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Short communications

Effect of biventricular pacing on heart function evaluated by gated blood pool study in patients with end-stage heart failure

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Abstract

BACKGROUND: Biventricular cardiac pacing has been used as a complementary form of therapy in patients with severe heart failure. The aim of this study was to evaluate the effect of the synchronous stimulation of both ventricles on the heart function measured by gated blood pool study (GBP).

MATERIAL AND METHODS: Ten patients (9 men and 1 woman aged 53–74 years) with end-stage heart failure (HF) were studied. In all patients long-term biventricular pacing (BV) was applied. The obtained results were compared with single-chamber stimulation in 5 patients and with sinus rhythm (SR) in 8 patients. All patients underwent repeated GBP with RBC labelled with 740 MBq of 99 mTc-pertechnetate. The LVEF was calculated according to the standard method based on the count rates. Phase analysis was performed with the standard method using first Fourier element.

RESULTS: Clinically in almost all patients moderate to important symptomatic improvement has been observed. The analysis of LVEF values revealed that BV pacing resulted in significantly higher values only in comparison with SR (21.6% ± 10.3 v. 20.1% ± 10.1; $p < 0.05$). The phase shift between both ventricles by BV pacing was positive and similar to that obtained with SR and RV stimulation (14.0° ± 29.6 v. 13.4° ± 37.6 and 7.4° ± 26.5 v. 6.0° ± 17.1 respectively). However, in comparison with LV pacing, BV stimulation revealed a change of dominant conduction abnormalities with a delay of RV contraction in relation to LV (9.0° ± 17.5 v. –3.0° ± 11.4).

CONCLUSIONS: Biventricular pacing results in slight improvement of LVEF in patients with heart failure and can be considered a promising approach in patients with end-stage heart failure. Synchronous stimulation of both ventricles not always results in decrease of interventricular shift, however that observation requires further studies on a larger population.

Key words: biventricular pacing, gated blood pool, LVEF

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Introduction

Biventricular cardiac pacing has been used as a complementary form of therapy in patients with severe heart failure. That mode of pacing is thought to improve cardiac function by promoting a more coordinated ventricular contraction than single-chamber pacing, resulting in improved ventricular ejection fraction.

Gated blood pool (GBP) imaging with Fourier analysis has been extensively used to assess quantitatively global ventricular function and regional ventricular contraction in space and time [1].

The aim of our study was to evaluate the effect of the synchronous stimulation of both ventricles on the heart function measured by gated blood pool study.

Material and methods

Study population

Ten patients (9 men and 1 woman aged 53–74 years, mean 63.5 years) with end-stage heart failure (HF) were studied. Before the pacemaker implantation, 4 patients were in New York Heart Association (NYHA) functional class III and 6 in class IV. In 6 pa-

tients the cause of HF was ischaemic and in 4 patients it was primary dilated cardiomyopathy. In all patients long-term biventricular pacing (BV) was applied. The obtained results were compared with single-chamber (LV or RV) stimulation in 5 patients and with sinus rhythm or atrial pacing (SR) in 8 patients. In two subjects the substitution of BV pacing by another stimulation mode was not possible because of technical reasons or intracardiac conduction insufficiency.

Gated blood pool study

All patients underwent repeated gated blood pool scintigraphy 3 weeks after pacemaker implantation. Red blood cells were labelled with 740 MBq of technetium-99m pertechnetate. ECG gated images were obtained using single head camera, positioned in the individual LAO projection for best septal visualisation. For each study 26 frames were acquired in 64 × 64 matrix with the zoom factor of 1.5.

During examination each patient underwent at least two acquisitions with the same detector-heart orientation (Table 1, Fig. 1).

Data were processed with the standard software in the MAX Delta system. LV regions were drawn manually. In every patient the same LV regions were used for all acquisitions data obtained in this study. The LVEF was calculated according to the standard method based on the count rates in the region of interest, corrected for background activity.

Table 1. Pacing modes and number of acquisitions (N) performed in patients

PTS	Pacing				N
	SR	BV	LV	RV	
A	+	+	+	+	4
B	+	+	+	+	4
C	+	+	+		3
D	+	+	+		3
E	+	+		+	3
F		+	+	+	3
G	+	+			2
H	+	+			2
I	+	+			2
J		+		+	2
Total	8	10	5	5	

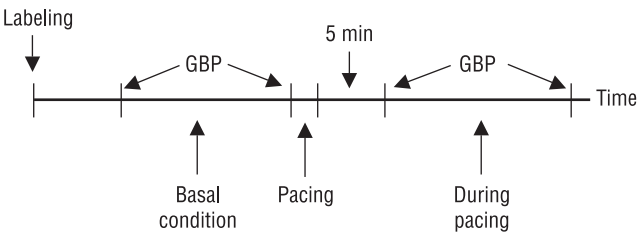

Figure 1. Acquisitions with the same detector-heart orientation.

Phase (φ) analysis was performed with the standard method using first Fourier element. LV and RV regions were drawn manually on phase images. Mean phase values per pixel were calculated in the left (φLV) and right (φRV) ventricle. The phase shift between both ventricles was assessed according to the fomula: $\Delta\varphi LR = \varphi LV - \varphi RV$.

Results

Clinically in almost all patients moderate to important symptomatic improvement has been observed by a decrease of at least 1 NYHA functional class and the increase in the distance patients were able to walk. One month after pacemaker implantation 5 patients were in functional NYHA class II, 4 in class III and one patient in class IV.

The LVEF data are shown in Figure 2. In the majority of patients LVEF values obtained during BV pacing were to various degrees higher than in SR, however not very different from those obtained during LV or RV pacing. The analysis of LVEF values revealed that BV pacing resulted in significantly higher values only in comparison with SR (21.6% ± 10.3 v. 20.1% ± 10.1; $p < 0.05$) (Fig. 3).

The phase shift between both ventricles by BV pacing was positive and similar to that obtained with SR and RV stimulation (14.0° ± ± 29.6 v. 13.4° ± 37.6 and 7.4° ± 26.5 v. 6.0° ± 17.1 respectively). However, in comparison with LV pacing, BV stimulation revealed a change of dominant conduction abnormalities with a delay of RV contraction in relation to LV (9.0° ± 17.5 v. –3.0° ± 11.4) (Fig. 4).

Discussion

The presence of ventricular dyssynchrony results in abnormal wall motion, impaired ventricular contractility, decreased ventricular filling, and increased mitral regurgitation. Biventricular pacing has been recently proposed as an adjunct therapy for advanced heart failure in patients with ventricular conduction abnormalities [2].

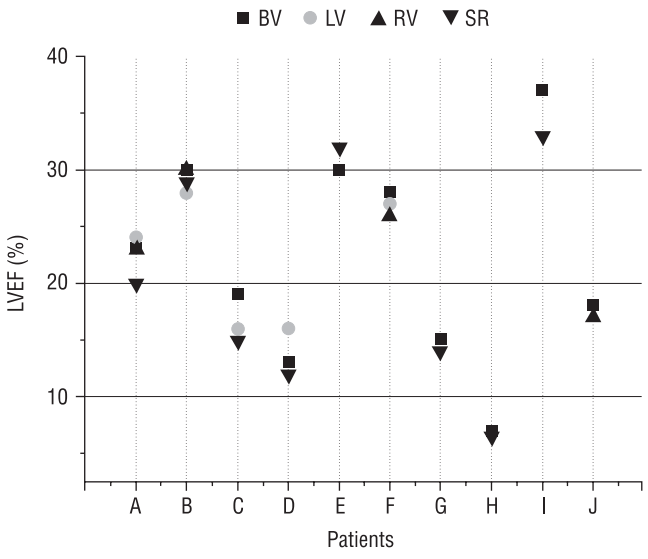

Figure 2. LVEF values with regard to pacing mode.

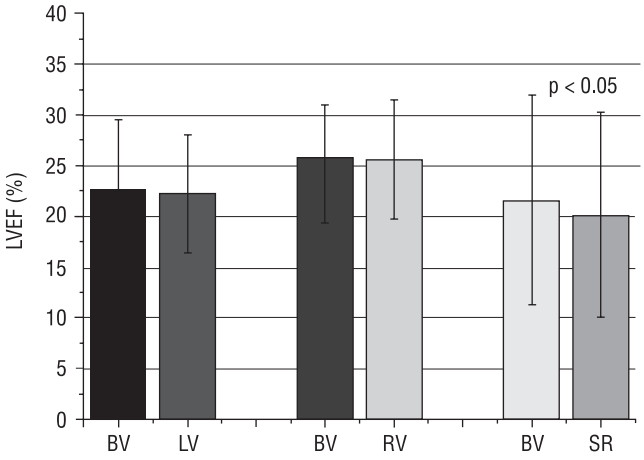

Figure 3. Influence of pacing on LVEF.

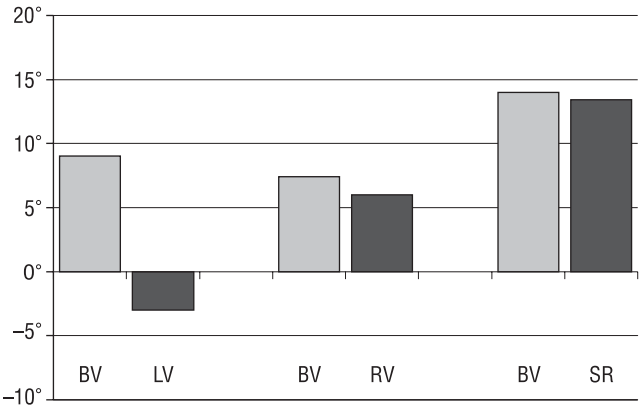

Figure 4. φLV in relation to φRV.

The results of our study concerning clinical improvement agree with the preliminary studies of Cazeau et al. and Rest et al. [3, 4]. However, the LVEF values, even if slightly increased with BV pacing in relation to SR, cannot be considered as the only factor of clinical improvement.

The mechanism of improvement is certainly complex and it may be presumed that LVEF is not a sufficient marker in such patients. One should consider another possible reason for clinical improvement - interventricular synchronisation of contractility [4]. That suggestion however has not been confirmed in our study, where interventricular phase shift was similar during BV to that during SR and RV. It was only during LV stimulation that the LV phase delay markedly decreased and even became negative. This finding agrees with normal data obtained by Durrer et al., who observed that the beginning of RV activation starts 5 to 10 ms after LV [5].

It should be regarded as a limitation of our study that the time between pacemaker implantation in the patient and our study did not exceed 1 month. It may be presumed that BV stimulation needs a longer time for ventricle remodelling, which leads to significant functional changes in GBP imaging even if acute clinical improvement takes place.

Conclusions

Biventricular pacing results in a slight improvement of LVEF in patients with heart failure and can be regarded as a promising approach in patients with end-stage heart failure.

Synchronous stimulation of both ventricles does not always result in decrease of interventricular shift, however that observation requires further studies on a larger population.

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