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CLINICAL RESEARCH

Very late effects of dual chamber pacing therapy for obstructive hypertrophic cardiomyopathy

Effets à très long terme du traitement électrique dans la cardiomyopathie hypertrophique obstructive

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KEYWORDS
Hypertrophic obstructive cardiomyopathy;
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Dual chamber pacing;
Heart failure

Summary
Background. — The very long-term effects of dual chamber pacing as a primary treatment for hypertrophic obstructive cardiomyopathy (HOCM) are poorly known and controversial.
Aims. — To examine the intermediate- and long-term clinical and haemodynamic effects of permanent dual chamber pacing in patients presenting with HOCM.
Methods. — Between 1991 and 2007, 51 patients (mean age 59 ± 14 years) presenting with HOCM and New York Heart Association (NYHA) functional class ≥ II despite optimal medical therapy underwent implantation of DDD pacemakers with or without a defibrillator and were followed for 11.5 years (range 0.4—21.8 years).
Results. — During follow-up, no patient underwent myectomy or septal alcohol ablation. NYHA functional class and other disease manifestations decreased significantly over 1—2 years of follow-up and remained stable thereafter. The left intraventricular (LV) gradient decreased by a mean of 78% over 1—2 years, reaching 89% at end of follow-up, along with disappearance of systolic anterior motion of the mitral valve. Mean LV ejection fraction decreased from a mean of 64 ± 8% before pacing to 56 ± 9% at end of follow-up ($P = 0.05$), while LV end-diastolic diameter did not change significantly. The 5- and 10-year actuarial survival rates were 90% and 65%, respectively. Among 22 deaths, 10 were due to cardiovascular and 12 to non-cardiovascular causes; two patients underwent cardiac transplantation after 8 and 13 years of DDD pacing, respectively.

Abbreviations: AV, atrioventricular; HOCM, hypertrophic obstructive cardiomyopathy; ICD, implantable cardioverter defibrillator; LV, left ventricular; LVOT, left ventricular outflow tract; NYHA, New York Heart Association; RV, right ventricular.

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Conclusions. — In this sample of patients with HOCM, DDD pacing alleviated symptoms and improved haemodynamic function over the very long term. The merits of this treatment should be revisited in a controlled trial.

MOTS CLÉS
Cardiomyopathie hypertrophique obstructive ;
Stimulation cardiaque double-chambre ;
Traitement électrique ;
Insuffisance cardiaque

Résumé
Contexte. — L'efficacité de la stimulation cardiaque double-chambre comme traitement primaire de la cardiomyopathie hypertrophique obstructive (CMHO) reste controversée. Les effets à très long terme ne sont pas connus.
Objectifs. — Décrire les effets cliniques et hémodynamiques à moyen et à long terme observés après traitement électrique.
Méthodes. — Cinquante-quatre patients (59 ± 14 ans) ayant une CMHO et demeurant symptomatiques (dyspnée NYHA > 2) sous traitement médical optimisé, ont bénéficié de l'implantation d'un stimulateur double-chambre DDD avec ou sans fonction de défibrillation entre 1991 et 2007. Le suivi moyen est de 11,5 ans (extrêmes : 0,4—21,8).
Résultats. — Aucun patient n'a eu de myectomie ou d'ablation septale secondaire. Le stade NYHA diminue au cours du suivi (93 % en stade 1—2 en fin de suivi vs 43 % avant l'implantation, $p < 0{,}0001$). Angor et lipothymies/syncopes diminuent significativement. Le gradient intraventriculaire gauche initialement de 79 ± 36 mmHg diminue à 20 ± 24 à trois mois, 11 ± 15 entre un et deux ans et 8 ± 21 en fin de suivi ($p < 0{,}0001$). Le SAM présent initialement chez 52 patients n'est retrouvé que sept fois après implantation ($p < 0{,}0001$). La fraction d'éjection tend à diminuer en fin de suivi (56 ± 9 % vs 64 ± 8 % ; $p < 0{,}05$) alors que le diamètre télédiastolique VG reste sable. Le taux de survie actuariel est de 90 % à cinq ans et de 65 % à dix ans. Parmi les 22 décès, dix sont de cause cardiovasculaire et 12 de cause non cardiovasculaire.
Conclusions. — Le traitement par stimulation DDD semble être bénéfique à très long terme sur les symptômes et les paramètres hémodynamiques. Il altère peu ou pas la fonction systolique VG. Ces résultats incitent à réévaluer cette modalité de traitement dans de nouveaux essais contrôlés.

Background

Right ventricular (RV) apical pacing with preservation of atrioventricular (AV) synchrony lowers the left intraventricular gradient and increases cardiac output in patients with obstructive hypertrophic cardiomyopathy (HOCM) [1,2]. A delay in septal contraction and long-term ventricular remodelling have been suggested as putative mechanisms [3]. The implantation of a DDD pacemaker has therefore been proposed in selected patients with HOCM who remain symptomatic despite optimal medical management [1,3,4]. In contrast with other non-pharmacologic treatments of obstruction, i.e. surgical or alcohol septal reduction, DDD pacing has been evaluated in several small short randomized studies, which showed no significant short-term clinical benefit compared with a placebo effect [5—8]. While its long-term effect is poorly known, a few observational studies have suggested a sustained benefit after 4—5 years of pacing [9,10]. This study was performed to evaluate the clinical and haemodynamic effects of this treatment over the very long term in patients whose symptoms were insufficiently alleviated by medical management alone.

Methods

Inclusion criteria

We included in this study all patients who, between June 1991 and January 2007, underwent implantation of permanent DDD pacemakers, with or without an implantable cardioverter defibrillator (ICD), for the treatment of HOCM that remained symptomatic despite optimal medical management. During the study period, short AV delay DDD pacing was the preferred option for treating obstruction at our institution; eight other patients had surgical myectomy and five had transcatheter septal ablation as the primary approach. Inclusions were stopped from 2007 to have a minimum follow-up time of 5 years. The diagnosis of HOCM was based on the World Health Organization criteria, i.e. diastolic interventricular septal thickness ≥ 15 mm (≥ 13 mm in familial HOCM) measured by transthoracic echocardiography. Intra left ventricular (LV) dynamic obstruction was defined as ≥ 30 mmHg resting or provoked peak subaortic gradient. All patients were in New York Heart Association (NYHA) functional class ≥ II and had undergone unsuccessful treatment attempts with one or more pharmaceutical known to be effective in the treatment of HOCM, including beta-adrenergic blockers, verapamil/diltiazem or disopyramide, or were intolerant of these medications. Patients with NYHA functional class II had to report at least one other symptom, syncope/presyncope or chest pain to be included. No patient had a primary indication for permanent cardiac pacing [11].

Pacemaker implantation

All patients underwent implantation of a DDD pacemaker, with or without ICD [12], and with the ventricular lead implanted at the very apex of the right ventricle. Before

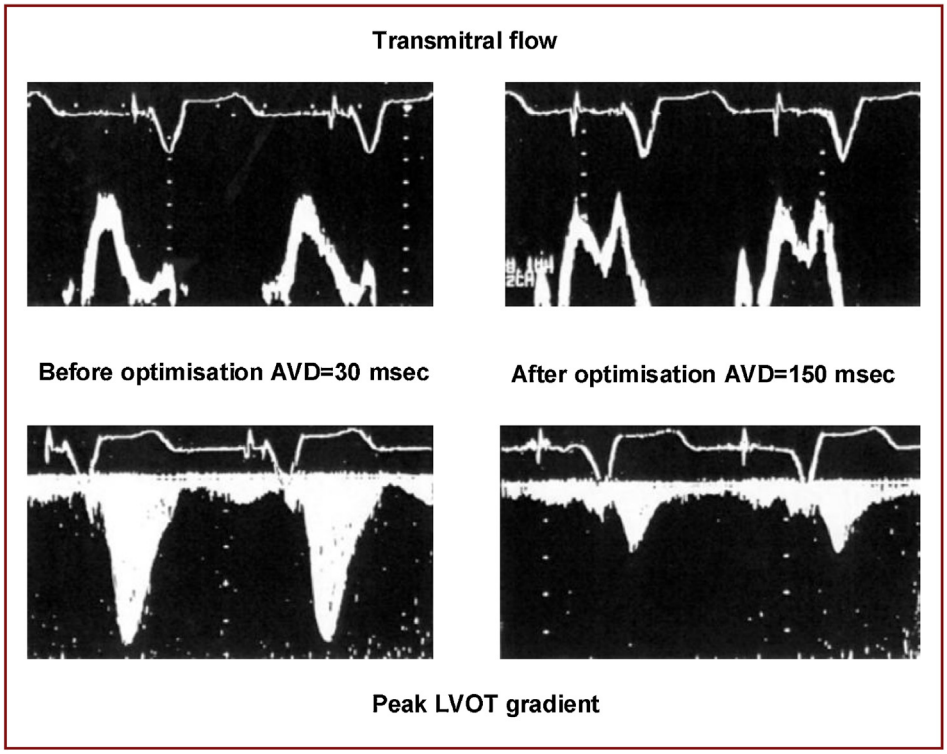

Figure 1. Optimization of left heart atrioventricular (AV) synchrony by AV node radiofrequency modification. Left panel: initial programming. Due to short intrinsic PR interval (70 ms), the AV delay (AVD) had to be programmed at a very short value (30 ms) to achieve complete ventricular capture from the right ventricular (RV) apex. Transmitral flow shows short left ventricular (LV) filling time with no evidence of left atrial contribution. LV outflow tract (LVOT) obstruction is still present with a peak gradient of 70 mmHg. Right panel: after RF modification of the AV node, the intrinsic PR interval is lengthened to 240 ms. Full ventricular capture is preserved while programming the AVD at 150 ms. LVOT obstruction is abolished while left heart AV synchrony is improved as indicated by the presence of ample and well-synchronized A wave on the transmitral flow.

hospital discharge, the AV delay was systematically programmed at an 'optimal' value, i.e. the longest interval associated with complete ventricular capture, at rest and during exercise. Radiofrequency modification of the AV junction was performed in patients whose short spontaneous PR interval precluded the complete capture of the ventricles (Fig. 1) or in patients with histories of poorly tolerated recurrent atrial fibrillation refractory to antiarrhythmic drug therapy. In patients whose P wave duration was $\geq$ 120 ms, a third lead was placed in the coronary sinus and connected to a biatrial DDD pacemaker to resynchronize the atria [13]. Pharmacological treatment was continued in all patients.

Patient follow-up

After device implantation, follow-up data were collected at 3 months, between 1 and 2 years, in the year preceding the patient's death or in 2011 in all survivors. The sources of information included pacemaker implantation records and the cardiologists' and primary physicians' progress notes. In patients whose medical information was missing, vital status was ascertained by consulting the public records. At each visit at the implanting centre, the patient's functional status was estimated, based on NYHA classification and other reported symptoms, ongoing treatment and possible interim adverse events were recorded and the patients underwent a physical examination, a 12-lead electrocardiogram recording with interrogation and verification of the pacing system's proper function and transthoracic echocardiography with the AV interval programmed to obtain the smallest left intraventricular gradient.

Statistical analyses

Continuous variables are expressed as means $\pm$ standard deviations and categorical variables as counts and percentages. Continuous variables were compared using repeated measures analysis of variance and categorical variables were compared using McNemar's Chi-square test. Survival analyses were performed using the Kaplan-Meier method and compared using the log-rank test. A P value < 0.05 was considered significant.

Results

Patient population

This retrospective observational study included 51 DDD pacemaker recipients who were followed at Rennes University Medical Centre. The main baseline characteristics of the sample are shown in Table 1. Before undergoing device implantation, 41% of patients had a history of syncope or presyncope, more than 20% complained of angina pectoris and more than 60% were in NYHA functional class > II. All but one patient, who tolerated neither drug regimen, were treated with drugs recommended for the treatment of

Table 1 Baseline characteristics of the 51 recipients of DDD pacemakers or cardioverter defibrillators.

Characteristic	
Men	24 (47)
Age (years)	59 ± 14 (24–83)
NYHA functional class	
II	20 (39)
III	28 (54)
IV	3 (6)
Syncope or presyncope	21 (41)
Angina pectoris	10 (21)
History of myectomy	1 (2)
Echocardiographic measurements	
Left ventricular ejection fraction (%)	63.5 ± 7.5 (44–81)
Diastolic interventricular septal thickness (mm)	18 ± 4 (13–26)
Peak left ventricular outflow tract gradient at rest (mmHg)	79 ± 36 (0–155)
Mitral systolic anterior motion	49 (96)
Mitral regurgitation grade	
0	2 (4)
1	21 (41)
2	23 (45)
3	5 (10)
Drug therapy	
None	1 (2)
Beta-adrenergic blocker	36 (71)
Calcium antagonist	14 (27)
Amiodarone	9 (18)
Disopyramide	1 (2)
Type of device implanted	
Dual chamber pacemaker	47 (92)
Dual chamber implantable cardioverter defibrillator	4 (8)

Values are mean ± standard deviation (range) or number (%). NYHA: New York Heart Association.

symptomatic HOCM. Beta-blockers were prescribed to two-thirds of patients, alone or in combination with amiodarone ($n = 7$), a calcium channel blocker (verapamil; $n = 3$) or disopyramide ($n = 1$). Verapamil alone was prescribed to 20% of patients. A single patient had undergone myectomy 12 years before pacemaker implantation.

The maximum diastolic interventricular septal thickness ranged between 13 and 26 mm. Systolic anterior motion of the mitral valve was present in 49/51 patients. In five patients without severe LV outflow tract (LVOT) obstruction under basal conditions, the administration of nitroglycerine increased the LVOT gradient from a mean of 22 ± 9 mmHg to 65 ± 23 mmHg. While nearly all patients presented with some degree of mitral insufficiency, it was > 2 in only five patients.

Procedural data

Dual chamber ICDs were implanted in four patients for secondary prevention indications. Interruption or modulation of the AV junction was performed before hospital discharge in four patients, to optimize AV synchrony for very short PR intervals during sinus rhythm ($n = 2$) and for recurrent atrial fibrillation with a rapid ventricular rate ($n = 2$). Biatrial DDD pacemakers were implanted to resynchronize the atria in 21 patients (41%). In all cases, biatrial pacing was activated at the time of implantation.

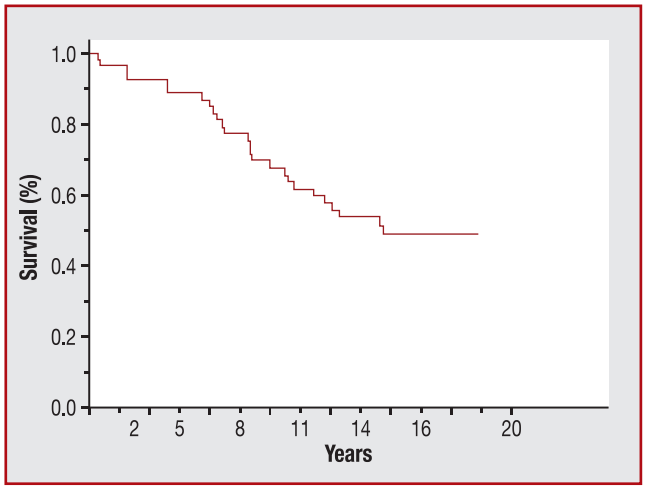

Figure 2. Actuarial survival curve.

Clinical outcomes

Over a median of 11.5 years (range 0.4–21.8 years), 22 patients died and two patients underwent cardiac transplantation after 8 and 13 years of DDD pacing, respectively (Fig. 2). Among 10 patients who died of cardiovascular causes, four died suddenly, none had an ICD implanted, three died of end-stage heart failure, two died of stroke and one died in the wake of implantation of a ventricular assist device as a bridge to transplantation, after 5 years of pacing. The 12 remaining patients died of non-cardiovascular causes, 8 years on average after the implantation of the DDD pacing system. No patient underwent a supplemental procedure during follow-up, such as surgical myectomy or alcohol septal ablation with a view to alleviate residual LVOT obstruction. The actuarial survival of the sample is shown in Fig. 2.

At last follow-up, three (7%), 24 (57%) and 15 (36%) patients were in NYHA functional classes III, II and I, respectively, compared with 27 (53%), 21 (41%) and zero patients, respectively, before the onset of DDD pacing (Fig. 3). An increase in functional capacity was observed at the first follow-up, 3 months after the index implantation procedure. During follow-up, a single patient complained of recurrent syncope and presyncope compared with 21 before the onset of DDD pacing, and two patients complained of chest pain compared with 10 patients before pacing ($P < 0.0001$). Table 2 shows the changes in NYHA functional class and major disease manifestations from before implantation of the pacing system to last follow-up.

Table 2 Changes in New York Heart Association functional class and disease manifestations from before pacing system implantation to last follow-up.

	Follow-ups				P^a
	Preimplant	3 months	1–2 years	Last	
	($n=51$)	($n=48$)	($n=45$)	($n=42$)	
NYHA functional class					
I	0	15 (36)	16 (36)	15 (36)	
II	21 (41)	26 (54)	26 (58)	24 (57)	
III	27 (53)	7 (15)	3 (7)	3 (7)	< 0.0001
IV	3 (6)	0	0	0	
Syncope/dizziness	21 (41)	2 (4)	2 (4)	1 (92)	< 0.001
Chest pain	10 (21)	2 (4)	2 (4)	2 (4)	< 0.001

Values are numbers (%). NYHA: New York Heart Association.
[a] Preimplant follow-up versus last follow-up.

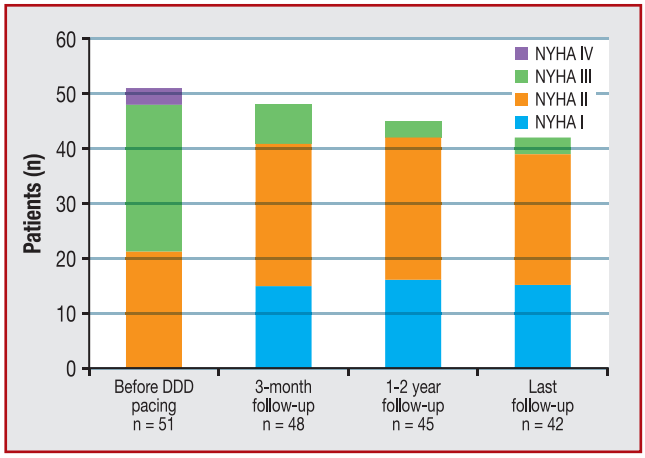

Figure 3. Distribution of New York Heart Association (NYHA) functional classes before DDD pacing and at each follow-up.

Echocardiographic observations

The echocardiographic measurements made at baseline and throughout follow-up are shown in Table 3. Following implantation of the pacing system, the peak LVOT gradient at rest decreased from a mean of 79 ± 36 mmHg before implantation to 20 ± 24 mmHg at 3 months, 11 ± 15 mmHg at 1–2 years and 8 ± 21 mmHg at the final follow-up after DDD system implantation ($P < 0.0001$; Fig. 4A) in patients with permanent obstruction at baseline. Systolic anterior motion of the mitral valve was present in 6/41 patients (15%) at last follow-up, compared with 49/51 patients (96%) before DDD pacing ($P < 0.0001$). When comparing paired individual measurements, mean LVEF decreased gradually from $64 \pm 8\%$ before implantation to $61 \pm 7\%$ at 3 months, $59 \pm 7\%$ at 1–2 years and $56 \pm 9\%$ at the last echocardiographic examination ($P = 0.05$; Fig. 4B). An LVEF less than 45% developed in four patients between 2 years and the end of follow-up, two of whom underwent cardiac transplantation. Mean interventricular septal thickness decreased up to the 1–2-year follow-up but this could not be confirmed at late follow-up (Fig. 4C). Paired measurements of LV end-diastolic diameters, available in 21 patients, revealed no significant change before and after long-term DDD pacing; furthermore, the mitral regurgitation grade tended to decrease during follow-up.

Drug therapy

At the end of follow-up, 27 patients (64%) were being treated with a beta-adrenergic blocker, either alone ($n = 17$; 63%) or combined with verapamil ($n = 7$; 26%) or amiodarone ($n = 5$; 19%), while two patients received the three classes of drugs. Calcium channel blockers were prescribed to 15 patients (36%), either alone ($n = 3$; 20%) or combined with a beta-adrenergic blocker ($n = 5$; 33%) or amiodarone ($n = 4$; 27%). Amiodarone alone was prescribed to three patients.

Therapeutic procedures

During follow-up, 19 patients underwent radiofrequency ablation of AV conduction, to optimize AV synchrony ($n = 12$) and for the management of poorly tolerated and recurrent episodes of atrial fibrillation ($n = 7$). DDD pacemakers were replaced by a dual chamber ICD in six patients, for primary prevention indications ($n = 4$) and for the management of sustained ventricular tachycardia ($n = 2$).

Major treatment-related adverse events

During the study period, procedure- or device-related complications occurred in 11/21 recipients of triple-lead systems versus 7/30 recipients of dual-lead systems ($P < 0.05$). In 11 patients, complications developed before hospital discharge, including four dislodgements of leads that had been placed in the coronary sinus, two dislodgements of other leads, two pericardial effusions, one pneumothorax and one pulse generator pocket infection. Complications that developed ≥ 30 days after the index implant procedure included: loss of capture at three coronary sinus, two RV and one right atrial leads; connector dysfunctions of three triple-lead systems; and two cases of lead endocarditis. In total, three infections were observed during this more than 10-year study period: one early pocket

Table 3 Echocardiographic measurements before and during DDD pacing, up to the last examination.

	Echocardiographic examinations				*P*
	Preimplant	3 months	1–2 years	Last	
	(*n* = 51)	(*n* = 48)	(*n* = 45)	(*n* = 42)	
Left ventricular ejection fraction (%)	64 ± 8	61 ± 7	59 ± 7	56 ± 9	0.05
Peak left intraventricular gradient (mmHg)	79 ± 36	20 ± 24	11 ± 15	8 ± 21	< 0.0001
Interventricular septal thickness (mm)	18 ± 4	18 ± 4	15 ± 6	17 ± 4	0.32
Left ventricular end-diastolic diameter (mm)	47 ± 5	NA	NA	43 ± 12[a]	0.34
Mitral valve systolic anterior motion	49 (96)	13/34 (38)	10/34 (29)	6/41 (15)	< 0.0001
Missing data	0	14/48	11/45	1/42	
Mitral insufficiency grade					
0	2 (4)	6/30 (20)	5/32 (16)	11/40 (28)	
I	20 (39)	24/30 (80)	19/32 (59)	13/40 (32)	
II	24 (47)	0	8/32 (25)	15/40 (38)	0.07
III	5 (10)	0	0	1/40 (2)	
IV	0	0	0	0	
Missing data	0	18/48	13/45	2/42	

Values are mean ± standard deviation or number (%).
[a] Paired measurements available in 21 patients.

infection and two late lead infections, all requiring device explantation. Amiodarone-induced thyroid dysfunction and amiodarone-induced lung disease were observed in 12 and two patients, respectively. Among the ICD recipients, three received inappropriate shocks due to lead fractures and two received appropriate shocks for sustained ventricular tachycardia.

Discussion

The very late effects of dual chamber pacing for drug-refractory HOCM have not been described. Our study revealed prominent improvements in haemodynamic and clinical status conferred by DDD pacing without evidence of significant LV remodelling. However, the recent practice guidelines issued by the North American professional societies regarding the management of HOCM have assigned DDD pacing a IIb recommendation, level of evidence B, for patients who remain symptomatic despite optimal medical therapy [12]. In contrast, myectomy and transcatheter alcohol septal ablation were assigned a class IIa recommendation, despite having never been scrutinized in controlled studies. This recommendation is based on the experience of several medical institutions that found both therapies highly effective in alleviating symptoms and LVOT obstruction [14–17]. The superiority of surgical myectomy compared with catheter ablation remains unproven. Several meta-analyses failed to show significant differences between these two therapies in all-cause mortality or risk of sustained ventricular tachyarrhythmias [18,19]. The only significant difference pertains to the risk of AV block and need for pacemaker implantation, which is prominently higher after catheter ablation (10–20%) than after myectomy (2%). It is recommended that either procedure be performed in experienced medical centres to limit the risk of major complications and to obtain optimal and reproducible results.

In contrast, the implantation of a DDD pacemaker remains simple, widely available and associated with a relatively low rate of major short- and long-term complications. As opposed to the other treatments, DDD pacing has been evaluated in three controlled studies, which used functional endpoints and yielded conflicting results. In a small pilot study from the Mayo Clinic, DDD pacing was associated with a significantly smaller LVOT gradient than control (AAI pacing), although it conferred no significant clinical benefit [6]. A similar multicentre study comparing DDD with AAI pacing in 83 patients observed a significantly greater decrease in LVOT gradient as well as in NYHA functional class and quality of life score conferred by DDD pacing, although it had no significant effect on exercise capacity, which was the primary study endpoint [7]. Finally, in another similarly designed study, no significant difference was observed between DDD and AAI pacing in NYHA functional class, peak exercise O_2 consumption and quality of life [8].

These studies suffered from several limitations, including: small sample sizes; a high proportion of minimally symptomatic patients, which limited the ability to measure an increase in functional capacity; suboptimal primary endpoints, such as duration of exercise or peak exercise O_2 consumption; insufficient study duration to reliably evaluate the development of possible ventricular remodelling by pacing; and the suboptimal use of the implanted devices and their programmable features.

Furthermore, the importance of individually optimizing AV synchrony in the left heart was not understood. In practice, the benefit conferred by DDD pacing depends on two main conditions: complete ventricular capture from the RV apex, which allows the complete reversal of the LV activation sequence and alleviation of the dynamic obstacle to systolic ejection by delaying septal contraction; and the preservation of optimal LV filling by left atrial contraction, a critical event in cardiac disorders characterized by diastolic dysfunction. Optimal AV synchrony is, therefore, critical and

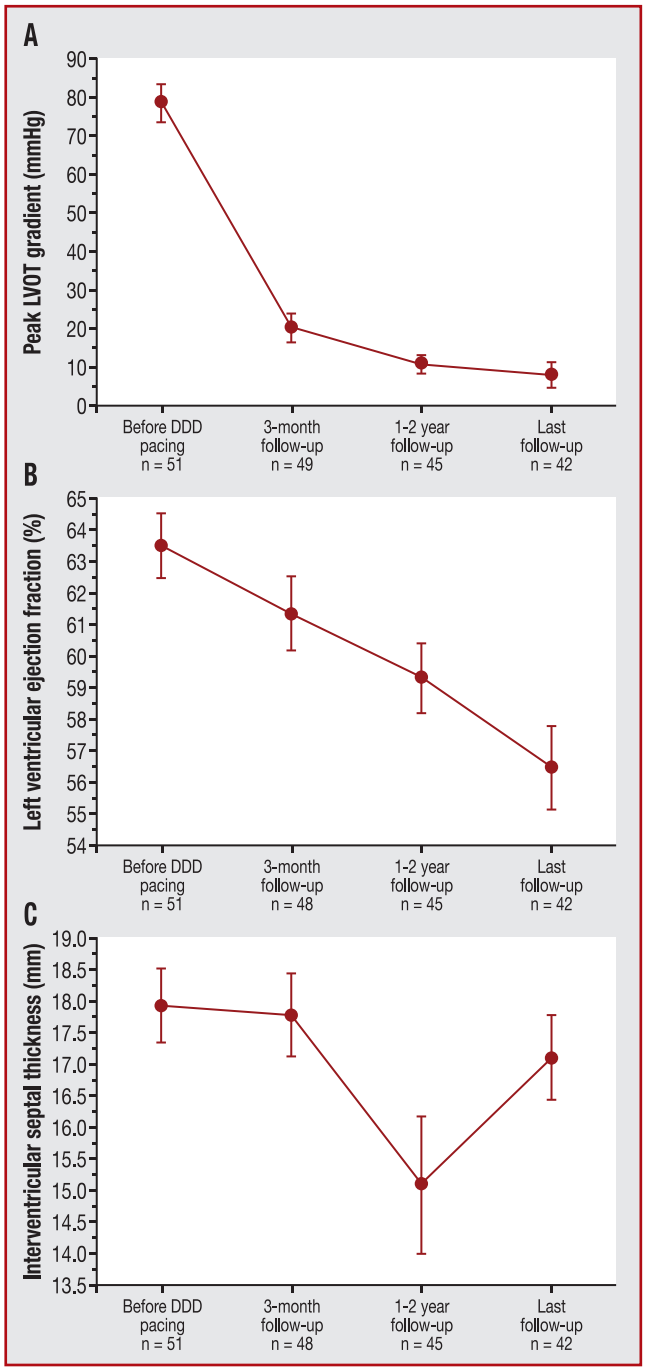

Figure 4. A. Peak left ventricular outflow tract (LVOT) gradient. B. Left ventricular ejection fraction. C. Interventricular septal thickness.

mandates the programming of the longest AV delay associated with complete ventricular capture.

In the present study, we sought to reach optimal AV synchrony in all patients. When baseline programming did not allow the achievement of the two conditions mentioned earlier, we intensified the drug treatment in order to lengthen the intrinsic PR interval and optimize LV filling. At the end of follow-up, 83% of patients were treated with AV node conduction-slowing drugs, such as a beta-adrenergic blocker, verapamil or both, and seven patients underwent ablation of the AV junction after unsuccessful intensification of medical therapy. Finally, 21 patients who presented with prominent intra-atrial conduction disturbances and delayed left atrial contraction received a biatrial DDD pacemaker to resynchronize the atria [13,20]. Individual optimization of left AV synchrony possibly explains the greater decline in LVOT gradient observed in this study compared with others.

In this study, pacing effectively alleviated symptoms, as NYHA functional class, angina pectoris, syncope and presyncope all regressed significantly during follow-up and remained stable over time in the majority of patients. Besides the functional improvement, dynamic obstruction was clearly alleviated. It is noteworthy that the improvement in echocardiographic measurements, the decrease in gradient and the suppression of mitral valve systolic anterior motion in particular, occurred progressively throughout the follow-up.

As expected, RV apical pacing depressed LV systolic function, although the effect was modest, as LVEF decreased from $63.5 \pm 7.5\%$ before implantation of the pacemakers to $56 \pm 9\%$ at last follow-up. Among patients whose ventricular size was measured serially, LVEF decreased without concomitant ventricular dilatation. Except for the two patients who developed refractory heart failure and underwent cardiac transplantation after 8 and 12 years of pacing, we observed no evolution toward LV systolic dysfunction caused by permanent pacing.

The results of this study are encouraging. Long-term pacing for HOCM has been the subject of scarce reports. An observational study of 50 patients in NYHA functional classes III and IV, over a shorter follow-up of 5 ± 3 years on average, reported similar clinical results (decrease in NYHA functional class, increase in distance covered during hall walk test and improvement in quality of life) as well as echocardiographic observations (decrease in resting gradient from 86 ± 29 mmHg to 28 ± 24 mmHg at the end of follow-up and decrease in LVEF after pacing without LV dilatation) [9]. Similar results were observed in another study of 18 patients followed for a mean of 4.1 years [10]. The clinical benefits observed in our study were maintained over a period of 11.5 years on average. While the 90% survival at 5 years was close to that observed after myectomy in large clinical registries, it decreased to 65% at 10 years. The mean age of the patients included in our study was 59 years, considerably older than the mean age of 45 years of the patients included in surgical series. Actually, our data can be compared to those of a prospective registry from the Mayo Clinic that included 544 consecutive patients presenting with asymptomatic or minimally symptomatic HOCM with the same mean age (59 ± 16 years) as that of our population [21]. They observed a 10-year survival rate of 69.3%, close to that of the general population in the USA. However, in patients with a high gradient ($V_{max} > 4$ m/s), the survival rate was 53%, consistent with the rate observed in our patient sample. The non-cardiovascular death rate was higher in our study (73% vs 46%), perhaps reflecting more prevalent and more severe co-morbidity. Nearly similar data were reported in another large Canadian registry [22].

In patients with intra-atrial conduction block, we used biatrial synchronous DDD pacing to further optimize AV synchrony in the left heart. However, because of a high rate

of postoperative complications, mainly coronary sinus lead dislodgment, the risk-benefit ratio of this practice is unclear.

Finally, the role of ICD in HOCM remains controversial [12]. In this historical series, few patients received devices with ICD function, including four patients at initial implant for secondary prevention, two patients who underwent device upgrade after experiencing life-threatening ventricular tachyarrhythmias and four patients who had primary prevention indications [12] at the time of device replacement. In the overall population, 4/10 cardiovascular deaths were sudden and occurred in recipients of devices without ICD function. These observations could support wider indications of devices with ICD function in HOCM patients treated by DDD pacing.

Study limitations

This study has the intrinsic limitations of an observational retrospective single-centre study. The more than 20-year follow-up explains missing data with a small proportion of paired data for LV dimensions as well as the loss of patient follow-ups.

In five patients, LV obstruction was not present at rest but was provoked by nitroglycerine, which is no longer recognized as a physiological manoeuvre. No exercise echocardiography was performed in this historical series.

Conclusions

Our study illustrates the beneficial effects of very long-term DDD pacing in patients with symptomatic HOCM refractory to medical therapy. The benefit was both clinical and haemodynamic, with a clear decrease in the LVOT gradient. The effects appeared within a few weeks of pacing and were maintained or even enhanced over more than 20 years of follow-up. The place of this easily accessible and relatively safe treatment should be reconsidered, in particular for patients of advanced age or in patients with indication for an ICD, although its risk-benefit ratio should be first precisely examined in a multicentre study, over a sufficiently long period of observation.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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