropriate. However, with the widening of classical pacing indications and the realisation that some patients developed deterioration of left ventricular function and sometimes heart failure after pacing, it became the subject of studies into its effect on left ventricular function[(1,2)].

The deleterious effect of nonphysiologic right ventricular apical pacing on left ventricular systolic function has been recognized since the 1920s.The unexpected increased rates of death and hospital admission for heart failure among patients who were randomly assigned to the dual chamber, rate-adaptive (DDDR) mode were purportedly due to the adverse effect of right ventricular apical pacing on left ventricular structural remodeling.[(2)]

Results of subsequent trials have supported the notion that right ventricular apical pacing might lead to adverse clinical outcomes in patients with standard pacing indications. Nevertheless, right ventricular apical pacing continues to be practiced by many physicians because of its easy accessibility and relative stability over time; the

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optimal mode and site of pacing remain undefined. [3,4]

Experimental studies have demonstrated that long-term right ventricular apical (RVA) pacing induces abnormal histologic changes with myofibrillar disarray, as well as asymmetrical LV hypertrophy and thinning.[5]

Asynchronous ventricular activation during ventricular pacing is associated with abnormal regional myocardial blood flow and metabolism and reduces systolic and diastolic left ventricular (LV) function.[6] Furthermore, these functional abnormalities of ventricular pacing appear to have potential deleterious effects over time. For many years the attention given to optimising the atrio-ventricular delay during dual chamber pacing has delayed an understanding of the importance of the effect of pacing site on global and regional myocardial function. This is despite the fact that diminished ventricular function during pacing at the right ventricular apex has been known for decades from numerous human studies [6-7] The asynchronous activation induces asymmetrical hypertrophy of the left ventricular wall. This asymmetric hypertrophy by itself however does not primarily influence the pump function. Abnormal electrical activation may thus lead to depressed left ventricular function [8,9] by the classical theory of "loss of effective muscle mass". According to this theory, during ventricular pacing the ventricle looses a part of its effective muscle mass due to reduced function of the early-activated regions. An alternative or probably additional mechanism is that RV apical pacing results in inferior interventricular coupling, since during RV pacing the right ventricular pressure rises much earlier than that in the LV and this causes significant paradoxical septal motion.[9]

In a previous clinical study, it was shown that long-term RVA pacing leads to regional myocardial perfusion defects and wall motion abnormalities, which become more pronounced as the duration of pacing increases, and subsequently impairs LV function [10]

During ventricular pacing the impulse conduction occurs predominantly through the working myocardium and the normal conduction system is bypassed. During right ventricular pacing the right ventricle is activated first followed by trans-sepal activation of the left ventricle, then the remaining part of the left ventricle is activated. The QRS duration is increased, due to a combination of slow trans-septals activation (local and diffuse), and delayed activation of the remaining part of the left ventricle. . Right ventricular apical pacing causes significant intraventricular conduction delay. Segments of the left and right ventricle contract at different times and the interventricular septal wall contracts abnormally. [9-12]

This phenomenon results in decreased contractility, reduced diastolic filling and prolonged duration mitral regurgitation. The abnormal activation of the ventricles via right ventricular apical pacing may result in multiple abnormalities of cardiac function, which may ultimately affect clinical outcome. [12,13]

Ventricular desynchronization itself may occasionally cause severe mitral regurgitation that may precipitate atrial fibrillation and CHF. Left ventricular contraction initiated by apical RV pacing alters papillary muscle function, with resultant derangement of the time sequence of activation of the mitral valve apparatus. Mitral annular movement, which influences mitral valve function, is also affected by LV dyssynchrony. Pacemaker-induced mitral regurgitation may be largely reversible or attenuated in many cases by restoration of LV synchrony.[13,14]

AIM OF THE STUDY:

To evaluate the effect of right ventricular pacing on left ventricular systolic function by ECHO study.

METHODS:

In this study, 80 patients with permanent right ventricular apical pacing (VDD and DDD) randomized to assess left ventricular systolic function particularly LVEF% .primary end point was LVEF% after 1 year of pacing.

PATIENTS:

Eighty patients with perminant pacemacker who were collected from April 2010 to February 2011, in Ibn-Albitar center for cardiac surgery who were undergoing a regular follow up programming in a programming unit(CRM unit) were included in this study.The patients were initially selected after detailed history about time of pacemaker implantation and their indications , associated risk factors,symptoms of heart failure in addition to compelete physical examination .

Inclusion criteria:Any patient with DDD pacing more than 1 year, Patient with VDD pacing more than 1 year, Right ventricular apical pacing and available baseline echocardiography.

Exclusion criteria: Patient with VVI pacemaker, VDD or DDD programed to VVI, Patients whose baseline echocardiographic record was not available, Patients known to have ischemic heart disease(by coronory angiography), Patients with

baseline LV dysfunction, LVEF% <50%.[15-16] RV septal or outflow pacing, abnormal thyroid function tests and history of alcoholism.

All patients underwent:ECG(superior axis and LBBB usefull to localize RV apical pacing), CXR to localize RV lead position, Echocardiography to assess LV systolic function, Pacemaker programming especially percentage of RV pacing

All included patients underwent:

1. ECG ,superior axis and LBBB usefull to localize RV apical pacing.

2-Echocardiography to assess LV systolic function(particularlly LVEF%).Patients evaluated by at least two echocardiographers and two different echocardiography mechines.The methods used for calculation of LVEF% were both of the following:

a.Eye ball, assessment; 2D echocardiography.[(17)]

b.From LV dimensions measured with M-mode echocardiography. M- Mode or 2D echocardiographic measurement of LV dimensions from the mid ventricular level is used to calculate LVEF as follows.[(17)]

LVEF%= $(LVEDD^2 – LVESD^2)/LVEDD^{(2)}$.

3- Pacemaker programming: for Important related parameters (especially percentage of RV pacing).

4- Inspirartory CXR film to localize RV lead position(postero-anterior and lateral).

5.Blood tests sent to evaluate associated risk factors which enclude:blood sugar,serum urea , creatinine ,lipid profile panale(total serum cholesterol , LDL, HDL, total serum triglyceride)and thyroid function tests(TSH,T4 and T3).

6.Patients with echocardiographic evidance of LV systolic dysfunction(LVEF% equal or less than 45%)sent for cardiac catheterization to evaluate coronory arteries and LV function.[(15,16)]

RESULTS:

Eighty patients with VDD and DDD pacemaker, 37(46.3%) were male and 43 (53.7%) were female, with a mean age of (56±4.3) years.

DDD 58(72%), and 22(27.5%) had VDD .Table 1.

The reduction in LVEF% after 1 year was significant in both VDD and DDD groups (p value 0.0001).

The most frequent associated risk factor was hypertension (32 patient, 40%), followed by smoking (28 patients, 35%), D.M (22 patients, 27.5%) and hyperlipidemia (14 patients, 17.5%).

Most of the patients included in this study had DDD pacemaker (72%), and only 22patients (27.5%) had VDD permanent pacemaker. Table 1.

The reduction in LVEF% after 1 year was significant in both VDD and DDD groups (p value 0.0001).

The mean baseline LVEF% of all was (67.47±2.94) ,while the mean of LVEF% after 1 year declined to (55.89±8.41) .This reduction in LVEF was highly significant(p-value 0.0001). Table 2.

Table 1: Mode of pacemakers.

parameter	No. of patient	%	Mean baseline EF%	Mean EF%>1y	P value
VDD	22	27.5	68.77±2.33	58.55±4.16	0.0001
DDD total	58 80	72.5 100	67.98±2.01	54.88±9.38	0.0001
P value			0.093	0.082	

Table2: Indications of pacemakers and their mean LVEF% (baseline and after 1 year).

parameter	No. of patient	%	Mean baseline EF%	Mean EF%>1y	P value
CHB	62	77.5	67.39±2.95	54.66±8.31	0.0001
2^{nd}.degreeHB total	18 80	22.5 100	67.60±2.82	61.67±4.20	0.0001
P-value			0.754	0.010	

DISCUSSION:

Asynchronous electrical activation during ventricular pacing has been shown to alter regional myocardial blood flow and work. This redistribution of regional myocardial blood flow and work is associated with abnormal structural and histological changes in the ventricles. Previous experimental studies have demonstrated that RV apical pacing results in greater impairment of ventricular function, as compared with pacing at other sites suggesting that the

size of the region with reduced function appears to be too large to be compensated during RV apical pacing. [18,19]

Previous observational studies involving patients who received right ventricular apical pacing ;suggested that the left ventricular ejection fraction was reduced by 5% after a follow-up period of three years.[20],howevere ; in recent studies the reduction in global LVEF% in patients receiving RV pacing (after one year) is about 7 to 14% [16-21].

In this study,the mean LVEF% of all patients who underwent RV pacing was significantly reduced after one year, from (67.47±2.94)to (55.89±8.41) , with absolute reduction of about 12%.This result is comparable with other study.[21]

The ten Patients (12.5% of total cases), with LV systolic dysfunction (EF% less than or equal to 45%) have a mean baseline EF% of 66.70±4.03 which was reduced to 37.50±6.38. This result is comparable to other studywhich found that 9.5% of patients had LV systolic dysfunction after 12 months of RV pacing .[16]

The reduction in LV systolic function seems to be related to a high cumulative percentage of right ventricular apical pacing. This results is comparable with previous studies [2-3] .Such pacing causes an abnormal left ventricular electrical-activation sequence, which is manifested on an electrocardiogram as left bundle-branch block[22]this abnormal sequence leads to an electromechanical delay in contraction (or systolic dyssynchrony) and, subsequently, to asymmetric hypertrophy, increased mitral regurgitation, and a decreased ejection fraction.[23,24,25].

In this study; the reduction in mean LVEF% after one year was more significant with third degree heart block than those with second degree heart block, this fact actually resulted from the degree of RV pacing were more in advanced and high grade heart block. [26,27]

Abnormal wall motion abnormalities and variable degree of mitral valve regurgitation were more frequent in patient with LV dysfunction. All patients with LVEF% equal or less than 45% have dyssynchrony and mitral valve regurgitation (mild to moderate) due to LV dilatation and remodelling, these findings are consistent with Daggett et al study. [10,11]

CONCLUSIONS AND RECOMMENDATIONS

The present study demonstrates that in patients with normal systolic function, conventional right ventricular apical pacing resulted in adverse left ventricular remodelling and in a reduction in the left ventricular ejection fraction The left ventricular systolic dysfunction should be suspected in any patient with permanent right ventricular pacing particularly in those with high cumulative percentage of pacing and after long period of pacing. Biventricular pacing may be considered in patients with high risk for left ventricular remodelling or dysfunction.

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