

## DOES THE RESYNCHRONIZATION THERAPY LEAD TO REDUCTION OF SYMPTOMS AND TO IMPROVEMENT OF LEFT VENTRICULAR FUNCTIONS IN PATIENTS WITH CHRONIC HEART FAILURE?

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**Aim.** To evaluate the therapeutic effect of resynchronization in patients with chronic heart failure who are symptomatic despite adequate pharmacological medication.

**Sample and methodology.** 118 patients with chronic heart failure, mostly dilated cardiomyopathy and ischaemic heart disease, with depressed systolic function, decreased left ventricular ejection fraction (LVEF) and left bundle branch block wide QRS complex, underwent implantation of the biventricular system between the years 2000–2006. We assessed changes in the NYHA functional class, hemodynamic parameters acquired during right heart catheterization, the maximum oxygen consumption during stress spiroergometric examination, as well as echocardiographic parameters.

**Results.** A statistically significant improvement was found in the NYHA functional class (from  $2.8 \pm 0.4$  to  $2.3 \pm 0.5$  after 3m,  $p < 0.001$  and to  $2.5 \pm 0.6$  after 12m,  $p < 0.01$  respectively), as well as an increase in the maximum oxygen consumption during spiroergometric examination ( $VO_2$  max from  $14.1 \pm 3.1$  ml/kg/min to  $15.3 \pm 3.1$  ml/kg/min,  $p < 0.001$  and to  $15.3 \pm 2.5$  ml/kg/min,  $p = \text{NS}$  respectively). In regard to hemodynamic parameters, there were increases in cardiac output and cardiac index after three months. After 12 months the change was not statistically significant (CO from  $3.9 \pm 1$  l/min to  $4.2 \pm 0.9$  l/min,  $p < 0.05$ , and to  $4.1 \pm 0.9$  l/min,  $p = \text{NS}$ , CI from  $2 \pm 0.5$  l/kg/min to  $2.2 \pm 0.4$  l/kg/min,  $p < 0.05$ , and to  $2.1 \pm 0.4$  l/kg/min,  $p = \text{NS}$ ). Mean pulmonary artery pressure, as well as pulmonary capillary wedge pressure was reduced after 3, as well as after 12 months to a statistically significant degree (MPA from  $29.1 \pm 11.5$  mm Hg to  $23.9 \pm 10.3$  mm Hg,  $p < 0.001$ , and to  $24.9 \pm 11.8$  mm Hg,  $p < 0.01$  respectively, and PCWP from  $19.9 \pm 9.5$  mm Hg to  $15.2 \pm 9.2$  mm Hg,  $p < 0.01$ , and to  $15.6 \pm 9$  mm Hg,  $p < 0.01$  respectively). In regard to echocardiographic parameters, there was an increase in LVEF, a reduction in the end-diastolic diameter of the left ventricle, as well as a statistically significant reduction in severity of mitral regurgitation after 3, as well as 12 months (LVEF from  $20.5 \pm 5.3\%$ , to  $23 \pm 6.5\%$ ,  $p < 0.001$ , and to  $24.5 \pm 8\%$ ,  $p < 0.001$ , LVEDD from  $69 \pm 9$  mm to  $68 \pm 9$  mm,  $p < 0.01$  and to  $65 \pm 12$  mm,  $p < 0.01$  respectively, mitral regurgitation from  $2.2 \pm 0.8$  to  $1.9 \pm 0.8$ ,  $p < 0.001$ , and to  $2 \pm 0.8$ ,  $p < 0.001$ ).

**Conclusions.** In patients with chronic heart failure, resynchronization therapy leads to reduced symptoms, reduction in dyspnea and to improvements in cardiac performance due to increase in the systolic function of the left ventricle and hemodynamic changes.

## INTRODUCTION

Even today, despite significant developments in pharmacological<sup>1–3</sup> and non-pharmacological treatment, chronic heart failure (CHF) still has a very negative prognosis. The five – year survival of patients with advanced heart failure in the NYHA III – IV class with optimum pharmacological medication is reported to be 50% (ref.<sup>4</sup>). The most frequent cause of CHF is ischaemic heart disease (IHD); the second most frequent cause is dilated cardiomyopathy (DCMP).

Patients with CHF who suffer from a significant decrease in systolic function of the left heart ventricle are often diagnosed with inter or intraventricular conduction delay. These delays manifest as extension of the duration

of the QRS complex to levels exceeding 120 ms. A significant slowdown in conduction, with the width of the QRS complex above 140 ms, can be shown in up to 28% of symptomatic patients<sup>5</sup>. This parameter has been identified as an independent predictor of death risk in patients with CHF<sup>6</sup>. Moreover, a number of studies have shown that the width of the QRS complex reflects to a certain extent the growing severity of CHF. The highest mortality has been found in cases where the duration of the QRS complex exceeds 170 ms (ref.<sup>7</sup>).

The conduction delay described above leads to a) a disruption of atrioventricular synchronization, b) dyssynchronization between the right and the left ventricle and c) delay in activation of the left – ventricle free wall against interventricular septum. The result is mechani-

cal disorders such as: a) limited ventricle contribution to ventricle filling, b) diastolic mitral regurgitation, c) shortening of diastolic filling time of both ventricles, d) non-coordinated ejection and relaxation of the left ventricle, and e) non-coordinated contraction of both ventricles. Correction of these defects is the aim of **cardiac resynchronization therapy using biventricular stimulation**.

The main objective of our study was to evaluate changes in performance and in echocardiographic and hemodynamic parameters 3 and 12 months after implantation of biventricular pacemakers in patients with chronic heart failure.

## METHOD OF IMPLANTATION OF BIVENTRICULAR PACEMAKER

The stimulation electrode for the left ventricle is implanted under X-ray control, via coronary sinus (the venous branches of which are injected with a contrast medium to display the anatomy of heart veins), usually into the lateral or the posterolateral branch. The reason for this is that the lateral wall of the left ventricle has been identified by electromagnetic mapping as the area of latest activation in the majority of patients. Another electrode is implanted into the right atrium and the last electrode into the area of mid-septum of the right ventricle, in case of implantation of defibrillation electrode then into the apex or septum of the right ventricle. Standardised measurement of stimulation parameters is an integral part of every implantation.

The success rate of left – ventricle electrode implantation is about 95% (ref.<sup>8</sup>). In case of failure of left – ventricle electrode implantation via coronary sinus, there is still the possibility of “stitching on” the electrode epimyocardially in a surgical procedure. In this case, under general anaesthesia and with antibiotic prophylaxis, left-sided lateral thoracotomy is carried out, with follow-up incision of pericardium and implantation of epimyocardial lead, also into the area of the lateral wall. Standard measurement of thresholds, tunnelling into the subclavian area, and a connection to the implanted biventricular pacemaker or defibrillator follow. Surgical sutures along layers according to heart surgical conventions are done at the end of the operation.

## METHODOLOGY

118 patients with chronic heart failure, depression of left – ventricle systolic function with EF < 30% with optimum pharmacological medication lasting for more than 3 months, the presence of left bundle branch block on ECG and the width of the QRS complex > 120ms on ECG were included in the study in 1st Department of Internal Medicine, St. Anne's University Hospital in Brno.

Before implantation of the biventricular system and 3 months (to assess temporary changes) and 12 months (to assess long-term effects) after application of the re-

synchronization therapy, each patient underwent the following examinations:

- Patient history and physical examination – establishment of diagnosis and CHF etiology (echocardiography examination and coronary angiography), severity of heart failure according to the NYHA functional classification, assessment of the pharmacological therapy (medication of heart failure according to recommended guidelines of the Czech Society of Cardiology)
- The standard 12-lead ECG examination – determination of sinus rhythm or atrial fibrillation, determination of QRS complex width, LBBB presences
- Echocardiographic examination – assessment of left ventricle global systolic function by calculating the volumes of the left ventricle according to Teicholz, formulation of left ventricular ejection fraction (LVEF) in %, measurement of the left ventricle end diastolic diameters (LVEDD) in 2-D projection. Using coloured Doppler imaging, the presence of mitral regurgitation was verified and a semi-quantitative assessment of the regurgitation size was made using a 4-point scale (1–4)
- Spiroergometric examination – stress examination on a bicycle ergometre to determine the maximum oxygen consumption V02 max. as an indicator of cardiac performance
- Right heart catheterization – measurement of mean pulmonary artery pressure (MPA) and pulmonary capillary wedge pressure (PCWP), cardiac output (CO) determination by using the thermodilution method and the cardiac index (CI) calculated ( = cardiac output related to body surface).

## SAMPLE OF PATIENTS

The basic characteristics of our patient group is given in the Table 1.

## STATISTICAL EVALUATION

The commercial software StatSoft Statistica 7.0 was used for analysis. The data were tested for normality (Shapiro – Wilk test) and non-parametric tests were used as a result. The Wilcoxon paired sample test was used to compare changes in observed parameters for each patient over time. Statistical significance was set at  $p < 0.05$ . Comparisons of individual values in a time frame were made at: a) before implantation of the biventricular system and 3 months after implantation, b) before implantation of the biventricular system and 12 months after implantation, and c) comparison between the 3rd and the 12th month after application of the resynchronization therapy. All values given are means ± standard deviation.

**Table 1.** The characteristics of our patients.

		Men	Women
Total number	118	90 (76.3%)	28 (23.7%)
Age	62.17 ± 5.68	59.4 ± 4.82	64.4 ± 7.26
Dg. Coronary artery disease	37 (31.5%)	30 (81%)	7 (19%)
Dilated cardiomyopathy	73 (61.7%)	53 (72.6%)	20 (27.4%)
CAD + DKMP	7 (5.9%)	6 (85.7%)	1 (14.3%)
AVR	1 (0.9%)	1 (100%)	0 (0%)
ECG: sin. Rhythm	96 (81.4%)	72 (75%)	24 (25%)
Atrial fibrillation	22 (18.6%)	18 (81.8%)	4 (18.2%)
NYHA II	5 (4.3%)	5 (100%)	0 (0%)
II - III	26 (22%)	19 (73%)	7 (27%)
III	72 (61%)	55 (76.4%)	17 (23.6%)
III - IV	15 (12.7%)	11 (73.3%)	4 (26.7%)

CAD - coronary artery disease, DKMP - dilated cardiomyopathy, AVR - aortic valve replacement, NYHA - New York Heart Association classification

## RESULTS

Between the years 2000–2006, the biventricular system was implanted into 118 patients. 77 patients (65.3%) were implanted with a biventricular pacemaker; in case of 41 patients (34.7%) indications were present to implant an ICD and a biventricular ICD was implanted. Implantation was done successfully in 111 patients, with a left-ventricle lead being implanted via coronary sinus. In the majority of cases (72 cases), the left-ventricle electrode was implanted into the posterolateral branch of coronary sinus, others into the lateral branch (32 patients, 28.8%); 4 electrodes (3.6%) were implanted into

the anterolateral branch because of atypical branching of the coronary veins. In the case of 3 patients (2.7%), the specific location of left-ventricle lead was not mentioned. In the case of 7 patients, the left-ventricle leads were implanted epimyocardially under total anaesthesia in a cardiosurgical operating theatre from lateral minitoracotomy or sternotomy.

A total of 98 patients underwent the above mentioned examinations before and 3 months after application of the resynchronization therapy. Of these, 66 patients also underwent examination after 12 months. The results are given in the Table 2 and 3:

**Table 2.** Resynchronization therapy results.

	BEFORE	3 months after	12 months after	p <sub>1</sub>	p <sub>2</sub>	p <sub>3</sub>
NYHA	2.8 ± 0.4	2.3 ± 0.5	2.5 ± 0.6	< 0.001	< 0.01	< 0.001
LVEF (%)	20.5 ± 5.3	23 ± 6.5	24.5 ± 8	< 0.001	< 0.001	NS
LVEDD (mm)	69 ± 9	68 ± 9	65 ± 12	< 0.01	< 0.01	NS
MR	2.2 ± 0.8	1.9 ± 0.8	2 ± 0.8	< 0.001	< 0.001	NS
SE (ml/kg/min)	14.1 ± 3.1	15.3 ± 3.1	15.3 ± 2.5	< 0.001	NS	NS
CO (l/min)	3.9 ± 1	4.2 ± 0.9	4.1 ± 0.9	< 0.05	NS	NS
CI (l/kg/min)	2 ± 0.5	2.2 ± 0.4	2.1 ± 0.4	< 0.05	NS	NS
MPA (mm Hg)	29.1 ± 11.5	23.9 ± 10.3	24.9 ± 11.8	< 0.001	< 0.01	NS
PCWP (mm Hg)	19.9 ± 9.5	15.2 ± 9.2	15.6 ± 9	< 0.01	< 0.01	NS

NYHA - New York Heart Association, LVEF - left ventricular ejection fraction, LVEDD - left ventricle end-diastolic diameter, MR - mitral regurgitation, SE - spirometric examination, CO - cardiac output, CI - cardiac index, MAP - mean artery pressure, PCWP - mean capillary wedge pressure

p<sub>1</sub> - significance of difference between the condition before implantation of BiV and 3 months after implantation of BiV

p<sub>2</sub> - significance of difference between the condition before implantation of BiV and 12 months after implantation of BiV

p<sub>3</sub> - significance of difference between the 3rd and the 12th month

We classified as responders those patients who showed:

- improvement by 0.5 – 1 class according to the NYHA classification or
- increase of LVEF by 5%, reduction of LVEDD by 5mm, reduction of the mitral regurgitation by 0.5 – 1 degree or
- increase in maximum O<sub>2</sub> consumption during stress spirometric examination by 2ml/kg/min or

- increase in CO by 0,5 l/min, reduction of MPA and PCWP by 5 mmHg

Classified as non – responders were also patients who showed a deterioration of the observed parameters from input values. In total, we recorded 33.4% of non-respondents.

**Table 3.** Complications related to application of resynchronisation therapy recorded in our sample of patients compared to other studies.

Complicaton	Our sample	MIRACLE	In-Sync	MUSTIC
Success rate of implantation	94%	92.8%	94.1%	92%
Dislocation of electrodes	4.2 %	8.6%	6%	12%
Dissection of CS	0.85%	4%	N/A	N/A
NP stimulation	1.7%	3%	2%	12%
Pocket infection and decubitus	2.5 %	2%	3%	0%
Repeated revision	1.7%	N/A	N/A	N/A
Vegetation on electrode	2.5%	N/A	N/A	N/A
Death related to implantation of CRT	0.85% (= 1 patient)	0.09%	0.045%	N/A

CS – coronary sinus (sinus coronarius), NP – nervus phrenicus, CRT = cardiac resynchronization therapy, MIRACLE – The Multicenter InSync Randomized Clinical Evaluation, InSync = a study of the Medtronic company, named after the name of an InSync cardiac pacemaker, MUSTIC – Multisite Stimulation In Cardiomyopathy Study

## DISCUSSION

Resynchronization therapy has been an established treatment for patients with chronic heart failure for several years. Its contribution to the treatment of patients with heart failure who continue to be symptomatic despite optimal pharmacological medication has been shown in a large number studies<sup>9</sup>.

Patients referred to our institution for resynchronization therapy were, despite optimal pharmacological medication, in the functional class of NYHA II – IV; over 60% of patients were in the NYHA III class, i.e. patients symptomatic even after slight exertion. Patients in the NYHA II class suffered from serious ventricle arrhythmia was present where LBBB with a wide QRS complex and a reduced systolic function of the left ventricle, were implanted with a biventricular ICD.

The QRS complex was calculated to be 160 ms on average. In the majority of our patients, improvement in echocardiographic parameters was found both after 3 and 12 months. Increase in systolic function of the left ventricle, reduction of the left ventricle size and reduction of mitral regurgitation. According to some authors, the left ventricle resynchronization effect means improvement of left ventricle systolic function (LVEF), mitral regurgitation and remodelling of the left ventricle<sup>10</sup>. The pathological mechanism of mitral regurgitation in dilated cardiomyopathy of ischemic and non-ischemic etiology can have the form of either a) own dilatation of the left

ventricle with changed anatomical ratios between papillary muscles, dilatation of mitral anulus, or b) the actual mechanical dyssynchrony of left ventricle contraction<sup>11</sup>.

According to right heart catheterization, as shown in the results above, there was a statistically significant reduction in mean pulmonary artery pressure and pulmonary capillary wedge pressure after 3 months and the improvement remained after 12 months. Even though there was a deterioration of values between the 3rd and the 12th month, there was overall improvement from the input values. Similarly, for cardiac output and cardiac index, there was an increase in both values after 3 months. However, when input values were compared with values after 12 months, no statistically significant difference was found. These findings thus indicated improvement in the observed parameters after application of resynchronization therapy (above all in a shorter period of time), and even though there was no significant improvement after 12 months of observation, it should be emphasized that the improvement continued even after a longer period of time and thus was beneficial. These findings also correlate with changes during stress spirometry, in which statistically significant changes in values of maximum oxygen consumption were recorded, as well as in the parameter of patients' performance.

In our sample, 38 patients died during the observed period. The most frequent cause of death was terminal cardiac failure – in 28 patients (73.7%). In the COMPANION study, cardiac etiology of death occurred in 83.2% of cases



in the CRT- P group (out of these, 40.5% was cardiac failure and 36.6% sudden cardiac death), in the CRT -D group the number was 72.4% (terminal cardiac failure - 49.5% and sudden cardiac death - 16.2% of patients). Similarly, acute myocardial infarction was found in 1.5% of patients in the CRT - P group and in 3.8% of patients in the CRT - D group. In our sample, the number of acute myocardial infarctions was 2.6% of patients. Non-cardiac cause of death was recorded in 13.1% of patients in our results, and in 10.7% or 20% of patients in the COMPANION study.

In the literature<sup>12-14</sup>, the most frequently mentioned complications of biventricular system implantation are: lead dislocation, coronary sinus dissection and stimulation of the phrenic nerve. Less frequently, perforation of heart vein or coronary sinus can occur, as well as asystole or complete AV block. Further causes of failure include anatomical variations of coronary sinus and atypical branching of cardiac veins; these occur in 10-15% of implantations according to the literature<sup>15</sup>. Some authors stress the placement of left ventricle electrode into the lateral wall of the left ventricle, for reason of better hemodynamic response than other walls of the left ventricle<sup>16</sup>. Stimulation of the left ventricle anterior wall can lead to deterioration of cardiac failure and mitral regurgitation<sup>17</sup>.

In the CONTAK CD<sup>18</sup> study, the success rate of biventricular system implantation via coronary sinus was 91%; the MIRACLE study reported 92.8% (ref.<sup>19</sup>). Dislocation of electrode was recorded in 6% of patients in the CARE-HF study and in 4% of patients in the MIRACLE study; the authors of the MUSTIC study report an occurrence of 12% (ref.<sup>20-22</sup>). Coronary sinus dissection is usually reported in the range of 0.4-4% of patients.

The success rate of implantation in our sample was 94%, the cause of failure being coronary sinus perforation in one patient. Further there were problems with sheath introduction into the coronary sinus, most likely because of valve presence in the coronary sinus ostium and for anatomical deviations in the branching of coronary veins, especially acute angle branching and thinness of branches. For these reasons, it was not possible to find an optimal position for the left-ventricle electrode.

Due to lead dislocation, repositioning was carried out in 5 patients in our sample (4.2%). Diaphragma stimulations are reported in 1.6%-12% of patients, the MIRACLE ICD study<sup>23</sup> reports 4% of patients; in our sample, repositioning of electrode was required in 2 patients (1.7%). Diaphragma stimulation was mostly detected during implantation. However, it can sometimes occur at later periods. This is more frequent in patients with extreme left ventricle dilatation. Sometimes, a reprogramming of pacemaker is sufficient and sometimes a revision with electrode repositioning is necessary. Newer models of the biventricular system enable so-called "electrical repositioning".

Other complications, such as infections and decubitus in pacemaker pocket, or vegetation on leads (which also occurred in our sample) are described in the literature to occur in small numbers as well.

However, progress in cardiosurgery can influence the frequency of epimyocardial left - ventricle electrode im-

plantations. A disadvantage of the surgical solution is the necessity of general anaesthesia and the longer period of hospitalisation. Implantation of left - ventricle electrode via coronary sinus appears to be a more "elegant" solution than surgical treatment, but due to variability of the venous bed, or the presence of valve in sinus coronarius, difficult introduction or missing target branch, this procedure can be more time-consuming. Moreover, it means more radiation for the patient and the doctor and his/her co-workers. The risk of more serious complications, such as perforation of coronary sinus, pericardial tamponade etc. also have to be taken into account.

The results of our patients as in other studies, show the beneficial effect of biventricular stimulation. Even so, appx. 20-30% of patients do not profit from this therapy<sup>24</sup>; such patients are classified as non-respondents.

#### *Further question related to cardiac resynchronization treatment:*

##### *Width of QRS complex*

The extended duration of QRS complex above 120 ms occurs in patients with chronic cardiac failure in from 14% - 47% (ref.<sup>25</sup>), more often in the form of left bundle branch block than the right bundle branch block (25%-36% vs. 4-6%) (ref.<sup>26</sup>). In a study with more than 3,500 patients, Shenkman et al.<sup>27</sup> pointed to a gradual increase in the prevalence of systolic dysfunction of the left ventricle with the width of the QRS complex more than 120 ms. Patients with heart failure and extended QRS complex have higher mortality and also higher incidence of sudden death as opposed to patients with narrow QRS complex<sup>28</sup>. Nevertheless, a careful analysis in some studies has shown that 20-30% of patients do not benefit from CRT despite the presence of extended QRS complex. On the other hand, in some patients, mechanical asynchrony of left - ventricle contraction is present without extended QRS complex.

##### *Electroanatomical mapping*

In patients with left bundle branch block, the overall activation of the left ventricle is prolonged and the latest place of depolarisation is the lateral wall of the left-ventricle. The result is intraventricular mechanical delay which can be demonstrated using tissue Doppler echocardiography, although even this examination method has its limitations. Electromagnetic mapping using 3D imaging which would clearly localize the area of the latest activation of the left ventricle and thus the most suitable location for implantation of the left- ventricle electrode could be useful<sup>29</sup>. The concurrent use of the examination method which maps out the area which is activated with the longest delay and at the same time also the anatomical parameters of the cardiac venous system could improve and simplify implantation of the biventricular system.

##### *Atrial fibrillation and biventricular stimulation*

Atrial fibrillation is a frequent arrhythmia in patients with cardiac failure and its prevalence increases with the severity of the heart failure and with the age of patients. In a study of 2,848 patients with a significant left ventricle

dysfunction, Wyse et al.<sup>30</sup> found atrial fibrillation was an independent mortality risk factor. Despite the high occurrence of atrial fibrillation in patients with cardiac failure, most studies describe the influence of biventricular stimulation in patients with sinus rhythm. Smaller studies, usually from one centre, described the positive effect of biventricular stimulation in patients with chronic atrial fibrillation and cardiac failure, but in the majority of cases, patients also underwent AV node ablation. Against AV node ablation in patients who have been implanted with a biventricular stimulator is a citation, according to which cardiac resynchronization therapy leads to reversible remodelling of the left ventricle and to reduction of mitral regurgitation, which can lead to sinus rhythm restitution. In our sample, atrial fibrillation was present before implantation in 22 patients (18.6%), and newly occurred in the course of the observation in 14 patients (11.8%). The presence of atrial fibrillation was recorded in 31.4% of deceased patients (i.e. 11 patients from the total number of 35 deceased patients in our group).

#### *CRT in parallel with ICD?*

The literature mentions the 5-year mortality in chronic heart failure to be as much as 50%. The cause of death differs according to the severity of the cardiac failure. Patients with severe heart failure (NYHA III – IV) die much more frequently because of terminal cardiac failure, whereas in the NYHA II class, patients with this diagnosis die less often, the usual cause is sudden cardiac death. Resynchronization therapy mainly improves the symptoms of more severe heart failure and there is also, among others, an improvement from NYHA III – IV to NYHA II – III. At this point, the patients falls into a “group” in which they are additionally threatened by sudden death, which is a fact pointed out by proponents of biventricular ICD implantation. There are also citations mentioning the proarrhythmogenic effect of resynchronization therapy, where a change in left ventricle activation leads to an extension of the QT interval and condition for reentrant tachycardia. At the stage of repolarisation, frequent extrasystoles occur which play an important role in the release of serious ventricle arrhythmias. These changes are mainly present in parallel with extended QT interval and, moreover, were observed in a case of epimyocardial left – ventricle electrode implantation. On the other hand, cardiac resynchronization therapy leads to the already mentioned remodelling of the left ventricle and thus to regression of potential substrate for ventricle arrhythmias. Thus, if resynchronization therapy is more beneficial to patients with an extended QRS complex, it seems plausible that there is no reason to implant ICD into all patients indicated for resynchronization therapy but only into some.

#### CONCLUSIONS

The results of this study show that in the majority of patients with chronic heart failure who continue to be symptomatic even despite optimal pharmacological

medication, resynchronization therapy leads to improved performance, increase in systolic function of the left ventricle, reversible remodelling of the left ventricle expressed by reduction of end-diastolic dimensions of the left ventricle and to reduction in the severity of mitral regurgitation. Hemodynamic parameters point to the effect of biventricular stimulation in this area as well. As a result of the resynchronization therapy, there was an increase in cardiac output, or, more precisely, in cardiac index, but also a reduction in mean pulmonary artery pressure and pulmonary capillary wedge pressure which contribute to the reduced symptoms in patients with cardiac failure, especially to reduced dyspnoea and to improved stress examination.

It is significant that these improvements in the given parameters were also observed after 12 months, even though, compared with 3-month values, the improvement was not as significant (some parameters had even slightly deteriorated). However, overall improvement after 12 months from input values was still present. Especially noteworthy is the reduction of size of the left ventricle according to echocardiography examination after 12 months of biventricular stimulation which is a proof of significant remodelling of the left ventricle. Further observations will be able to answer the question if, several years after implantation of the biventricular system, there will be a significant reversible remodelling of the left ventricle.

Despite these results, about 33% of non-respondents were identified in our sample – patients who did not gain any benefit from the therapy. It remains to look for more precise indication criteria for selecting patients who will profit from resynchronization therapy.

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