Original article

Usefulness of electrocardiographic and echocardiographic parameters for predicting the efficacy of atrioventricular synchronisation during a single lead VDD/R pacing

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Abstract

Background: The VDD/R pacing is accepted as an alternative to DDD/R pacing in patients with atrioventricular conduction block (AVB) and intact sinus node function.

Aim: To determine the relationship between parameters obtained during assessment of the patient for the implantation procedure, using electrocardiographic (ECG) and echocardiographic (ECHO) data, and the effectiveness of AV synchronisation.

Methods: The study involved a group of 65 patients (43 males, 22 females), aged 66.6 ± 12.7 with clinically significant disturbances of AV conduction, who did not reveal symptoms of concomitant abnormalities in sinus node automaticity. Selected ECG and ECHO parameters were studied prior to the implantation procedure. Repeat examinations were done at 3-4 days and at 1, 3, 6 and 12 months after the procedure. The effectiveness of AV synchronisation (PAS) has been estimated by event counter read-out and ECG Holter monitoring.

Results: In 74% patients (subgroup A) synchronisation was highly effective (PAS ≥ 95%); in the remaining 26% subjects (subgroup B) PAS occasionally fell below 95%. In subgroup B, the P wave was longer than that in subgroup A (105 ± 16 vs. 92 ± 13 ms; $p < 0.05$). The dimensions of the right and left heart chambers were greater in subgroup B. Patients in subgroup B had lower ejection fraction (49.4 ± 13.7% in B vs. 58.2 ± 11.3% in A) and revealed symptoms of heart failure. The following cut-off values for each echocardiographic and electrocardiographic parameter predisposing to PAS < 95% during VDD/R pacing ('undersensing') were identified: RVEDd > 26 mm, RVESd > 24 mm, LVEDd > 59 mm, LVESd > 37.3 mm, APD LA > 44 mm, SID RA > 52 mm, LMD RA > 48 mm, RA_{vol} > 54 ml, RA_{area} > 19 cm^2, SID LA > 57 mm, LMD LA > 46 mm, EF < 52%, P wave width > 100 ms. Significant predictors of PAS < 95% in the univariate analysis were RVEDd, RVESd, LVEDd, LMD RA, SID RA, RA_{vol}, RA_{area}, EF, and in the multivariate analysis RVEDd, RVESd, LMD RA, RA_{area}, EF.

Conclusions: Selected parameters obtained from ECG (P wave width) and echo examinations are correlated with effective AV synchronisation. Enlargement of the right and left heart chambers (atrial, ventricular), reduction of the ejection fraction and congestive heart failure are associated with impaired AV synchronisation in VDD/R pacemakers. In multivariate analysis, only the higher dimensions of the right ventricle and atrium and the lower ejection fraction of the left ventricle were significantly associated with the PAS < 95%.

Key words: VDD stimulation, AV synchronisation, ECG and ECHO parameters

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Introduction

According to the ESC guidelines 2007 [1] VDD/R pacing is recommended for patients with atrioventricular (AV) block and intact sinoatrial node function (SA). This mode of pacing is regarded as an incomplete form of dual chamber pacing, because of obtaining AV synchrony and no possibility for atrial stimulation. It uses a single lead with two electrodes – a classical ventricular lead on a distal tip and a dipole a few centimeters above as a bipolar atrial lead for atrial sensing. As the electrode is not attached to the atrium, it is referred to as a floating atrial lead sensing atrial activity in the blood pool. Upon sensing a spontaneous atrial signal the pacemaker triggers ventricular activity [2].

The development of VDD/R pacing has been triggered by the need to reduce the number of implanted electrodes in patients with intact sinus node function, but requiring an atrioventricular junction prosthesis [2, 3]. Ventricular stimulation regulated by the sinus node provides optimal cardiac output at rest and during exercise. The sinus node activity may be regarded as an ideal physiological indicator of metabolic demand [4].

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The VDD/R system has several advantages over the DDD/R system. There is no need to place another electrode in the heart, there is no electrode-atrial tissue interaction, the implantation procedure is easier and fluoroscopy time is shorter. The lower complication rate reduces morbidity as a consequence. The VDD/R pacing probably prevents from the AF episodes, reduces mortality and is cost--effective [5-10].

Despite the advantages of the VDD/R pacing and a large number of studies documenting its efficacy, there is considerable controversy regarding this form of treatment. The main reason being transient or permanent loss of AV synchronisation in some patients.

A search for the factors responsible for AV synchrony disturbances has provided a list of electrophysiological parameters, technical and construction characteristics, and procedural and post-procedural factors [8-10]. There are no reports describing the effects of anatomical, hemodynamic and echocardiographic factors on this mode of pacing. The identification of a relationships between these parameters and the efficacy of AV synchronisation would facilitate pre-procedural patient selection and reduce the pacing failure rate. Echocardiographic and electrocardiographic (ECG) indicators of long-term maintenance of AV synchronisation have not been widely studied and are not present in the current guidelines.

Accordingly, the present study was undertaken to determine the relationship between surface ECG and echocardiographic parameters, and the effectiveness of AV synchronisation.

Methods

Patients

The study involved a group of 65 patients in a mean age of 66.6 ± 12.7 years, including 22 (34%) females and 43 (66%) males. Differences in age between males and females were not significant.

Indications for pacemaker implantation included second-degree AV block (36.5%), third-degree AV block (39.7%), second- and third-degree AV block (22.2%), and trifascicular block (1.6%).

The following conditions were the most common among the patients: ischemic heart disease (49%), previous acute coronary syndrome (14%), arterial hypertension (29%), arterial hypertension with left ventricular hypertrophy (38%), and heart failure (23%). During the selection procedure sinoatrial node function was intact. All patients were followed for 12 months.

Inclusion criteria

The indications for VDD/R pacing were those recommended by the ESC.

The normal chronotropic response of the sinus node was assessed according to the following criteria:

1. a sinus rate ≥ 40 bpm at night and ≥ 60 bpm during the day in 24 h ECG recording and/or,
2. a sinus rate increase > 100 bpm during ECG exercise test and/or,
3. an increase of intrinsic sinus rate ≥ 90 bpm immediately after atropine administration in a dose of 0.02 mg/kg or > 20-50% of the basic sinus rate.

Exclusion criteria

1. Absence of the normal chronotropic response of the sinus node.
2. A history of paroxysmal atrial fibrillation (AF) or other supraventricular tachyarrhythmias.
3. A significant congenital or acquired heart defect.
4. Prior cardiac surgery and RF ablation procedure.

Measurements

Prior to VDD/R pacemaker implantation

1. Standard 12-lead ECG in the supine position at a paper speed of 50 mm/s and calibration 1 mV = 20 mm. Analysis of P wave amplitude [mV] and P wave width [ms] in lead II.
2. Analysis of the chronotropic response of the sinus node.
3. Standard transthoracic echocardiogram (ECHO) according to the Polish Cardiac Society guidelines [11]. Examinations were performed using an Aloka ALFA 10 (Toschiba) device and a planar transducer 2.5/3.5 MHz.

Table I summarises echocardiographic parameters, methodology and normal values.

Pulsed-wave Doppler in the apical 4-chamber view (4CH) was performed to record tricuspid blood flow and measure:

- maximal E-wave velocity – $V_{max}E$,
- maximal A-wave velocity – $V_{max}A$,
- deceleration time – EdT,
- maximal tricuspid regurgitation velocity V_{max} IT – using continuous wave Doppler,
- tricuspid insufficiency – based on two-dimensional echocardiography (2D echo) and color flow imaging – and graded as follows:
  insufficiency wave area /right atrial area
  – mild – < 20%,
  – moderate – 20-40%,
  – severe – >40%,
- direction of the regurgitant jet in the right atrium (septal leaflet site of attachment 0°, anterior leaflet site of attachment 180°).

The right atrial (RA) volumes were calculated from 2D echo. The RA volume was calculated by Simpson`s method (computer calculations) using single – plane RA area – length algorithm from 4CH views.

Implantation

Implantation was performed according to standard techniques. We used VDD/R pacemakers and electrodes manufactured by Biotronik GmbH&Co, Germany.

During the implantation procedure of the VDD pacemaker the amplitude (assumed minimum A > 1 mV) and stability of atrial potential detection were estimated in relation to breathing condition. The position of the atrial dipole was also determined. Atrial potential parameters were monitored (A_{mean}, A_{min}, detection threshold) in relation to respiration manoeuvers and body position over a 12-month follow-up.

Prospective observation – 12-month follow-up

All patients received an optimal pharmacological treatment over the 12 months of the follow-up. Routine pacemaker checks were carried out at 3-4 days (d) after implantation and at 1, 3, 6 and 12 months (m) using a CDM 3000 programmer (Biotronik) to obtain readout of event counter during each pacemaker check. Events were displayed graphically and numerically, and printed out.

The percentage of atrial synchronisation (PAS) was calculated from the event counter data and expressed the number of atrial sensed events followed by ventricular paced events. The PAS (%) was calculated according to the following formula [12]:

$$PAS = [(A_s - V_p) + A_{rs}]/V_p \times 100\%,$$ where:

A_s – intrinsic atrial activity outside of the atrial refractory period, A_{rs} – intrinsic atrial activity in the atrial refractory period, V_p – ventricular paced events.

The PAS was categorised into 2 types:
- < 95% – ineffective synchronisation (‘undersensing’),
- ≥ 95% – proper synchronisation.

Continuous 24-hours ECG was recorded at 3-6 months after the implantation. The effectiveness of synchronisation (PAS) in VDD/R pacing was calculated using the formula:

$$PAS = (R - PVC - US)/(R - PVC) \times 100\%,$$ where:

R – the number of counted R waves, PVC – the number of premature ventricular complexes, US – the number of undersensed P waves.

A repeat echocardiogram was recorded at 12 months after the implantation.

We compared the effectiveness of atrioventricular synchronisation (PAS) in time intervals between pacemaker checks and 24-hours ECG recording.

The study population was divided according to the PAS=95% into: subgroup A with preserved PAS ≥ 95% (proper synchronisation) and subgroup B with PAS below 95%, even transiently (ineffective synchronisation, ‘undersensing’). Subgroup A and B consisted of 48 (74%) and 17 (26%) patients, respectively. Patients in subgroup B were older (B vs. A: 70 vs. 64, $p < 0.05$) and mainly males (M vs. F: 88 vs. 12%, $p < 0.025$).

Table I. Echocardiographic parameters, methodology and normal values

Parameter	Normal values
M-mode long axis parasternal view (ECHO-M)	
RVEDd [mm]	9-26
RVESd [mm]	15-22
LVEDd [mm]	36-56
LVESd [mm]	23-39
APD LA [mm]	23-40
2D apical 4-chamber view (ECHO-2D)	
SID RA [mm]	34-49
LMD RA [mm]	30-46
RA_{area} [cm^2]	8.3-19.5
RAvol [ml]	
SID LA [mm]	34-49
LMD LA [mm]	30-46
LVEF [%]	55-70

Abbreviations: RVEDd – right ventricular end-diastolic diameter, RVESd – right ventricular end-systolic diameter, LVEDd – left ventricular end-diastolic diameter, LVESd – left ventricular end-systolic diameter, APD LA – left atrium anterior posterior diameter, SID RA – right atrium superior inferior diameter, LMD RA – right atrium lateral medial diameter, RA_{vol} – right atrium volume, SID LA – left atrium superior inferior diameter, LMD LA – left atrium lateral medial diameter, LVEF – left ventricular ejection fraction

Statistical analysis

The measured variables are expressed as mean ± SD. Correlation and regression analyses were used to identify relationships between the parameters. Student’s t-test was used to test for the significance of quantitative data, whereas the chi-square test was applied for qualitative data. A p value < 0.05 was considered significant. Receiver operator characteristic curves were constructed using the computer programme of MedCalc v. 10.4.3.0. Uni- and multivariate analyses were performed to evaluate the predictive value of echocardiographic and electrocardiographic parameters for identification of patients with PAS < 95%. The generalised lineal model with logit link function was used. Statistical analysis was carried out employing the STATISTICA v8 of firm of StatSoft, Inc. 2007.

Results

Surface ECG

Mean P wave amplitude in lead II was 0.15 ± 0.06 mV (0.05-0.3), whereas mean P wave width: 96.1 ± 14.4 ms (70-140). The P wave amplitude most frequently ranged from 0.1 to 0.24 mV (79.2%), whereas the P wave width ranged from 100 to 109 ms (41.5%).

Intracardiac ECG

The variability of A wave potential (A_{mean}) in relation to breathing during the procedure was insignificant, except for the Valsalva manoeuvre amplitude of A was (2.24 ± 1.34 mV in the subgroup A vs. 1.67 ± 0.84 mV in the subgroup B, $p < 0.05$). In the majority of patients the atrial

Table II. Echocardiographic characteristics of the study patients

ECHO-M					
	RVEDd [mm]	RVESd [mm]	LVEDd [mm]	LVESd [mm]	APD LA [mm]
Min	16	12	43	24	29
Max	42	38	76	66	69
Mean	25.6	20.7	56.0	36.7	43.2
SD	4.9	4.4	6.6	8.9	7.5

ECHO-2D							
	SID RA [mm]	LMD RA [mm]	RA_{vol} [ml]	RA_{area} [cm^2]	SID LA [mm]	LMD LA [mm]	EF [%]
Min	39	22	30	13	37	37	25
Max	69.5	58	130	30	80	60	82
Mean	53.4	43.6	59.5	19.2	53.8	45.1	56.0
SD	6.1	6.1	18.6	3.6			

ECHO-2D Doppler							
	V_{max} E [cm/s]	V_{max} A [cm/s]	EdT [ms]	Vmax IT [m/s]	UFZ IT [st]	Severity of IT (n)	
Min	30	28.00	140	0	0	negligible	20
Max	130	90.00	480	3.6	120	mild	33
Mean	53	51.00	269.0	1.69	55.0	moderate	6
SD	16	14.00	65.8	1.37	43.7	severe	2

Abbreviations: see Table I

dipole was placed in the upper part of the right atrium, as shown by optimally stable detection of the A wave potential.

Echocardiography

Table II summarises the results of echocardiography prior to implantation. There were no significant differences in the echo parameters between baseline and follow-up measurements.

Atrioventricular synchronisation

The mean atrioventricular synchronisation (PAS) during Holter recording was 95.2 ± 13.3 (35-100). The mean PAS calculated from a pacemaker memory for the whole group was 95% (Figure 1). Two patients developed the signs of sinus node failure related to beta blocker overdosing. Another 8 patients with the signs of significant heart failure had recurrent AF by the end of the follow-up. In 6 patients synchronisation disturbances were due to transient sensing disorders. Three patients had moderate or severe tricuspid regurgitation, including two patients with additional heart chamber enlargement. In one patient atrial rings were placed too high and were dislocated temporarily to the vena cava superior, further complicating atrial sensing.

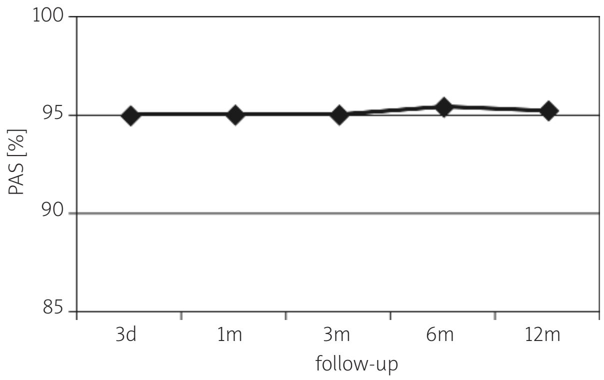

Figure 1. PAS over the 12 months of follow-up (mean values for a given time interval)

Analysis of the relationship between PAS, ECG and ECHO parameters

We demonstrated significant association between PAS and ECG/ECHO parameters prior to implantation. Analysis of surface ECG in both subgroups revealed that the duration of P wave was longer in the subgroup B than in the subgroup A (105 ± 16 vs. 92 ± 13 ms; $p < 0.05$). The P wave amplitude did not differ between the subgroups.

Analysis of intracardiac ECG in both subgroups revealed that the differences in the value of a amplitude during respiratory manoeuvres with respect to normal breathing or according to body position were statistically insignificant during the whole observation period. No significant differences in the atrial potential parameters were found during follow up measurements for both subgroups.

Analysis of echocardiograms in both subgroups showed significant differences. In subgroup B the dimensions and volumes of the heart chambers were significantly higher than in subgroup A. Out of Doppler-derived parameters describing tricuspid blood flow, only the $V_{max}E$ differed significantly between the subgroups. The remaining parameters such as $V_{max}A$, EdT, V_{max} IT, as well as the size and direction of tricuspid regurgitant jet did not differ between the subgroups (see Table III). The ECHO parameters obtained at 12 months did not differ significantly from the baseline.

The qualifying electrocardiographic and echocardiographic data served as a basis for defining the cut-off values to predict PAS < 95% during VDD/R pacing. We identified the values that differentiated significantly subgroup A from B searching for the threshold criteria for each parameter. The following cut-off values for each echocardiographic parameter were identified: RVEDd > 26 mm, RVESd > 24 mm, LVEDd > 59 mm, LVESd > 37.3 mm, APD LA > 44 mm, SID RA > 52 mm, LMD RA > 48 mm, RA_{vol} > 54 ml, RA_{area} > 19 cm^2, SID LA > 57 mm, LMD LA > 46 mm, and EF < 52%. The cut-off values of the parameters predisposing to PAS < 95% and positive, negative predictive values on the base of ROC curves are presented in Table IV. Figures from 2 to 10 display ROC curves for each analysed parameter. With respect to electrocardiographic analysis, the P wave width > 100 ms was the cut-off value for PAS < 95% (ROC curve) (Figure 11).

Significant predictors of PAS < 95% in the univariate analysis are presented in Table V. After including these eight (RVEDd, RVESd, LVEDd, LMD RA, SID RA, RA_{vol}, RA_{area}, EF) parameters into the multivariate analysis only RAarea (p < 0,001), EF (p < 0,001), RVESd (p < 0,001), LMD RA (p < 0.001), RVEDd (p < 0.05) remained significant.

Table III. Comparison of echocardiographic parameters of the subgroups A and B

Parameter	Subgroup A	Subgroup B	p
RVEDd [mm]	24.5 ± 4.4	28.9 ± 5.3	< 0.001
RVESd [mm]	19.9 ± 3.8	22.9 ± 5.4	< 0.01
SID RA [mm]	52.4 ± 5.5	56.5 ± 6.8	< 0.01
LMD RA [mm]	42.7 ± 6.2	46.4 ± 5.3	< 0.01
RA_{area} [cm^2]	18.4 ± 3.3	21.8 ± 3.5	< 0.001
RA_{vol} [ml]	55.5 ± 16.0	71.0 ± 21.3	< 0.001
VmaxE [cm/s]	60.0 ± 20.0	50.0 ± 10.0	< 0.025
LVEDd [mm]	54.9 ± 6.0	59.1 ± 7.4	< 0.025
LVESd [mm]	35.9 ± 7.9	39.9 ± 11.0	< 0.05
APD LA [mm]	42.2 ± 7.7	46.4 ± 6.2	< 0.025
SID LA [mm]	51.6 ± 9.9	60.3 ± 9.7	< 0.0025
LMD LA [mm]	43.7 ± 12.1	49.0 ± 6.6	< 0.05
EF [%]	58.2 ± 11.3	49.4 ± 13.7	<0.01

Abbreviations: see Table I

Discussion

The adequacy of the VDD/R pacing system has usually been discussed from the viewpoint of technique, optimisation of implantation and atrial sensing performance [13, 14]. No predictors of long-term stability of P wave sensing have been established so far. One of the reasons may be the overlooking of anatomical, hemodynamic and clinical factors that are equally critical

Table IV. Optimal cut-off values for identification of patients with PAS < 95%. on the base of ROC curves

	Parameter						
	RVEDd [mm]	RVESd [mm]	LVEDd [mm]	LVESd [mm]	APD LA [mm]	SID RA [mm]	LMD RA [mm]
Cut-off	> 26	> 24	> 59	> 37.3	> 44	> 52	> 48
Sensitivity	100	64.7	83.3	86.7	87.5	94.7	56
Specificity	73.6	98.0	89.1	78.7	82.6	65.8	97.8
PPV	53.6	100	66.7	56.5	63.6	50	90
NPV	100	88.2	95.8	95	95	97	86
Significance (p <)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

	Parameter					
	RA_{vol} [ml]	RA_{area} [cm^2]	SID LA [mm]	LMD LA [mm]	EF [%]	P [ms]
Cut-off	> 54	> 19	> 57	> 46	< 52	> 100
Sensitivity	100	93.7	81.2	81.2	93.7	78.6
Specificity	61.7	70.2	84.1	77.3	67.0	93.0
PPV	48	52	65	56.5	50	78.6
NPV	100	97	92.5	92	97	93
Significance (p <)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

Abbreviations: PPV – positive predictive value, NPV – negative predictive value

Table V. Significant predictors of PAS < 95% in the univariate analysis

	RVEDd [mm]	RVESd [mm]	LVEDd [mm]	LVESd [mm]	APD LA [mm]	SID RA [mm]	LMD RA [mm]	RA_{vol} [ml]	RA_{area} [cm^2]	SID LA [mm]	LMD LA [mm]	EF [%]	P [ms]
OR	6.68	11.0	3.33	1.57	3.40	4.77	6.25	15.95	11.29	4.77	2.61	4.5	2.28
95% CI	1.63-27.3	2.54-47.5	0.92-12.0	0.47-5.21	0.92-12.61	1.21-18.78	1.39-27.92	1.93-131.6	2.26-56.41	1.21-18.78	0.76-8.95	1.28-15.8	0.54-9.54
p	0.05	0.001	0.05	NS	NS	0.05	0.001	0.001	0.001	NS	NS	0.001	NS

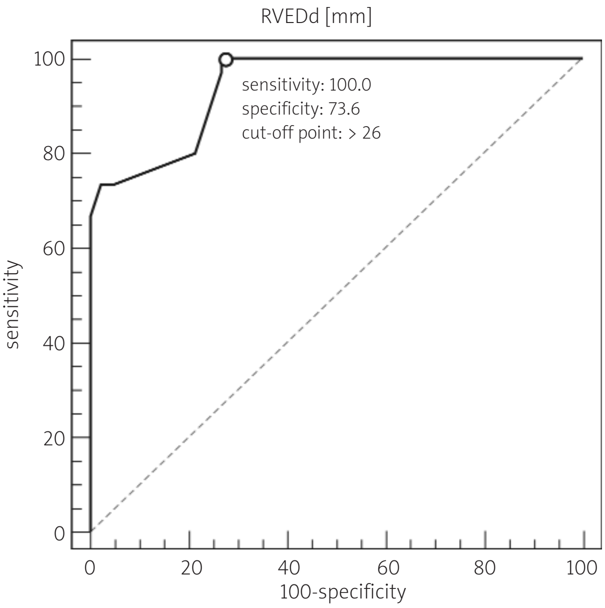

Figure 2. ROC curve for RVEDd [mm]

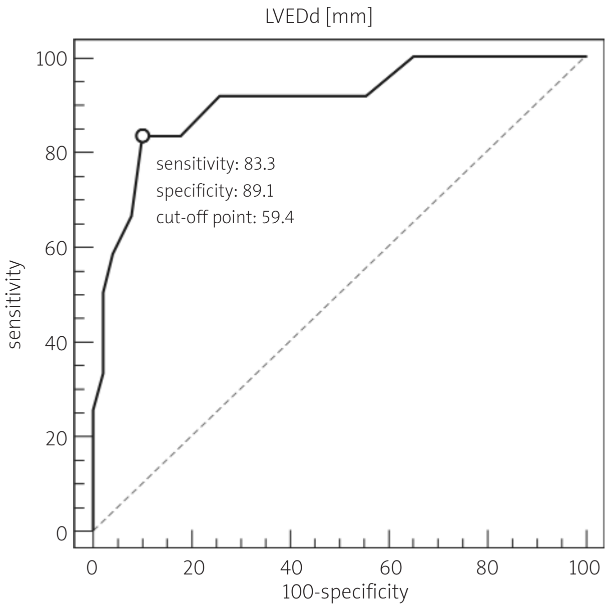

Figure 3. ROC curve for LVEDd [mm]

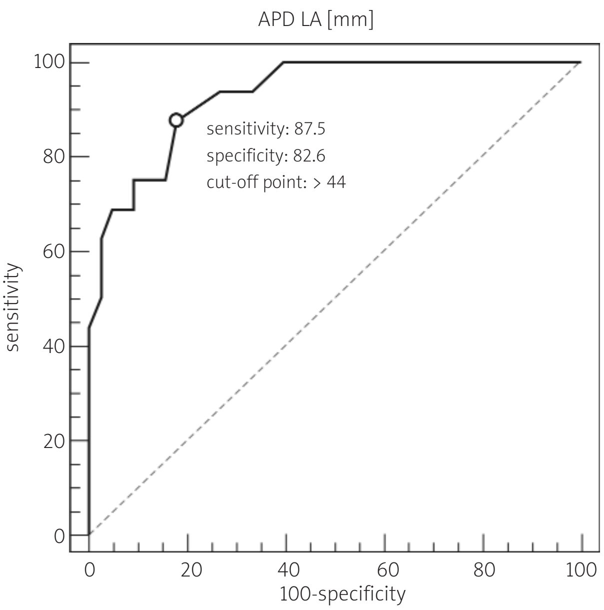

Figure 4. ROC curve for APD LA [mm]

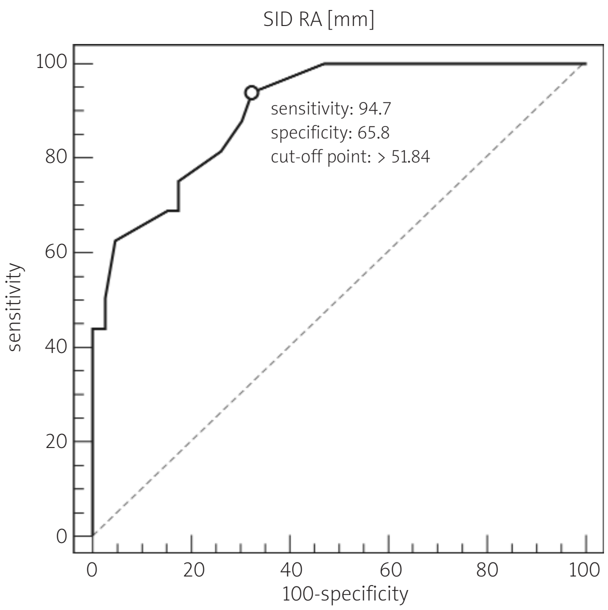

Figure 5. ROC curve for SID RA [mm]

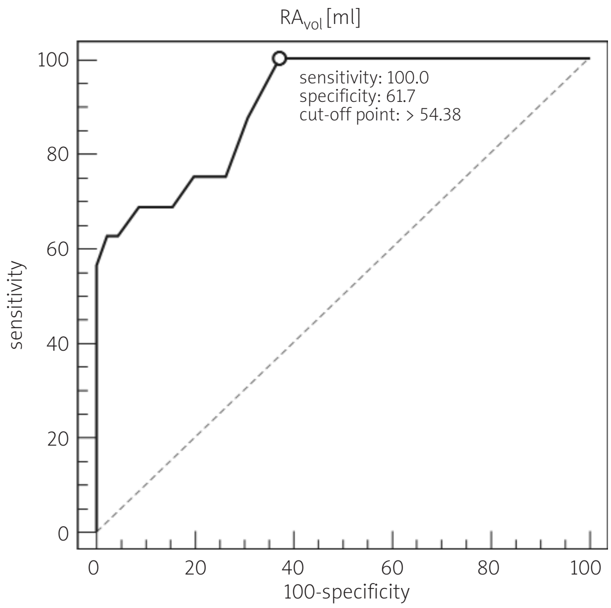

Figure 6. ROC curve for RA$_{vol}$ [ml]

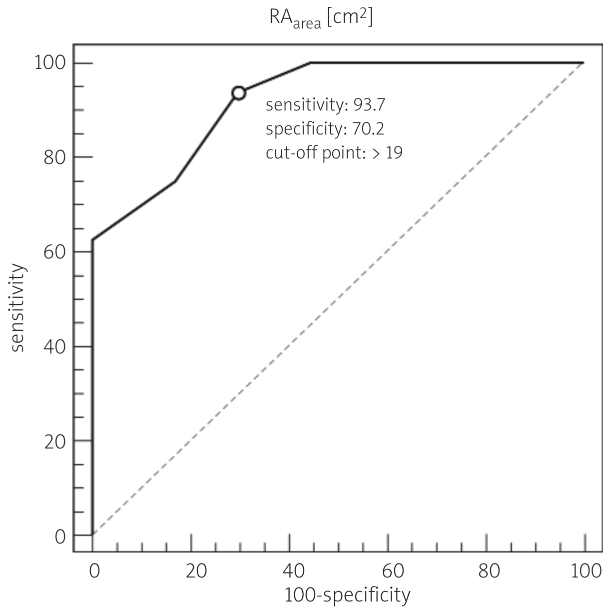

Figure 7. ROC curve for RA$_{area}$ [cm^2]

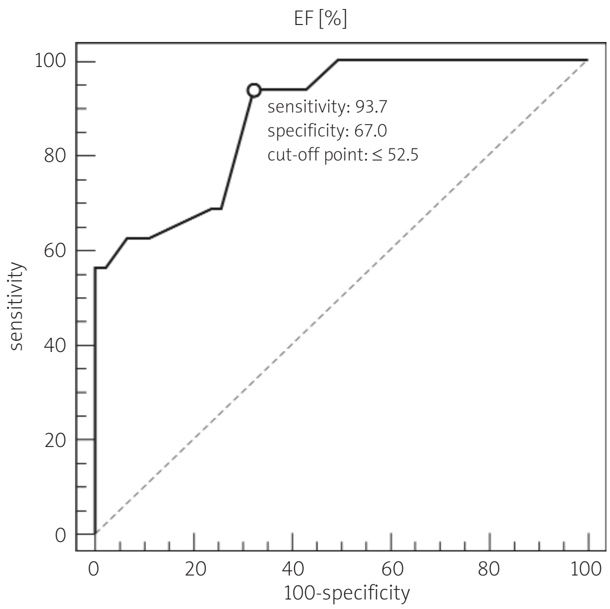

Figure 8. ROC curve for EF [%]

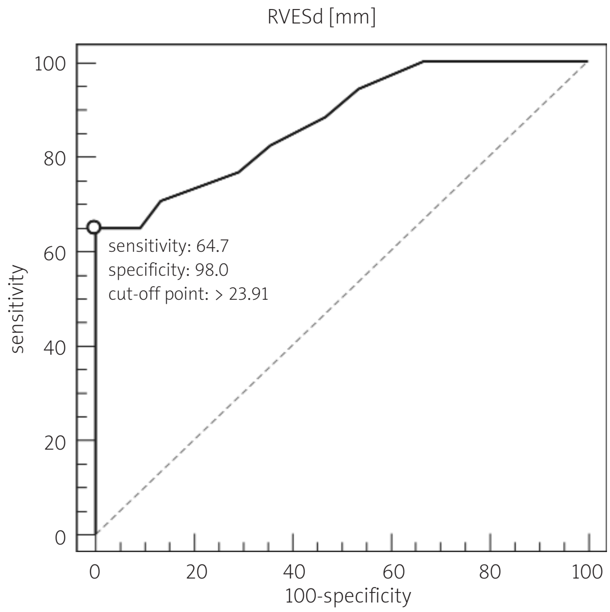

Figure 9. ROC curve for RVESd [mm]

in assuring the system efficacy. An additional advantage of such a predictor would be a possibility of preoperative verification. Comprehensive assessment of the prognostic value of ECG and echocardiographic parameters as predictors of the VDD/R system efficacy has not been studied yet by other investigators.

As the maintenance of AV synchrony, a prerequisite for physiological pacing is a clear advantage of the VDD/R systems, it is necessary to define optimal synchronisation. Most investigators have accepted the threshold of 95% of AV synchronised pacing events as denoting the system efficacy [15].

Our study demonstrated that the P wave morphology and some ECHO parameters had a significant effect on the long-term PAS values. The P wave width in the surface ECG was the most powerful predictor of proper synchronisation: the longer the P wave (> 100 ms), the less effective the AV synchronisation.

The majority of echocardiographic parameters showed significant differences between the groups. The size of RV

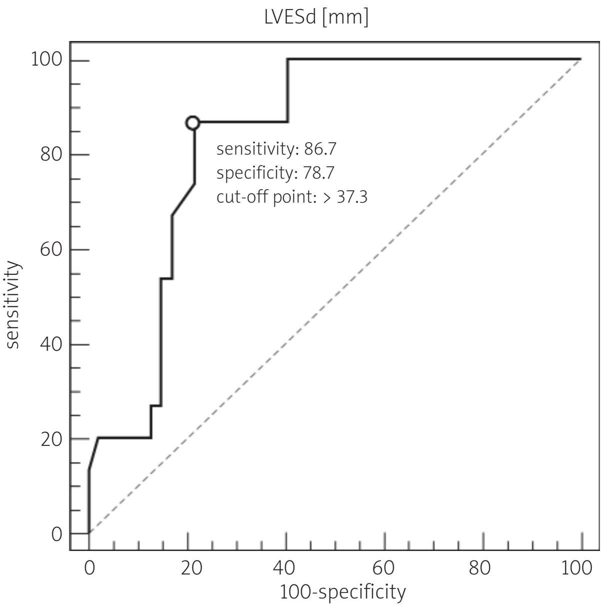

Figure 10. ROC curve for LVESd [mm]

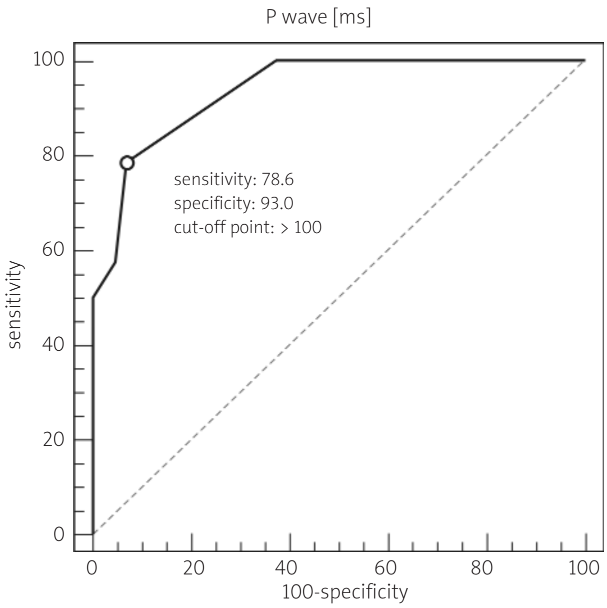

Figure 11. ROC curve for P wave width [mm]

and RA was significantly larger in group B (PAS < 95%). A similar relationship was observed for LA.

The parameters describing tricuspid blood flow and regurgitant jet did not differ significantly between groups A and B. In the present study there were not enough patients with moderate and severe regurgitation. Probably most such patients have chronotropic disturbances or AF episodes which disqualify them for VDD/R implantation. All patients with significant tricuspid insufficiency showed less effective AV synchronisation.

The relationship between right heart dimensions and long-term stability of atrial sensing has been discussed in single reports which included small patient groups [16-18]. De Cock et al. [17] documented a good correlation between the parameters describing right heart dimensions and the effectiveness of atrial sensing. In their study the RA end-diastolic volume was the best predictor of atrial sensing; the value ≥ 80 ml predicted ineffective PAS. In our study, RA_{vol} > 54.0 ml and RA_{area} > 19 cm^2 predisposed to disturbances in AV synchronisation. This may imply that disadvantageous relationship between PAS and RA volume may occur earlier than expected i.e. in the presence of lower values.

Similar relationship was found for the size of LA and LV, and for LVEF, which was lower in patients with the PAS < 95%. It is also noteworthy that CHF was three times more frequent in patients with the PAS < 95%.

Schubert et al. [19] attempted to determine whether LV dysfunction expressed as EF < 45% had an effect on the VDD system efficacy. The investigators did not find any restrictions for the use of single lead VDD pacing systems in patients with LV dysfunction. The parameters obtained during the implantation and the effectiveness of synchronisation were similar to those in patients with preserved LV systolic function.

However, it should be remembered that CHF is characterised by progressive changes in cardiac chamber size and geometry. Right atrial and LA enlargement and remodeling, combined with progressive LV dysfunction, may lead to the loss of PAS due to sensing disorders, development of AF or symptoms of bradycardia, as demonstrated by other investigators [20, 21].

An entirely different issue in VDD/R pacing is placement of an electrode tip in the right ventricular apex (RVA). Staniewicz et al. [22] analysed the adequacy of atrial sensing and AV synchronisation in single lead VDD pacing system with the electrode located in the right ventricular outflow tract (RVOT). The efficacy of synchronisation was similar to that achieved with the electrode located in the RVA. Clinical observations confirm that passive fixation electrodes used for RVOT pacing assure an effective and safe mode of pacing.

Summing up, we believe that measurements of P wave width and some ECHO parameters should be obtained prior to implantation to optimise patient selection. The VDD/R pacing will probably evolve, perhaps as a component of more complex systems (biventricular resynchronisation systems) combined with active fixation electrodes [23].

Our study has some limitations, mainly too small group size and too short follow-up. However, available evidence shows that permanent loss of AV synchronisation in VDD/R pacing most frequently occurs within the first months after implantation [24, 25]. There is also controversy regarding the PAS formula to calculate efficacy of synchronisation [12]. It may be worthwhile to extend the scope of ECHO parameters describing RV systolic and diastolic function by including the assessment of tricuspid annulus plane systolic excursion (TAPSE) or using tissue Doppler echocardiography (TDE).

Conclusions

Selected parameters obtained from ECG (P wave width) and echo examinations are correlated with effective AV synchronisation. In multivariate analysis, the higher dimensions of the right ventricle and atrium and the lower ejection fraction of the left ventricle identified patients with PAS < 95%.

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Przydatność niektórych parametrów echokardiograficznych i elektrokardiograficznych w przewidywaniu skuteczności synchronizacji przedsionkowo-komorowej w stymulacji VDD/R z pojedynczą elektrodą

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Streszczenie

Wstęp: System VDD/R jest alternatywnym w stosunku do DDD/R systemem stymulacji u chorych z zaawansowanymi zaburzeniami przewodzenia przedsionkowo-komorowego (AV) i prawidłową funkcją węzła zatokowo-przedsionkowego (SA). Do tej pory nie ustalono jednoznacznie predyktorów stabilności synchronizacji AV i nie wykazano, w jakich grupach chorych należy unikać tej formy leczenia.

Cel: Próba ustalenia związków pomiędzy parametrami uzyskanymi w trakcie kwalifikacji do zabiegu na podstawie badań elektrokardiograficznych i echokardiograficznych a efektywnością synchronizacji AV.

Metody: Badaniem objęto grupę 65 chorych (22 kobiety i 43 mężczyzn) w wieku średnio 66,6 ± 12,7 roku, z istotnymi klinicznie zaburzeniami przewodzenia AV, u których wykluczono współistniejące zaburzenia automatyzmu węzła SA. Przed wykonaniem implantacji przeprowadzano analizę wybranych parametrów EKG oraz badania echokardiograficznego. Kontrolę przeprowadzono w następujących okresach: 3.–4. doba oraz 1., 3., 6. i 12. miesiąc po zabiegu. W trakcie obserwacji oceniano efektywność synchronizacji AV (PAS) na podstawie odczytów licznika zdarzeń oraz monitorowania EKG metodą Holtera.

Wyniki: Podczas 12-miesięcznej obserwacji współczynnik PAS utrzymywał się dla całej badanej grupy średnio na poziomie 95%. U 74% badanych (podgrupa A) odnotowano prawidłową efektywność synchronizacji (PAS ≥ 95%), u pozostałych 26% (podgrupa B) PAS okresowo wynosił poniżej 95%. Wykazano wyraźne, znamienne statystycznie związki pomiędzy szerokością załamka P powierzchniowego EKG a skutecznością PAS. W podgrupie B w porównaniu z A załamek P miał dłuższy czas trwania (105 ± 16 *vs* 92 ± 13 ms; p < 0,05). Podobne zależności wykazano w odniesieniu do parametrów badania echokardiograficznego. Wymiary prawych jam serca były większe w podgrupie B. Ponadto chorzy z podgrupy B mieli niższą frakcję wyrzutową (EF) niż chorzy z podgrupy A (49,4 ± 13,7 *vs* 58,2 ± 11,3%) i mieli objawy niewydolności krążenia.

Zdefiniowano następujące wartości parametrów echokardiograficznych i elektrokardiograficznych predysponujące do PAS < 95% (wg krzywych ROC): RVEDd > 26 mm, RVESd > 24 mm, LVEDd > 59 mm, LVESd > 37,3 mm, APD LA > 44 mm, SID RA > 52 mm, LMD RA > 48 mm, RA_{vol} > 54 ml, RA_{area} > 19 cm^2, SID LA > 57 mm, LMD LA > 46 mm, EF < 52%, szerokość fali P > 100 ms.

W analizie jednoczynnikowej były to parametry: RVEDd, RVESd, LVEDd, LMD RA, SID RA, RA_{vol}, RA_{area}, EF, a w analizie wieloczynnikowej: RVEDd, RVESd, LMD RA, RA_{area}, EF.

Wnioski: 1. Parametry uzyskane na podstawie analizy EKG powierzchniowego (szerokość załamka P) oraz badań echokardiograficznych korelują z efektywnością synchronizacji AV.

2. Powiększenie prawych i lewych jam serca (przedsionka, komory), obniżenie EF oraz niewydolność krążenia są ujemnymi predyktorami efektywnej synchronizacji AV w systemach VDD/R.

3. W analizie wieloczynnikowej tylko zwiększone wymiary prawej komory serca i prawego przedsionka oraz obniżona frakcja wyrzutowa lewej komory znacząco wpływały na PAS < 95%.

Słowa kluczowe: stymulacja VDD, synchronizacja AV, parametry elektro- i echokardiograficzne

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