# Clinical Experience with Dual Chamber Pacing in Patients with Hypertrophic Obstructive Cardiomyopathy

S.A. YUZVINKEVICH, V.V. FEDOROV, A.N. KRUTIKOV, A.A. DOMASHENKO, V.N. KHIRMANOV
I.P. Pavlov State Medical University, Cardiology Research Institute, Clinical Hospital No.26, St. Petersburg, Russia

M. SCHALDACH
Department of Biomedical Engineering, University of Erlangen-Nuremberg, Germany

## Summary

*This study has been undertaken in patients with hypertrophic obstructive cardiomyopathy (HOCM) to elaborate indications and contraindications for electrotherapy of the heart (in the form of the dual chamber pacing with the shortened AV delay), to evaluate clinical and hemodynamic effects of the therapy, as well as to develop algorithms to program a pacemaker individually to a patient. 40 patients with the resistant to medication HOCM have been investigated. ECG and IEGM monitoring, bicycle ergometry, echocardiography (2D, Doppler), phono-cardiography, temporary dual chamber pacing along with simultaneous heart chamber sensing have been carried out; when indications have been met a pacemaker has been implanted. Temporary dual chamber pacing with the AV delay ranging from 50 to 120 ms in 83% of patients resulted in decreasing of the left ventricle outflow tract (LVOT) systolic pressure gradient (SPG). Dual chamber pacemakers have been implanted in 28 patients with intact sinus rhythm. Standard follow-up procedures have been undertaken during periods of 12-36 months (mean period is 25±2 months).*

*VDD and DDD pacing with the optimised AV delay (mean - 78±3 ms) resulted in reduction of main disease symptoms. Syncopes disappeared in 85% of the cases. Mean functional class of cardiac stenosis decreased from 2.3±0.1 to 1.3±0.1, and mean functional heart insufficiency class - from 2.1±0.1 to 1.3±0.1. Antiarrhythmic effect of the dual chamber pacing on atrial flimmer and tachycardia, as well as on ventricular arrhythmias was distinct.*

## Key Words

Hypertrophic obstructive cardiomyopathy, dual chamber pacing, shortened AV delay.

## Introduction

Medication and surgical treatment of HOCM often appears to be not effective [1-5]. In many cases dual chamber pacing with the shortened AV delay - new special kind of electrotherapy of the heart, is the only alternative for HOCM patients [6].

In 1975, P. Hassenstein, investigating peculiar features of intracardiac hemodynamics in patients with single chamber pacemakers implanted due to complete AV block, paid attention to the fact that right ventricle apex stimulation peculiarly in HOCM patients resulted in the LVOT SPG reduction. Improvement of the course of the HOCM disease with constant dual chamber pacing was first reported in the beginning of eighties (P. Gardner et al.) [7].

Recently, electrotherapy of HOCM patients is increasingly experienced in many clinical centres world-wide [8-13]. Main research topics are: indications and contraindications of the method, peculiarities of pacemaker programming, therapeutic effect on intracardiac hemodynamics, on the heart structure, on HOCM symptoms and course of the disease, associated sudden heart death. These questions have been tried to be answered also in this study.

## Material and methods

### Patients

40 patients with the drug resistant HOCM have been studied: 24 female and 16 male of the age ranging from 30 to 70 years. HOCM has been had diagnosed 1 to 24 years prior to the study. HOCM has the obstructive form in 36 cases and the non-obstructive - in 4 cases. 17 patients (43%) have manifested primary resistance to such medicaments as β-adrenergic

blockers, Ca-channel antagonists, cordarone. 16 patients (40%) have demonstrated the drug „exit" effect on the average after 18 months of the therapy. Proarrhythmic effect of antiarrhythmics was documented in 2 patients (5%). One patient (female) underwent myoectomy of the ventricular septum, that appeared to be as inefficient as the medication therapy. In other patients, drug therapy can hardly be used due to bradycardia. So. all patients of this group have had complicated, hardly cured with drugs, course of the HOCM disease.

## Methods

Patients underwent initially echo-cardiography, ECG Holter monitoring, bicycle ergometry, phono-cardiography. Dynamics of the LVOT SPG (direct blood pressure measurements in the aorta and the left ventricle) have been evaluated during temporary dual chamber pacing. When indications have been documented, a pacemaker has been implanted.

Control studies have been carried out including evaluation of the clinical course of the disease, of the data of echo-cardiography, phono-cardiography, bicycle ergometry, ECG Holter monitoring, IEGM trend analysis 12 months after the pacemaker implantation.

Dual chamber pacemakers have been implanted in 28 patients (Diplos 06, n=25, and Ergos 03, n=3; all BIOTRONIK, Berlin). HF ablation of the AV node has been performed in 3 patients with atrial flimmer and fibrillation, resistant to antiarrhythmic therapy, and in one patient with the constant tachysystolic form of atrial fibrillation.

### Electrotherapy indications and contraindications

Main indications for dual chamber pacing therapy with the shortened AV delay for patients with the *obstructive* form of HOCM were in our study as following:

- distinct HOCM clinical symptoms (second and higher functional classes of cardiac stenosis and of heart insufficiency, lower classes with syncopes and their resistance to drug therapy);
- high (more than 30 mmHg) SPG of the LVOT lowered to at least 25% by temporary dual chamber pacing with the shortened AV delay.

Dual chamber pacing was indicated for patients with the *non-obstructive* form of HOCM when:

- HOCM symptoms were distinct (second and higher classes of cardiac stenosis and of heart insufficiency, or lower classes, but with syncopes) and drug therapy was not efficient along with no increase of the LVOT SPG during temporary dual chamber pacing.

Besides that, independently from the HOCM form the procedure of pacemaker implantation, of course, was indicated in the case of the sick sinus syndrome or AV block of higher degree.

Dual chamber pacing electrotherapy of HOCM was contra-indicated in the case of:

- apical form of the disease,
- intrinsic short PQ interval that could not be prolonged by medicaments or ablation,
- constant form of flimmer,
- organic changes of the mitral valve,
- increased LVOT SPG during temporary dual chamber pacing.

## Results

### Dynamics of the LVOT SPG during temporary dual chamber pacing

Initially, the mean value of the LVOT SPG was 35±5 mmHg, that did not change significantly during temporary pacing in the AOO mode, 36±5 mmHg respectively (Fig. 1).

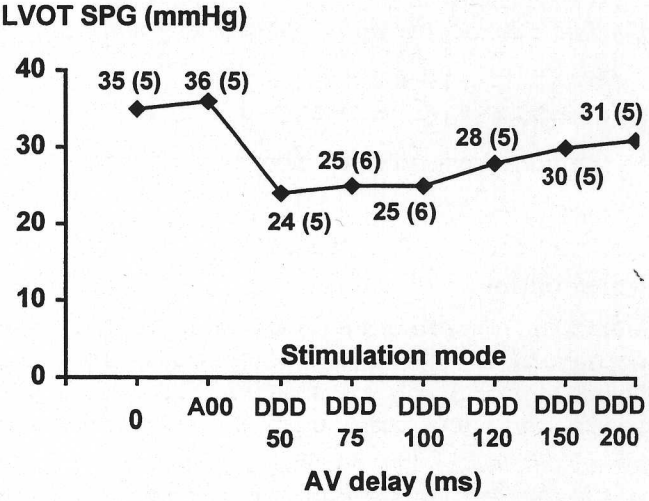


*Figure 1. Dependence of the LVOT SPG on the mode of temporary pacing and on the AV delay (M±m).*

This parameter increased (maximum with the AV delay equal to 75 ms, being 140% of the initial value) only in one case during the right ventricle apex stimulation in the dual chamber mode. In 4 patients with the non-obstructive form of HOCM the initial low value of LVOT SPG (4-5 mmHg) did not change

significantly. In other 24 patients the right ventricle apex stimulation in the dual chamber mode with the shortened AV delay has resulted in the LVOT SPG decrease of different degree (Fig. 2).

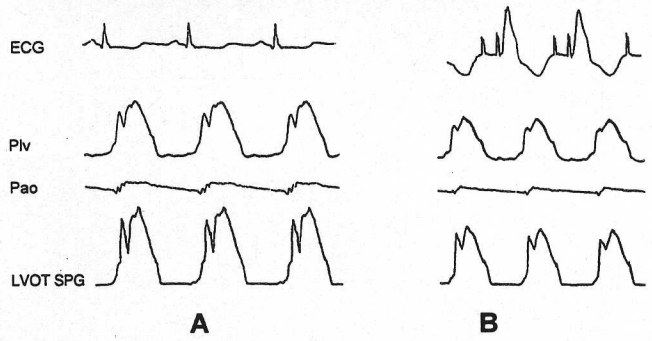


***Figure 2.*** *Dynamics of the LVOT SPG in 38 years old HOCM patient F: A - initial data with sinus rhythm (LVOT SPG is 76 mmHg), B - during dual chamber pacing with the AV delay of 100 ms (LVOT SPG is 60 mmHg). Plv - pressure in the left ventricle, Pao - pressure in the ascending aorta.*

With the AV delay of 50 ms the mean LVOT SPG has decreased to 24±5 mmHg, i.e. by 31% of the initial value (p=0.01). With the AV delay of 75 and 100 ms the LVOT SPG is on the average 25±6 mmHg, i.e. by 29% lower than the initial value (p=0.01), while at 120 ms - 28±5 mmHg (20% lower, p=0.01).

With the AV delay of 150 and 200 ms the LVOT SPG was 30±5 and 31±5 mmHg, appropriately (decreased by 11% in the former case, and increased by 3% in the latter case). But, these changes statistically are not significant (p>0.05) (Fig. 1).

Maximum reduction of the LVOT SPG falls to the AV delay value of 71±5 ms. No statistically significant change of the LVOT SPG has been registered during stimulation of the upper third of the ventricular septum.

It should be noted, that no significant pressure change in the ascending aorta during dual chamber pacing has been registered, i.e. the LVOT SPG has changed exclusively due to pressure decreasing in the left ventricle cavity during systole.

### Dynamics of the LVOT SPG during dual chamber pacing with the shortened AV delay

Initially, the mean value of the LVOT SPG was 35±5 mmHg, parameter values being the same whether measured directly or with the aid of the Doppler-echo-cardiography in the constant wave mode.

Follow-up study carried out after 25±2 months of the electrotherapy has shown that the LVOT SPG, measured by the Doppler-echo-cardiography, is decreased not only in comparison with initial values, but also in comparison with the values measured during temporary dual chamber pacing, being on the average 7±1 mmHg, p<0.05 (Fig. 3).

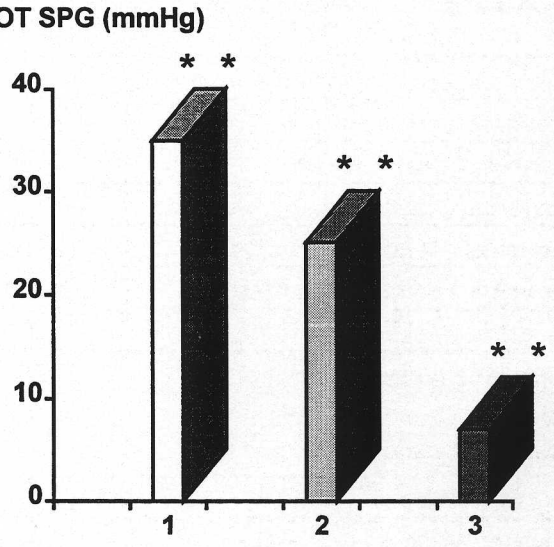


***Figure 3.*** *Dynamics of the LVOT SPG: 1 - initial, 2 - during temporary dual chamber pacing, 3 - after permanent dual chamber pacing therapy.*

### Dynamics of the HOCM clinical picture in the course of dual chamber pacing therapy with the shortened AV delay

All 28 patients had syncopes prior to pacemaker implantation, with the mean functional class of cardiac stenosis being 2.3±0.1 and the mean functional class of heart insufficiency being 2.1±0.1. Initial clinical picture in this group is presented in Table 1.

No one of patients have had syncopes during the first year after pacemaker implantation. 6 patients (21% of the initial number) have had dizziness, one of them having it much more rarely and only under physical load. The mean functional class of cardiac stenosis has decreased to 1.2±0.1, and the mean functional class of cardiac insufficiency - to 1.3±0.1 (Fig. 4 and 5, appropriately).

According to phono-cardiography 17 of 28 patients (61%) already beginning from the first month of electrotherapy had significantly lower amplitude and duration of the systolic ejection noise (Fig. 6).

During the first year of the therapy the number of paroxysmal atrial fibrillation (p=0.05), atrial flimmer (p=0.025), ventricular tachycardia (p=0.025) and ventricular extrasystoles (p=0.01) was significantly decreased. The number of atrial extrasystoles has not changed significantly (p>0.05). Dynamics of the atrial chaotic tachycardia and of the AV reciprocal tachycardia was not statistically evaluated due to their rare character.

| *Rhythm and conductance disturbance* | *n* | *%* |
|---|---|---|
| Paroxysmal atrial fibrillation | 7 | 25 |
| Paroxysmal atrial flimmer | 6 | 21 |
| Paroxysmal chaotic atrial tachycardy | 2 | 7 |
| Paroxysmal AV node tachycardy | 1 | 4 |
| Paroxysmal ventricular tachycardy | 7 | 25 |
| Atrial extrasystoles | 20 | 71 |
| Ventricular extrasystoles | 23 | 82 |
| SSS | 4 | 14 |
| I degree AV block | 3 | 11 |
| II degree AV block | 1 | 4 |
| Complete AV block | 2 | 7 |

***Table 1.*** *Initial picture of heart rhythm and conductance disturbances in HOCM patients prior to dual pacemaker implantation.*

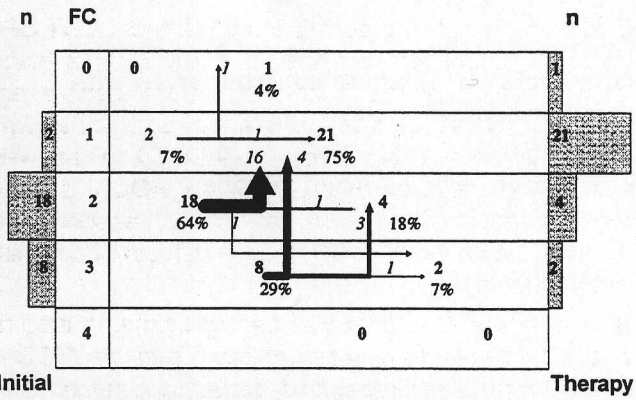


***Figure 4.*** *Dynamics of cardiac stenosis functional class (FC) in HOCM patients in the course of permanent dual chamber pacing with the shortened AV delay.*

7 patients with initially intact sinus node function had shown a distinct statistically significant (p<0.00001) decrease of the sinus rhythm in the course of permanent dual chamber pacing (in a month). All patients with implanted pacemakers have had significant (p<0.00001) sinus rhythm decrease.

The follow-up period was 24 months for 25 patients and 3 years for 3 patients. No mortality is registered in the group of patients with dual chamber pacemakers.

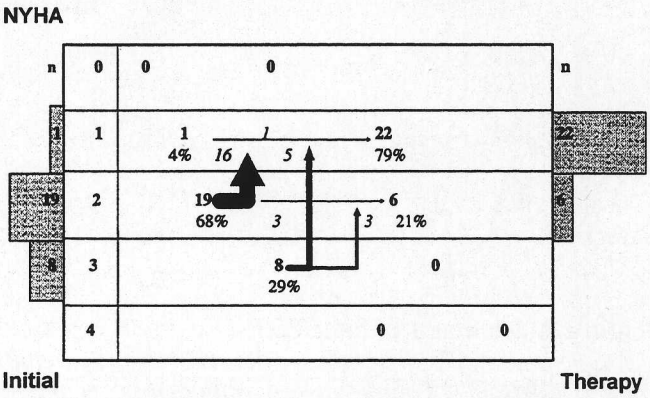


***Figure 5.*** *Dynamics of the heart insufficiency functional class NYHA in the course of permanent dual chamber pacing with the shortened AV delay.*

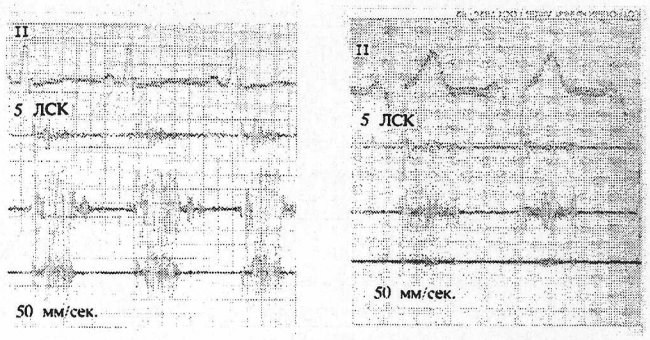


***Figure 6.*** *Dynamics of the phonocardiography in HOCM patient C in the course of permanent dual chamber pacing with the shortened AV delay (***A** *- initial,* **B** *- effect of therapy).*

The patients demonstrated further decrease of the functional class of cardiac stenosis and of heart insufficiency, to mean values of 1.0±0.1 and 1.1±0.1 (p<0.05), appropriately, in 24 months following the pacemaker implantation. Only 4 patients have had syncopes. Paroxysmal atrial fibrillation, atrial flimmer, ventricular tachycardia, as well as ventricular extrasystoles remained at the same level (p>0.05).

No syncopes were registered among patients followed up for 36 months. Cardiac stenosis and heart insufficiency of the second functional class were

registered only in one female patient. Other patients had cardiac stenosis and heart insufficiency of first functional class. Course of heart arrhythmias did not change significantly. In general, the number of patients in this group is not sufficient for statistical analysis.

The mean AV delay after the follow-up period of one year was 78±3 ms for sensed atrial event and 116±3 ms for paced atrial event.

### Effect of the electrotherapy on the heart structure and intracardiac hemodynamics

The echocardiographic data of the HOCM patients before and 25±2 months after the pacemaker implantation are presented in Table 2. The degree of the anterior systolic movement of the mitral valve has been estimated according to L. Fananapazir [7].

| Echocardiographic parameters | *Initial (M±m)* | *After 12 month long therapy* |
|---|---|---|
| LV wall thickness (cm): | | |
| - upper third of the IVS | 2,1±0,1 | 2,1±0,1 |
| - middle third of the IVS | 2,3±0,1 | 2,4±0,2 |
| - LV posterior wall | 1,4±0,1 | 1,4±0,1 |
| Heart chamber sizes (cm): | | |
| - LA | 4,8±0,2 | 4,8±0,2 |
| - LV (diastolic size) | 4,3±0,2 | 4,5±0,1 |
| - RA | 4,5±0,2 | 4,8±0,2 |
| - RA (diastolic size) | 3,2±0,1 | 3,2±0,2 |
| Mitral regurgitation degree | 1,18±0,19 | 0,96±0,18 |
| Degree of the MV ASM | 0,68±0,15 | 0,68±0,15 |
| LVOT SPG (mmHg) | 37±5 | 7±1 |
| E/A ratio | 1,2±0,1 | 1,2±0,1 |

***Table 2.*** *Dynamics of the echocardiographic parameters (IVS - interventricular septum, MV ASM - mitral valve anterior systolic movement).*

No statistically significant changes of mean values of the ventricle wall thickness in the upper and middle thirds of the septum and the posterior wall, as well as mean sizes of the left and the right heart chambers ($p>0.05$) have been observed. There have been no statistically significant changes in the degree of mitral regurgitation, in anterior systolic movement of the mitral valve and diastolic function of the left ventricle (peak ratio E/A) ($p>0.05$).

## Discussion

Dual chamber pacing with the shortened AV delay is a new method of therapeutical treatment of patients with the drug resistant HOCM, several problems of its application still remaining a problem of scientific analysis.

*Indications and contraindications are to be considered first.* Along with other investigators [7, 8, 10, 14, 15], we consider on the basis of our clinical experience the permanent dual chamber pacing with the shortened AV delay to be indicated for obstructive HOCM patients having high SPG in the LVOT at rest and distinct disease symptoms resistant to drug therapy.

The questions arise *whether the effect of permanent pacing in patients with the obstructive form of HOCM can be forecasted on the basis of the LVOT SPG changes during temporary pacing*, and if yes - what will be the criterion.

Direct correlation of the success of the therapeutic method with the LVOT SPG lowering during test temporary stimulation is proven. The criteria is a 25% and larger lowering of the pressure gradient [10, 15-18].

On the contrary, Fananapazir et al. [7] consider intracardiac hemodynamic changes during temporary stimulation not to be a forecasting criterion, and left heart chamber should not be probed with the aim to select HOCM patients for permanent dual chamber pacing.

Our study has shown correlation of distinct LVOT SPG lowering during temporary stimulation with its stable lowering as the result of permanent pacing and regression of main disease symptoms. That is why, we consider left heart chamber probing as very informative measure to select finally HOCM patients for permanent dual chamber pacing, especially to exclude the cases with obstructive defects of coronary arteries.

*Is permanent dual chamber pacing indicated also for patients with the non-obstructive form of HOCM?* Results have been recently reported that demonstrate the disease symptoms to be less distinct and the load tolerance been increased in patients with the non-obstructive form of HOCM in the course of the permanent dual chamber pacing with the shortened AV delay. The therapy is indicated for patients with the non-obstructive form of HOCM resistant to drugs and with distinct disease symptoms [19-21]. We follow up 5 patients of the latter case.

Temporary pacing has resulted in increased LVOT SPG in one of them, while in other four it has had no

effect. A dual chamber pacemaker has been implanted in those 4 patients, and significant regression of the disease symptoms has been observed after a year of the therapy. We imply on the basis of our results that permanent dual chamber pacing with the shortened AV delay is indicated for patients with the non-obstructive form of HOCM when the disease symptoms are distinct, resistant to drug therapy, and there is no increase in the LVOT SPG during a probe stimulation.

The therapy is indicated without any condition for patients with the obstructive and the non-obstructive HOCM forms when the disease is associated with the SSS or AV block of higher degree. The left heart chamber probing is not obligatory, but rather desirable, analysis of the systolic pressure gradient dynamics during the temporary pacing being useful to program an implantable pacemaker later on.

We agree with the majority of authors considering the permanent dual chamber pacing with the shortened AV delay not indicated for HOCM patients with organic changes of the mitral valve accompanied by its dysfunction, with the PQ interval being less than 160 ms and not subjected to prolongation by medication or by HF ablation; the therapy is contraindicated as well when probe stimulation results in the LVOT SPG increase or in increased mitral regurgitation [22]. We do not have patients with the apical form of HOCM in our clinical experience, but the therapy has been shown to be not efficient in that particular case [22].

*Should a pacemaker be implanted in HOCM patients with the paroxysmal atrial flimmer and fibrillation, especially frequent*? As our experience has shown, permanent dual chamber pacing with the shortened AV delay has antiarrhythmic effect in regard to paroxysmal forms of flimmer, hence we consider paroxysmal supraventricular, even frequent, lasting and drug resistant, not to be a contraindication for implantation of a dual chamber pacemaker in HOCM patients. In those cases the implantation can be applied alone or in combination with the drug therapy. If the measures are not effective, the AV node ablation is indicated.

*Can the electrotherapy be applied in HOCM patients with the permanent form of AF*? Evidently, the dual chamber pacing is not possible in those patients. Still, single chamber ventricular pacing is known to decrease the LVOT SPG in HOCM patients with the sinus rhythm. But, asynchronous functioning of atria and ventricles leads to negative hemodynamic effects - decrease of the systemic blood pressure and of the stroke volume, diminishing the effect of the LVOT obstruction decrease [15]. The problem of atria and ventricles synchronisation is no more actual at permanent form of AF, and the LVOT obstruction decrease in the case of the single chamber pacing is an important therapeutic factor as in the case of the dual chamber pacing. We have observed regression of HOCM symptoms due to permanent ventricular rate-adaptive pacing in a patient with the complete artificial AV block and permanent form of AF, the result reported also elsewhere [7, 14, 23].

*What is the effect of the electrotherapy on HOCM, on its symptoms dynamics*? The results demonstrated that syncopes disappeared or became very seldom in 96% of patients, cardiac stenosis and heart insufficiency as well were in regression. The results correlate with the data published elsewhere: 94% of HOCM patients have no syncopes or pre-syncopes after a period of dual chamber pacing [7, 12, 13, 15, 23-25], while cardiac stenosis is less pronounced changed from functional class III down to functional class I [13, 15, 26]. Heart insufficiency is also significantly lower, by one-two classes [15, 16, 25, 27]. These changes of the mean classes of heart insufficiency and of cardiac stenosis were not as pronounced in our study as in the cited data, the difference being probably due to initial lower classes and elder age of the followed up patients.

In the course of the 3 years long follow-up period we do not have had any lethal cases, as in the case study of N. Sadoul et al. [10]. L. Fananapazir et al. [7] report that 2 patients have suddenly died in the long follow-up period after the pacemaker implantation (1%). So, the HOCM therapy not only positively affects the disease symptoms, but probably lowers the risk of the sudden heart death.

*Dynamics of heart arrhythmias in the course of the electrotherapy is a problem of interest.* Permanent pacing resulted in significantly much more seldom paroxysms of AF, ventricular tachycardia and ventricular extrasystoles already in one month. We do not have observed recidives of atrial chaotic tachycardia after the therapy beginning. No similar stimulation effect has been observed in regard to atrial extrasystoles and reciprocal AV tachycardia, the latter being successfully treated by the AVT pacemaker mode. Along with that, L. Fananapazir et al. consider that in spite of the fact that dual chamber pacing decreases the LVOT obstruction, mitral regurgitation and blood pressure in the left atrium, it does not result in any significant decrease of the left atrium sizes and regression of supraventricular tachycardias. Due to that a conclusion is made that AF in HOCM patients is

rather a consequence of the „electrical atrial disease", than of the intracardiac hemodynamics failure, and hence should not be corrected with the aid of dual chamber pacing.

We have not observed any significant reduction of the left atrium cavity or mitral regurgitation decrease in patients with much more seldom paroxysms of atrial flimmer or fibrillation as well, but the antiarrhythmic effect of dual chamber pacing was quite evident. The mechanisms responsible for the effect are not yet quite clear and need to be studied further.

Studying the sinus rate variability in the course of the applied electrotherapy we have observed significant rate changes not yet described in the literature. The effect was a stable sinus bradycardy after one month of dual chamber pacing in patients with initial intact sinus node. The mechanism of the developed bradycardy is not yet clear, but it can be speculated that shortening of the AV delay is able to suppress sympathetic activity, thus acting as a β-adrenergic blocker.

The AV delay is the main stimulation parameter in the HOCM therapy without any doubt. *What are the criteria to estimate whether the AV delay is adequate*? We imply them to be, as accepted elsewhere [7, 14,28, 29]:

- constant (at rest as well at any kind of activity) presence of the most „broad" stimulated QRS complex in the surface ECG;
- maximum decrease of the LVOT SPG measured with the means of the constant-wave Doppler-echocardiography;
- positive dynamics of the disease course.

The PQ interval is known to decrease along with the heart rate increase. For that reason, a fixed value of the AV delay in the HOCM therapy will result in not full „capture" of ventricles by the pacemaker stimulus during physical activity or emotional stress, thus lowering the therapy efficiency. Due to that, we have applied the rate-adaptive AV delay in order to achieve maximal therapeutic effect.

The load is modelled by physical tests [7] or by isoproterenol [30] in order to adjust the rate-adaptive AV delay. Bicycle ergometry has been applied in our study.

The AV delay, optimal for the HOCM therapy, varies in rather wide ranges: values defined are 50-100 ms [15], or even 47-75 ms [10]. In compliance with the study [7] most often used values were 120 and 125 ms, but a good clinical effect was achieved also with the AV delay of 140, 150 and even 180 ms.

In our study, the mean optimal basic value of the AV delay in the case of the atrial sensed event was 78±3 ms after 12 months of the electrotherapy. In general, the optimal AV value during the probe pacing is significantly correlated to the optimal value in the course of the permanent 12 month therapy for the whole group of patients.

*What is the mechanism of the electrotherapeutic effect*? According to most accepted hypothesis, the right ventricle apex excitation synchronised with the atrial activity results in changes of the course of the left ventricle contraction, namely in the delayed ventricular septum activation. Along with that, the LVOT obstruction is decreased, the fact manifested in lowered LVOT SPG. Shortened time of the contact of the mitral valve with the upper third of the ventricular septum seems to play the main role in decreased LVOT obstruction [8, 14, 22, 31].

*Does permanent dual chamber pacing lead to heart remodelling*? There is no yet a distinct answer to the question, but just two different opinions. The one implies that only the left ventricle contraction sequence is changed by stimulation [15, 32, 33]. The other considers the stimulation effect to be more complicated and comprising two phases. First phase, starting immediately with the stimulation includes intracardiac hemodynamic changes of the reversible functional character that disappear on stimulation switching off. Second phase starts on approximately 12 months of permanent dual chamber stimulation and is characterised by heart structural changes that amplify the therapeutic effect of the stimulation. Measurable structural remodelling of the myocardium is observed in 23% of the cases and is due mainly to reduction of the left ventricle myocardium mass caused by decreased thickness of the anterior part of the ventricular septum and of the distal part of the left ventricle anterior wall [7, 8, 15, 18, 22].

What is the mechanism of the structural changes in the heart? May be, it is due only to decreased LVOT obstruction [8]. But, the LVOT obstruction is decreased also after septal myoectomy, the LV free wall thickness being not changed. Hence, the LVOT obstruction decrease itself can not cause heart structural changes [7].

Structural changes can not be caused also by paradoxical movement of the interventricular septum alone, as far as the movement is characteristic also for HOCM patients with the total block of the left His bundle fascia, but the patients demonstrate the

thickness reduction rather of the LV posterior wall than of the anterior part of the interventricular septum [34]. Hypotheses are also studied of possible changes of the spatial orientation and of the myocyte structure along with the permanent dual chamber pacing [35].

Most probable seems to be a theory that explains the heart structural changes due to permanent dual chamber pacing by early excitation of the right ventricle apex, early activation of the anterior part of the interventricular septum, and delayed activation of the posterior part of the interventricular septum, of the left ventricle posterior wall, of the anterior-lateral part of its free wall. Inhomogenity of the segmental contractile work and changes of the LV myocardium mass are observed along with that [7].

The hypothesis on structural remodelling of the heart due to permanent dual chamber pacing is confirmed by the phenomenon of the pacing therapeutical effect and of the reduced LVOT SPG preserved during a long period of time after a test pacemaker switching off [7, 35, 36].

In accordance with the results of other authors [7, 10, 15, 16,18, 37,38], our results demonstrate reduction of the LVOT SPG in the course of the dual chamber pacing with the ventricular electrode in the RV apex.

Along with that, no statistically significant changes of the LVOT SPG during the interventricular pacing at the upper third have been registered in contrast to the result of K. Matsumoto et al. who have observed even larger gradient decrease in that case than during the RV apex stimulation [39].

The LVOT SPG decrease has been recorded during temporary stimulation as well as during permanent pacing, the mean value after one year being decreased not only in comparison to the initial value, but even in comparison to the minimal mean value achieved during the temporary test stimulation. This trend has been described by L. Fananapazir et al. [7, 36], X. Jeanrenaud, J.J. Goy, L. Kappenberger [15], and N. Sadoul et al. as well [10].

In accordance with X. Jeanrenaud et al. [15, 16] our study has also revealed no significant changes of mean values of the left ventricle wall thickness and heart chamber sizes after 25±2 months of the electrotherapy, as well as no statistically significant therapy effect on the LV diastolic function in HOCM patients.

Thus, the results of the study are more in favour of the theory that explains the therapeutic effect not by changes of the LV wall thickness and of the myocardium mass, but rather by functional remodelling of the LV contraction sequence.

Along with that, L. Fananapazir et al. [7] have revealed the LV myocardium mass reduction in 23% of HOCM patients on the average after 2.3±0.8 years of the permanent dual chamber pacing. Some of our patients have demonstrated statistically insignificant reduction of the ventricular septum thickness and (or) of the LV posterior wall thickness after one year of the electrotherapy, but, probably, a longer period of permanent dual chamber pacing with the shortened AV delay is necessary to develop more distinct structural heart changes. Thus, it should be further elaborated whether decrease of the ventricular septum thickness and the LV myocardium mass reduction are possible.

## Conclusion

Electrotherapy of the heart is a new efficient method to cure patients with heavy, drug resistant, obstructive and non-obstructive forms of HOCM being advantageously much less traumatic in comparison to surgical methods. Its specific features are:

- Dual chamber pacing with the shortened AV delay decreases the LVOT obstruction in HOCM patients, as manifested by stable reduction of the LVOT SPG.
- Permanent dual chamber pacing improves clinical course of the disease - syncopes being very seldom, cardiac stenosis and heart insufficiency being less prominent.
- Atrial flimmer and fibrillation paroxysms and ventricular arrhythmias become rare, sinus rhythm decreases as well.
- No statistically significant changes of the LV wall thickness, of heart chamber sizes, of the anterior systolic movement of the mitral valve, of the mitral regurgitation degree, and of the LV diastolic function as well have been revealed after 25±2 months of pacing.
- Permanent dual chamber pacing with the shortened AV delay is indicated for patients with the obstructive form of HOCM when:
  - the disease symptoms are very distinct,
  - drug therapy resistance is present,
  - high LVOT SPG (more than 30 mmHg) at rest is reduced during temporary stimulation by 25% or more.

- Permanent dual chamber pacing with the shortened AV delay is indicated for patients with the non-obstructive form of HOCM when:
  - the disease symptoms are very distinct,
  - drug therapy resistance is revealed,
  - LVOT SPG is not increased during temporary stimulation.
- Permanent dual chamber pacing with the shortened AV delay is not indicated when:
  - organic mitral valve changes are present accompanied by its functional dysfunction,
  - PQ interval is very short (less than 160 ms) and can not be prolonged by medication or by HF ablation,
  - the LVOT SPG is increased during a test temporary pacing,
  - the disease has the apical form.

## References


1. M.S. Koushakovski. - Cardiomyopathies and myocardiodystrophies. - Leningrad: 1977, p. 22 (in Russian).
2. V.A. Almazov, L.V. Chireikin. Difficulties and failures in diagnostics of cardiovascular diseases. - Leningrad: Medicine, 1985, p. 286 (in Russian).
3. N.M. Moukharlyamov. - Cardiomyopathies. - Ìoscow: Medicine, 1990, p. 285 (in Russian).
4. Cardiomyopathies. - Report of the World Health Organization experts. - Geneve: 1990, p. 67.
5. E.N. Chazov (Ed.). - Cardiovascular diseases. Guide for physicians. - Moscow: Medicine, 1992 (in Russian).
6. M. Schaldach. - Electrotherapy of the heart. - Springer-Verlag, Berlin-Heidelberg-New York-London-Paris-Tokyo-HongKong-Barcelona-Budapest, 1992.
7. Fananapazir L., Epstein N.D., Curiel R.V., Panza J.A., Tripodi D., McAreavey D. /Long-term results of dual-chamber (DDD) pacing in obstructive hypertrophic cardiomyopathy // Circulation. - 1994. - 90, 6. - 2731-2742.
8. Kappenberger L., Aebischer N., Jeanrenaud X. /L'apport de la stimulation cardiaque dans les cardiomyopathies hypertrophiques obstructives// Ann. Cardiol. Angiol. - 1994.- 43,10. - 573-577.
9. Kappenberger L. /Pacing for obstructive hypertrophic cardiomyopathy // Brit. Heart J. - 1995. - 73, 2. - 107.
10. Sadoul N., Simon J.P., de Chillou C., Bruntz J.F., Isaaz K., Beurrier D., Reeb T., Dodinot B., Aliot E. /Interets de la stimulation cardiaque permanente dans les myocardiopathies hypertrophiques et obstructives rebelles au traitement medical// Archiv. Malad. Coeur Vaiss. - 1994. - 87, 10. - 1315-1323.
11. Futterman L.G., Lemberg L. / New indications for dual chamber pacing: hyper-trophic and dilated cardiomyopathy // Amer. J. Critical Care.- 1995.-4, 1.- 82-87.
12. Spirito P., McKenna W.J., Schultheiss H.P. / DDD pacing in obstructive hyper-trophic cardiomyopathy // Circulation.- 1995.-92, 6. - 1670-1673.
13. Slade A.K., Sadoul N., Shapiro L., Chojnowska L., Simon J.P., Saumarez R.C., Dodinot B., Camm A.J., McKenna W.J., Aliot E. / DDD pacing in hypertrophic cardiomyopathy: a multicentre clinical experience // Heart.- 1996.- 75,1.- 44-9.
14. McDonald K.M., Maurer B. /Permanent pacing as treatment for hypertrophic cardiomyopathy // Amer. J. Ñardiol. - 1991. - 68, 1. - 108 -110.
15. Jeanrenaud X., Goy J.J., Kappenberger L. /Effects of dual-chamber pacing in hypertrophic obstructive cardiomyopathy // Lancet. - 1992. - 339, 8805. - 1318-1323.
16. Jeanrenaud X., Vogt P., Goy J.J., Kappenberger L. /Interet de la stimulation cardiaque physiologique dans le traitement de la cardiomyopathie hypertrophique obstructive (CMO) // Schweiz.Med. Wochensch. // J. Suis. Med. - 1992. - 122, 16. - 593-596.
17. Sadoul N., Simon J.P., de Chillou C., Beurrier D., Dodinot B., Aliot E. / Usefulness of temporary dual chamber pacing to determine indication for pacemaker implantation in patients with drug-resistant obstructive hypertrophic cardiomyopathy //PACE. - 1993. - 16, 5. Pt.2. - 1120.
18. Sadoul N., Simon J.P., de Chillou C., Isaaz K., Bruntz J.F., Beurrier D., Dodinot B., Aliot E. /Long-term dual chamber pacing improves hemodynamic function in patients with obstructive hypertrophic cardiomyopathy // PACE. - 1993. - 16, 5. Pt.2. - 1120.
19. Hochleiter M., Horthagl H., Gschnitzer F. /Effects of dual-chamber pacing in hyperthrophic cardiomyopathy without obstruction // Lancet.- 1992. - 340, 8815. - 369 -370.
20. Seidelin P.H., Jones G.A., Boon N.A. /Effects of dual-chamber pacing in hypertrophic

cardiomyopathy without obstruction // Lancet. - 1992. - 17, 3. - 634-642.

21. Cannon R.O. 3d., Tripodi D., Dilsizian V., Panza J.A., Fananapazir L. /Results of permanent dual-chamber pacing in symptomatic nonobstructive hypertrophic cardiomyopathy // Amer.J. Cardiol. - 1994. - 73, 8. - 571-576.

22. Jeanrenaud X., Kappenberger L. / The optimal patient for pacemaker-treatment of hypertrophic obstructive cardiomyopathy // PACE. - 1993. - 16, 5. Pt.2. - 1120.

23. Chang A.C., McAreavey D., Tripodi D., Fananapazir L. /Radiofrequency catheter atrioventricular node ablation in patients with permanent cardiac pacing systems // Pacing Clin. Electrophysiol. - 1994. - 17, 1. - 65-69.

24. Fananapazir L., Dilsizian V., Bonow R.O. / Dual chamber pacing relieves angina and improves myocardial perfusion abnormalities in patients with obstructive hypertrophic cardiomyopathy // Circulation. - 1992. - vol.86. - Suppl.I. - 273.

25. Tascon J.C., Albarran A., Andreu J., Alonso M. /El tratamiento quirurgico pre-coz de la miocardiopatia hipertrofica obstructiva sintomatica. Argumentos en contra//Rev.Esp.Cardiol. - 1995. - 48, 4. - 229-234.

26. Kappenberger L., Jeanrenaud X. / Area shrinking during pacing for hypertro-phic obstructive cardiomyopathy // PACE . - 1993. - 16, 5. Pt.2. - 1121.

27. Kappenberger L., Jeanrenaud X., Aebischer N. / Le stimulateur cardiaque pour le traitement de la cardiomyopathie hypertrophique obstructive, un concept qui avance // Schweiz. Med. Wochenschr. -1995 - 125, 41.- 1950-1955.

28. Daubert J.C., Kappenberger L. /Pacing in cardiomyopathies. - Nice, 1994.- 8 p.

29. Gras D., de Place C., Le Breton H., Leclercq C., Paillard F., Mabo P., Daubert C. /L'importance du synchronisme auriculo-ventriculaire dans la cardiomyopathie hypertrophique obstructive traitee par stimulation cardiaque // Arch. Malad. Coeur Vais. - 1995.- 88, 2.- 215-23.

30. Merce J., Galve E., Cucurull E., Garcia del Castillo H., Moya A., Bosch R., Soler J. /Tratamiento de la miocardiopatia hipertrofica obstructiva mediante marcapasos bicameral. Empleo del isoproterenol para determinar el intervalo AV optimo // Rev. Esp. Cardiol. - 1994. - 47, 8. - 562-564.

31. Betocchi S., Losi M.A., Piscione F., Boccalatte M., Pace L., Golino P., Perrone-Filardi P., Briguori C., Franculli F., Pappone C., Salvatore M., Chiariello M./ Title Effects of dual-chamber pacing in hypertrophic cardiomyopathy on left ventricular outflow tract obstruction and on diastolic function// Amer. J. Cardiol. - 1996.- 77, 7.- 498-50.

32. Delahaye J.P., Azzano O. /Myocardiopathie hypertrophique obstructive: traite-ment actuel, indications et resultats // Presse Medicale. - 1994. - 23, 20. - 925-927.

33. Guize L., Iliou M.C., Lavergne T., Le Heuzey J.Y. /Le traitement de la cardiomyopathie obstructive par la stimulation ventriculaire apicale permanente // Annales de Cardiologie et d`Angeiologie. - 1995. - 44, 1. - 37-40.

34. Reneman R.S., Prinzen F.W., Cheriex E.C., Arts T., Delhaas T. /Asymetrical changes in left ventricular distolic wall thickness induced by chronic asynchronous electrical activation // FASEB J. - 1993. - vol.7,A. - A752.

35. McAreavey D., Fananapazir L. /Altered cardiac hemodynamic and electrical state in normal sinus rhythm after chronic dual-chamber pacing for relief of left ventricular outflow obstruction in hypertrophic cardiomyopathy // Amer.J. Cardiol. - 1992. - 70, 6. - 651-656.

36. Fananapazir L., Cannon R.O.3d., Tripodi D., Panza J.A./ Impact of dual-chamber permanent pacing in patients with obstructive hypertrophic cardiomyopathy with symptoms refractory to verapamil and beta-adrenergic blocker therapy// Circulation. - 1992. - 85, 6. - 2149-2161.

37. Fananapazir L., Cannon R.O.3d., Tripodi D. / Ability of dual chamber pacing to relieve syncope and presyncope associated with left ventricular outflow tract obstruction in patients with hypertrophic cardiomyopathy // J. Amer. Coll. Cardiol. - 1992. - 19, A. - 224A.

38. Fananapazir L., Chang A.C., Epstein S.E., McAreavey D. /Prognostic determinants in hypertrophic cardiomyopathy. Prospective evaluation of a therapeutic strategy based on clinical, Holter, hemodynamic, and electrophysiological findings // Circulation. - 1992. - 86, 3. - 730-740.

39. Matsumoto K., Saitou J., Mukousaka K., Asano Y., Yamamato T., Uchida M., Suga C., Tamura T., Dohi Y. /Influences of pacing site changes on the hemodynamic improvement by DDD pacing in HOCM // PACE. - 1993. - 16, 7. Pt.II. - 1598.