VIA MEDICA

ORIGINAL ARTICLE

Cardiology Journal
2021, Vol. 28, No. 3, 423–430
DOI: 10.5603/CJ.a2019.0088

ISSN 1897–5593
eISSN 1898–018X

Predictors of pacing-dependency in patients with cardiovascular implantable electronic devices

Wolfram Grimm[1], Kathrin Grimm[1], Brandon Greene[2], Mariana Parahuleva[1]

[1]Department of Cardiology, University Hospital of Marburg and Gießen, Philipps-University Marburg, Marburg, Germany
[2]Institute for Medical Bioinformatics and Biostatistics, Philipps-University Marburg, Marburg, Germany

Abstract

Background: *Data on the prevalence and predictors for the development of pacing-dependency in patients with cardiovascular implantable electronic devices (CIEDs) are sparse.*

Methods: *Pacing-dependency defined as an absence of intrinsic rhythm of ≥ 30 bpm was determined in 802 consecutive patients with CIEDs who visited the documented pacemaker or implantable cardioverter-defibrillator outpatient clinic for routine follow-up.*

Results: *A total of 131 (16%) patients were found to be pacing-dependent 67 ± 70 months after CIED implant. Multivariate analysis revealed a significant association between pacing-dependency and the following clinical variables: second or third-degree atrioventricular (AV) block at implant (OR = 19.9; 95% CI: 10.9–38.5, p < 0.01), atrial fibrillation at implant (OR = 2.15; 95% CI: 1.16–4.05, p = 0.02), left ventricular ejection fraction (LVEF) ≤ 30% (OR = 2.06; 95% CI: 1.03–4.15, p = 0.04), B-type natriuretic peptide (BNP) > 150 pg/mL (OR = 2.12; 95% CI: 1.16–3.97, p = 0.02), chronic kidney disease (OR = 1.86; 95% CI: 1.08–3.26, p = 0.03), and follow-up duration after implantation > 5 years (OR = 3.29; 95% CI: 1.96–5.64, p < 0.01). None of the remaining clinical variables including age, gender, diabetes mellitus, underlying heart disease, prior cardiac surgery or medication during follow-up including beta-blockers and amiodarone predicted pacing-dependency.*

Conclusions: *Pacing-dependency is associated with second or third-degree AV-block at implant, atrial fibrillation before implant, low LVEF, elevated BNP, chronic kidney disease and follow-up duration after implant.* (Cardiol J 2021; 28, 3: 423–430)

Key words: pacing-dependency, permanent pacemaker, implantable cardioverter-defibrillator

Introduction

Knowledge of pacing-dependency following implantation of cardiovascular implantable electronic devices (CIEDs) is very important in various clinical settings including elective generator change, potential electromagnetic interference and management of suspected lead or generator malfunction [1, 2]. Although several million permanent pacemakers and implantable cardioverter-defibrillators (ICDs) with bradycardia pacing capability have been implanted 60 years after the first pacemaker implantation in 1958, few studies have investigated the prevalence of pacing dependency and clinical predictors for the development of pacing dependency [3–17]. Thus, the aim herein was to determine prevalence and predictors of pacing dependency in a well-defined cohort of 802 patients with pacemakers or ICDs at the documented clinic.

Address for correspondence: Wolfram Grimm, MD, Department of Cardiology, Philipps-University Marburg, Baldingerstraße, 35033 Marburg, Germany, tel: +49-6421-586-9748, fax: +49-6421-586-8954, e-mail: grimmwk.rauschenberg@t-online.de

Received: 1.04.2019 Accepted: 26.08.2019

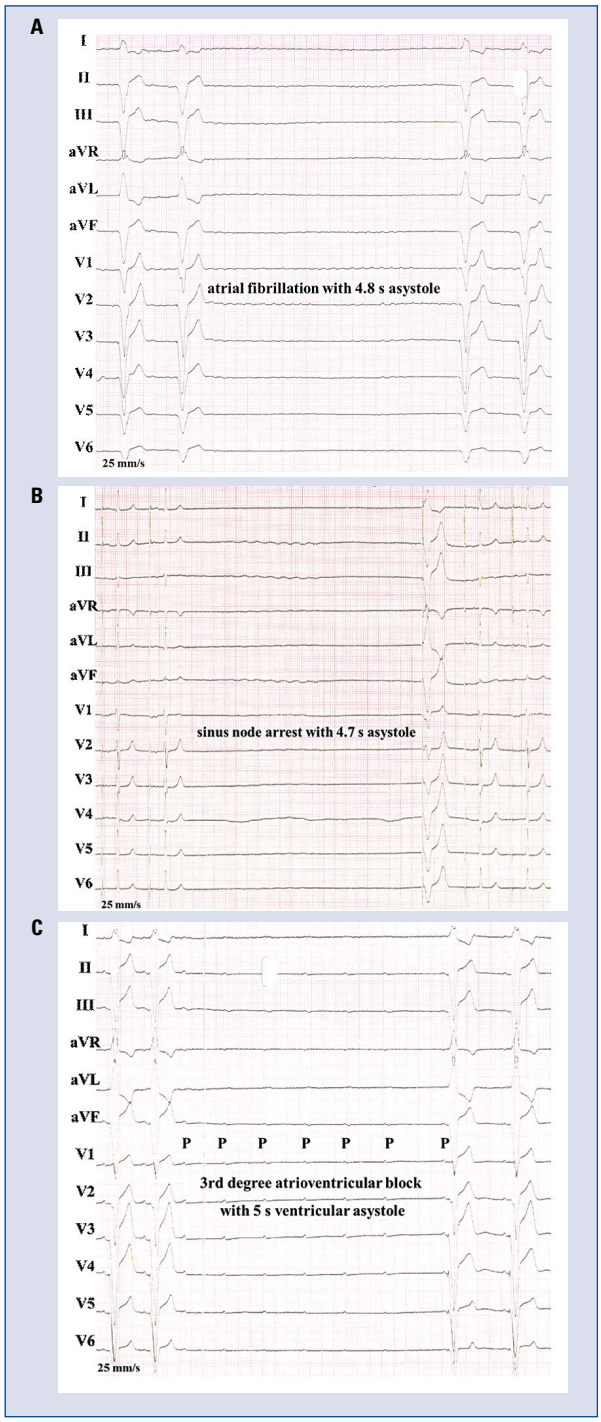

Figure 1. Electrocardiogram recordings with a paper speed of 25 mm/s showing typical examples of ventricular asystole following transient inhibition of pacing; **A.** Ventricular asystole due to third degree atrioventricular block (AVB) without ventricular escape rhythm in a patient with permanent atrial fibrillation; **B.** Ventricular asystole due to sinus arrest without escape rhythm in a patient with sinus node disease; **C.** Ventricular asystole due to third degree AVB without ventricular escape rhythm in a patient with second degree AVB type Mobitz at the time of pacemaker implant.

Methods

Study population

After written informed consent had been obtained, pacing dependency was determined prospectively in 802 consecutive patients who came to the pacemaker and ICD outpatient clinic for routine follow-up between January 2018 and December 2018 and in whom a permanent pacemaker or ICD had been implanted for at least 6 months by this institution. Pacing dependency was defined as an absence of intrinsic rhythm ≥ 30 bpm after lowering the pacing rate to 30 bpm for at least 10 s or after transient inhibition of pacing therapy (Fig. 1). A high-degree atrioventricular (AV) block at implant was defined as second degree AV block type Mobitz or third-degree AV block. Chronic kidney disease (CKD) of at least stage 3 was diagnosed in the presence of at least two estimated glomerular filtration rates (eGFR) using the Modification of Diet in Renal Disease formula below 60 mL/min per 1.73 m^2 with an interval of at least 3 months. The study protocol was reviewed and approved by the ethics committee of the Philipps-University of Marburg.

Statistical analysis

Results are expressed as mean ± standard deviation (SD) for continuous variables with normal distribution and median values with interquartile range (IQR) for continuous variables without normal distribution. Univariate comparisons of clinical characteristics between patients with and without pacing dependency were performed using the Student t-test or the Mann-Whitney U test for continuous variables, categorical values were compared using χ^2 and the Fisher exact tests, where appropriate. Logistic regression analysis was used to generate a multivariate model including all potential predictors of pacing dependency listed in Table 1 in order to investigate which factors showed independent effects on the risk of developing pacemaker dependency after adjustment for confounding by other factors including the presence or absence of ICD therapy as well as cardiac resynchronization therapy (CRT). All probability values reported are two-sided, and a probability value of $p < 0.05$ was considered to indicate statistical significance. R-software version 3.5.0 (www.R-project.org) was used for statistical analyses.

Results

Clinical characteristics

The clinical characteristics of 802 study patients are summarized in Table 1 and included 563

Table 1. Clinical characteristics of 802 patients with and without pacing dependency.

Clinical variable	All patients	Pacing-dependency		P
	N = 802	Yes (n = 131)	No (n = 671)	
Age [years]	74 ± 13	75 ± 12	74 ± 13	0.23
Male gender	521 (65%)	89 (68%)	432 (64%)	0.50
Body mass index [kg/m^2]	28 ± 12	28 ± 5	28 ± 13	0.86
Arterial hypertension	622 (78%)	105 (80%)	517 (77%)	0.27
Diabetes mellitus	143 (18%)	19 (15%)	124 (18%)	0.43
Atrial fibrillation before implant	242 (30%)	38 (29%)	205 (31%)	0.78
Left bundle branch block at implant	141 (18%)	25 (19%)	116 (17%)	0.62
Chronic kidney disease	330 (41%)	70 (53%)	260 (39%)	< 0.01
Heart failure severity				
Left ventricular ejection fraction ≤ 30%	179 (22%)	41 (31%)	138 (21%)	< 0.01
NYHA functional class III or IV	320 (40%)	74 (56%)	246 (37%)	< 0.01
B-type natriuretic peptide >150 pg/mL[a]	408 (57%)	77 (71%)	331 (54%)	< 0.01
Underlying cardiac disease				0.07
Coronary artery disease	313 (39%)	45 (34%)	268 (40%)	
Nonischemic dilated cardiomyopathy	119 (15%)	26 (20%)	93 (14%)	
Hypertensive heart disease	180 (22%)	35 (31%)	145 (22%)	
Valvular heart disease	101 (13%)	17 (15%)	84 (13%)	
Other cardiac diseases[b]	13 (2%)	4 (4%)	9 (1%)	
No structural heart disease	76 (9%)	4 (4%)	72 (11%)	
Previous cardiac surgery				
Aortocoronary bypass grafting	95 (12%)	17 (13%)	78 (12%)	0.77
Surgical aortic valve replacement	29 (4%)	4 (3%)	25 (4%)	0.90
Mitral valve reconstruction or replacement	15 (2%)	1 (1%)	14 (2%)	0.50
Transcatheter aortic valve replacement	43 (5%)	9 (7%)	34 (5%)	0.53
Cardiovascular implantable electronic device				
Antibradycardia pacemaker	563 (70%)	103 (79%)	460 (69%)	0.02
Implantable cardioverter-defibrillator	239 (30%)	28 (21%)	211 (31%)	0.02
Cardiac resynchronization therapy device	93 (12%)	20 (15%)	73 (11%)	0.07
Median amount of ventricular pacing (IQR)	30% (1–99)	100% (99–100)	12% (1–82)	< 0.01
Indication for CIED implantation				< 0.01
Sick sinus syndrome	196 (24%)	12 (9%)	184 (27%)	
Second or third-degree AV block	247 (31%)	95 (73%)	152 (23%)	
Atrial fibrillation with bradycardia	125 (16%)	14(11%)	111 (17%)	
Carotid sinus syndrome	2 (0.2%)	0 (0%)	2 (0.3%)	
Prophylactic[c]	232 (29%)	10 (7%)	222 (33%)	
Implant duration > 5 years	**330 (41%)**	**74 (56%)**	256 (38%)	**< 0.01**
Medication				
Beta-blockers	539 (67%)	85 (65%)	454 (68%)	0.14
Amiodarone	44 (5%)	7 (5%)	37 (6%)	0.94
Digitalis	68 (8%)	9 (7%)	59 (9%)	0.58
ACEI	419 (52%)	77 (59%)	342 (51%)	0.12
Angiotensin receptor blockers	171 (21%)	25 (19%)	146 (22%)	0.57
Diuretics	549 (68%)	100 (76%)	449 (67%)	0.04
Aldosterone antagonists	226 (28%)	28 (21%)	198 (30%)	0.07
Angiotensin-neprilysin inhibitor	25 (3%)	1 (1%)	24 (4%)	0.16

Plus-minus values are given as mean ± standard deviation; ACEI — angiotensin converting enzyme inhibitors; AV — atrioventricular; CIED — cardiovascular implantable electronic device; IQR — interquartile range; NYHA — New York Heart Association
[a]B-type natriuretic peptide was available in only 702 of 802 patients (88%)
[b]Other cardiac diseases include hypertrophic cardiomyopathy, cardiac sarcoidosis, cardiac amyloidosis, and tricuspid valve replacement
[c]Implantable cardioverter-defibrillator without symptomatic bradyarrhythmia at implant

(70%) patients with a permanent pacemaker and 239 (30%) patients with an ICD. Mean duration between device implant and follow-up visit was 67 ± 70 months with a minimum implant duration of 6 months. The majority of patients were male (65%). Mean age at device implant was 74 ± 13 years. Indication for pacemaker implantation was a high-degree AV block in 247 (31%) patients, sick sinus syndrome in 196 (24%) patients, carotid sinus syndrome in 2 (0.2%) patients, and atrial fibrillation with bradycardia in 125 (16%) patients. CRT devices were implanted in 93 of 802 study patients (12%) including CRT pacemakers in 25 of 563 pacemaker patients (4%) and CRT defibrillators in 68 of 239 (28%) patients with an ICD.

Prevalence and predictors of pacing dependency

A total of 131 of 802 study patients (16%) were found to be pacing dependent at follow-up 67 ± 70 months after the device implant. Pacing dependency at follow-up was found significantly more often in patients with New York Heart Association (NYHA) heart failure class 3 or 4, elevated B-type natriuretic peptide (BNP) > 150 pg/mL, decreased left ventricular ejection fraction (LVEF) ≤ 30%, CKD, high degree AV block at implant, left bundle branch block on electrocardiogram at implant, and implant duration > 5 years (Table 1). Multivariate logistic regression analysis revealed a significant association between pacing dependency and the following 6 clinical variables: second or third-degree AV block at implant (odds ratio [OR] = 19.9; 95% confidence interval [CI]: 10.9–38.5, p < 0.01), atrial fibrillation at implant (OR = 2.15; 95% CI: 1.16–4.05, p = 0.02), LVEF ≤ 30% (OR = 2.06; 95% CI: 1.03–4.15, p = 0.04), BNP > 150 pg/mL (OR = 2.12; 95% CI: 1.16–3.97, p = 0.02), CKD (OR = 1.86; 95% CI = 1.08–3.26, p = 0.03), and follow-up duration > 5 years (OR = 3.29; 95% CI: 1.96–5.64, p < 0.01) (Table 2). None of the remaining clinical variables including age, gender, body mass index, arterial hypertension, diabetes mellitus, underlying heart disease, prior cardiac surgery, transcatheter aortic valve replacement or medication during follow-up including beta-blockers and amiodarone predicted pacing dependency.

Subgroup analysis of 563 patients with permanent pacemaker

The results for the subgroup of 563 patients with permanent pacemaker without cardioverter defibrillator back-up are summarized in Table 3. Pacing dependency at follow-up was found significantly more often in patients with NYHA heart failure class 3 or 4, elevated BNP > 150 pg/mL, decreased LVEF ≤ 30%, CKD, second or third-degree AV block at implant, and implant duration > 5 years.

Subgroup analysis of 239 patients with ICD

The results for the subgroup of 239 patients with ICD are summarized in Table 4. Pacing dependency at follow-up was found significantly more often in patients with NYHA heart failure class 3 or 4, elevated BNP > 150 pg/mL, decreased LVEF ≤ 30%, CKD, non-ischemic dilated cardiomyopathy, amiodarone therapy, and implant duration > 5 years. In addition, left bundle branch block at implant, which was treated with a CRT defibrillator in 68 patients with ICD, was also associated with a higher prevalence of pacing dependency at follow-up (Table 4).

Discussion

The main finding of the present study is a 16% prevalence of pacing dependency at 67 months mean follow-up, which was associated with second or third-degree AV-block at implant, atrial fibrillation before implant, low LVEF, elevated BNP, CKD and implant duration. Although it is generally accepted that pacing dependency means absence of a sufficient intrinsic rhythm resulting in bradycardia-related symptoms during inhibition of pacing, the definition of pacing dependency is still controversial [12–14]. Similar to previous studies [5–7, 10], the current study defined pacing dependency as absence of an intrinsic rhythm of at least 30 bpm during pacemaker inhibition or ventricular pacing at a rate of lower than 30 bpm, whereas other investigators used an upper rate cutoff for the intrinsic rhythm of 40 bpm [4, 8, 9, 11] or 50 bpm [3] to define pacing dependency. The observed prevalence of pacing dependency of 16% in the present study is similar to the prevalence of 22% in a relatively large Canadian Trial of Physiologic Pacing (CTOPP), in which a pacemaker dependency test was performed in 2244 patients [4]. Of note, the prevalence of pacing dependency varies in the literature between 2% in the study of Lekalowski et al. [6] and 63% in the study of Merin et al. [8] as summarized in Table 5. The discrepancy between these studies may, in part, be explained by differences in study patients as well as different definitions used for pacing dependency. Whereas the current study enrolled consecutive patients who came for routine device follow-up visits at

Table 2. Results of the multivariate analysis for pacing dependency in 802 study patients.

Clinical variable	OR (95% CI)[a]	P[a]
Left ventricular ejection fraction ≤ 30%	2.06 (1.03–4.15)	0.04
B-type natriuretic peptide > 150 pg/mL	2.12 (1.16–3.97)	0.02
Second- or third-degree AV block at implant	19.9 (10.9– 8.5)	< 0.01
Atrial fibrillation before implant	2.15 (1.16–4.05)	0.02
Chronic kidney disease	1.86 (1.08–3.26)	0.03
Implant duration > 5 years	3.29 (1.96–5.64)	< 0.01

[a]After adjustment for potential confounding clinical variables as summarized in Table 1 including medication, implantable cardioverter defibrillator therapy and cardiac resynchronization therapy; AV — atrioventricular; CI — confidence interval; OR — odds ratio

Table 3. Subgroup analysis of 563 patients with permanent pacemaker.

Clinical variable	All patients	Pacemaker dependency		P
	N = 563	Yes (n = 103)	No (n = 460)	
Age [years]	76 ± 12	77 ± 12	76 ± 12	0.57
Male gender	336 (60%)	68 (66%)	268 (58%)	0.18
Atrial fibrillation before implant	194 (34%)	30 (29%)	164 (36%)	0.25
Left bundle branch block at implant	71 (13%)	11 (11%)	60 (13%)	0.51
Chronic kidney disease	230 (41%)	55 (53%)	175 (38%)	< 0.01
Heart failure severity				
Left ventricular ejection fraction ≤ 30%	60 (11%)	18 (17%)	42 (9%)	0.02
NYHA functional class III or IV	195 (35%)	53 (51%)	142 (31%)	< 0.01
B-type natriuretic peptide > 150 pg/mL[a]	264 (54%)	56 (68%)	208 (51%)	< 0.01
Underlying cardiac disease				0.05
Coronary artery disease	201 (36%)	37 (37%)	164 (36%)	
Nonischemic dilated cardiomyopathy	26 (5%)	8 (8%)	18 (4%)	
Hypertensive heart disease	169 (30%)	35 (34%)	134 (29%)	
Valvular heart disease	88 (16%)	16 (16%)	72 (16%)	
Other cardiac diseases[b]	5 (1%)	3 (3%)	2 (0.4%)	
No structural heart disease	74 (13%)	4 (4%)	70 (15%)	
Previous cardiac surgery				
Aortocoronary bypass grafting	55 (10%)	11 (11%)	44 (10%)	0.87
Surgical aortic valve replacement	20 (4%)	4 (4%)	16 (3%)	0.84
Mitral valve reconstruction or replacement	12 (2%)	1 (1%)	11 (2%)	0.37
Transcatheter aortic valve replacement	41 (7%)	8 (8%)	33 (7%)	0.83
Indication for pacemaker implantation				< 0.01
Sick sinus syndrome	190 (34%)	12 (12%)	178 (39%)	
Second or third-degree AV block	227 (40%)	79 (77%)	148 (32%)	
Atrial fibrillation with bradycardia	119 (21%)	12 (12%)	107 (23%)	
Carotid sinus syndrome	2 (0.4%)	0 (0%)	2 (0.4%)	
Cardiac resynchronisation[b]	25 (4%)	0 (0%)	25 (5%)	
Implant duration > 5 years	**222 (39%)**	**59 (57%)**	**163 (35%)**	**< 0.01**
Medication				
Beta-blockers	331 (59%)	59 (57%)	272 (59%)	0.47
Amiodarone	18 (3%)	0 (0%)	18 (4%)	0.08
Digitalis	46 (8%)	5 (5%)	41 (9%)	0.25
ACEI	278 (43%)	58 (56%)	220 (48%)	0.15
Angiotensin receptor blockers	114 (20%)	18 (17%)	96 (21%)	0.52
Diuretics	362 (64%)	73 (71%)	289 (63%)	0.12
Aldosterone antagonists	89 (16%)	12 (12%)	77 (17%)	0.26
Angiotensin-neprilysin inhibitor	9 (2%)	1 (1%)	8 (2%)	0.89

[a]B-type natriuretic peptide was available only in 467 of 539 patients (66%); [b]Patients with heart failure and left bundle branch block; abbreviations as in Table 1.

Table 4. Subgroup analysis of 239 patients with implantable cardioverter-defibrillator.

Clinical variable	All patients	Pacemaker dependency		P
	N = 239	Yes (n = 28)	No (n = 211)	
Age [years]	68 ± 12	68 ± 12	68 ± 12	0.93
Male gender	185 (77%)	21 (75%)	164 (78%)	0.81
Atrial fibrillation before implant	48 (20%)	8 (29%)	40 (19%)	0.41
Left bundle branch block at implant	70 (29%)	14 (50%)	56 (25%)	0.02
Chronic kidney disease	100 (42%)	15 (54%)	85 (40%)	0.18
Heart failure severity				
Left ventricular ejection fraction ≤ 30%	119 (50%)	23 (82%)	96 (45%)	< 0.01
NYHA functional class III or IV	125 (52%)	21 (75%)	104 (49%)	0.01
B-type natriuretic peptide > 150 pg/mL[a]	144 (61%)	21 (78%)	123 (59%)	< 0.01
Underlying cardiac disease				0.03
Coronary artery disease	112 (47%)	8 (29%)	104 (49%)	
Nonischemic dilated cardiomyopathy	93 (39%)	18 (64%)	75 (36%)	
Hypertensive heart disease	11 (5%)	0 (0%)	11 (5%)	
Valvular heart disease	13 (5%)	1 (4%)	12 (6%)	
Other cardiac diseases[b]	8 (3%)	1 (4%)	7 (3%)	
No structural heart disease	2 (1%)	0 (0%)	2 (1%)	
Previous cardiac surgery				
Aortocoronary bypass grafting	40 (17%)	6 (21%)	34 (16%)	0.66
Surgical aortic valve replacement	9 (4%)	0 (0%)	9 (4%)	0.27
Mitral valve reconstruction or replacement	3 (1%)	0 (0%)	3 (1%)	1.00
Transcatheter aortic-valve replacement	2 (1%)	1 (4%)	1 (0.5%)	0.56
Indication for antibradycardia pacing at ICD implant				< 0.01
Sick sinus syndrome	6 (3%)	0 (0%)	6 (3%)	
Second or third-degree AV block	20 (8%)	16 (57%)	4 (2%)	
Atrial fibrillation with bradycardia	6 (3%)	2 (7%)	4 (2%)	
Cardiac resynchronization therapy[b]	68 (28%)	20 (71%)	48 (23%)	
Implant duration > 5 years	**108 (45%)**	**15 (54%)**	**93 (44%)**	**0.03**
Medication				
Beta-blockers	208 (87%)	26 (93%)	182 (86%)	0.49
Amiodarone	26 (11%)	7 (25%)	19 (9%)	0.03
Digitalis	22 (9%)	4 (14%)	18 (9%)	0.52
ACEI	141 (59%)	19 (68%)	122 (58%)	0.31
Angiotensin receptor blockers	57 (24%)	7 (25%)	50 (24%)	0.88
Diuretics	187 (78%)	27 (96%)	160 (76%)	0.03
Aldosterone antagonists	137 (57%)	16 (57%)	121 (57%)	0.98
Angiotensin-neprilysin inhibitor	16 (7%)	0 (0%)	16 (8%)	0.27

[a]B-type natriuretic peptide was available in 235 of 239 patients (98%); [b]Patients with heart failure and left bundle branch block; abbreviations as in Table 1.

the pacemaker and ICD outpatient department, Nagatamo et al. [5] excluded patients with an intrinsic rate of < 30 bpm at implant which likely contributed to a low prevalence of pacing dependency of 4% in the study by Nagatamo et al. [5]. In contrast to the study by Nagatamo et al. [5] and the present study, Merin et al. [8] found a high prevalence of pacing dependency of 63% during follow-up. This discrepancy is likely to be due to the fact that the majority of patients in the study of Merin et al. [8] received a permanent pacemaker for third degree AV block without

Table 5. Prevalence of pacing-dependency in studies with at least 50 patients.

Author	Year	Patients	ICD	Cardiac surgery	Follow-up [months]	Pacing-dependency	Intrinsic rhythm [bpm][a]
Glikson et al. [3]	1997	86	0%	100%	41 (median)	51 (59%)	< 50
Tang et al. [4]	2001	2244	0%	NA	2 to 8	484 (22%)	< 40
Nagatomo et al. [5]	2004	518	0%	NA	44 ± 32	23 (4%)	< 30
Lelakowski et al. [6]	2007	3638	0%	NA	58 ± 22	76 (2%)	< 30
Onalan et al. [7]	2008	102	0%	100%	48 (mean)	21 (23%)	< 30
Merin et al. [8]	2009	58	0%	100%	72 ± 32	37 (63%)	< 40
Raza et al. [9]	2011	90	0%	100%	67 ± 50	36 (40%)	< 40
Rene et al. [10]	2013	98	0%	100%	43 ± 41	44 (45%)	< 30
Sood et al. [11]	2013	1058	100%	NA	50 ± 41	142 (13%)	< 40[b]
Present study	2019	802	30%	30%	67 ± 70	131 (16%)	< 30

[a]Intrinsic rhythm used to define pacemaker dependency; [b]Intrinsic rhythm < 40 bpm or < 50 bpm with symptoms; NA — data not available

sufficient ventricular escape rhythm following cardiac surgery [8].

The most important predictor of pacing dependency during follow-up in the current study was the presence second degree AV block type Mobitz or third-degree AV block at the time of pacemaker implant. This is consistent with the findings of most previous studies in patients with and without cardiac surgery prior to pacemaker implant [3, 5–8, 15–17]. Several previous investigators also found an association between pacing dependency during follow-up and body mass index [7], age [11], male gender [11], and a history of coronary artery disease [16]. Whereas none of these variables predicted pacing dependency in the present study, a significant association was found between pacing dependency and heart failure severity as indexed by a low LVEF ≤ 30% and an elevated BNP level. Furthermore, amiodarone use was associated with pacing dependency in the subgroup of patients with ICD in the current study. This is consistent with the results of Sood et al. [11], who also found a significant association between pacing dependency and amiodarone use in a large cohort of 1058 patients with ICD. The results of the present study support the hypothesis that patients with heart failure and high degree AV block at implant will probably be paced more frequently in the ventricle and may therefore benefit from physiological pacing [4]. Although CKD is a generally accepted important comorbidity in patients with heart disease of any etiology with regard to overall survival, the association between CKD and pacing dependency has not been investigated in previous studies [2–17]. Multivariate analysis in the current study revealed a twofold risk for pacing dependency in patients with CKD compared to patients without CKD.

Limitations of the study

There are several limitations of the present study. First, clinical patient data and implant data were collected retrospectively, although pacing dependency was determined prospectively between January 2018 and December 2018 at the documented pacemaker and ICD outpatient department. Secondly, pacing dependency was determined during a brief period of time at a single outpatient visit. It is well known that pacing dependency can occur transiently. Therefore, repeated pacing dependency tests and longer monitoring time may have revealed patients, in whom pacing dependency may have resolved or may have occurred at other times.

Conclusions

In conclusion, pacing dependency after CIED implantation depends on the pacing indication and is much more common in patients with high-degree AV-block at implant compared to patients with sick sinus syndrome. In addition, pacing dependency is associated with more advanced heart failure, CKD and follow-up duration after implant. Since pacing dependent patients who suffer from heart failure will need frequent ventricular pacing, physiological pacing should be considered in these patients.

Conflict of interest: None declared

References

1. Brignole M, Auricchio A, Baron-Esquivias G, et al. ESC Committee for Practice Guidelines (CPG), Document Reviewers. 2013 ESC Guidelines on cardiac pacing and cardiac resynchronization therapy: the Task Force on cardiac pacing and resynchronization therapy of the European Society of Cardiology (ESC). Developed in collaboration with the European Heart Rhythm Association (EHRA). Eur Heart J. 2013; 34(29): 2281–2329, doi: 10.1093/eurheartj/eht150, indexed in Pubmed: 23801822.
2. Steyers CM. 3rd, khera R, bhave P. Pacemaker dependency after cardiac surgery: a systematic review of current evidence. PLoS One. 2015; 10: e0140340.
3. Glikson M, Dearani JA, Hyberger LK, et al. Indications, effectiveness, and long-term dependency in permanent pacing after cardiac surgery. Am J Cardiol. 1997; 80(10): 1309–1313, doi: 10.1016/s0002-9149(97)00671-1, indexed in Pubmed: 9388104.
4. Tang AS, Roberts RS, Kerr C, et al. Relationship between pacemaker dependency and the effect of pacing mode on cardiovascular outcomes. Circulation. 2001; 103(25): 3081–3085, doi: 10.1161/01.cir.103.25.3081, indexed in Pubmed: 11425772.
5. Nagatomo T, Abe H, Kikuchi K, et al. New onset of pacemaker dependency after permanent pacemaker implantation. Pacing Clin Electrophysiol. 2004; 27(4): 475–479, doi: 10.1111/j.1540-8159.2004.00466.x, indexed in Pubmed: 15078400.
6. Lelakowski J, Majewski J, Bednarek J, et al. Pacemaker dependency after pacemaker implantation. Cardiol J. 2007; 14(1): 83–86, indexed in Pubmed: 18651439.
7. Onalan O, Crystal A, Lashevsky I, et al. Determinants of pacemaker dependency after coronary and/or mitral or aortic valve surgery with long-term follow-up. Am J Cardiol. 2008; 101(2): 203–208, doi: 10.1016/j.amjcard.2007.07.062, indexed in Pubmed: 18178407.
8. Merin O, Ilan M, Oren A, et al. Permanent pacemaker implantation following cardiac surgery: indications and long-term follow-up. Pacing Clin Electrophysiol. 2009; 32(1): 7–12, doi: 10.1111/j.1540-8159.2009.02170.x, indexed in Pubmed: 19140907.
9. Raza SS, Li JM, John R, et al. Long-term mortality and pacing outcomes of patients with permanent pacemaker implantation after cardiac surgery. Pacing Clin Electrophysiol. 2011; 34(3): 331–338, doi: 10.1111/j.1540-8159.2010.02972.x, indexed in Pubmed: 21208223.
10. Rene AG, Sastry A, Horowitz JM, et al. Recovery of atrioventricular conduction after pacemaker placement following cardiac valvular surgery. J Cardiovasc Electrophysiol. 2013; 24(12): 1383––1387, doi: 10.1111/jce.12260, indexed in Pubmed: 24028584.
11. Sood N, Crespo E, Friedman M, et al. Predictors of pacemaker dependence and pacemaker dependence as a predictor of mortality in patients with implantable cardioverter defibrillator. Pacing Clin Electrophysiol. 2013; 36(8): 945–951, doi: 10.1111/pace.12164, indexed in Pubmed: 23668483.
12. Korantzopoulos P, Letsas KP, Grekas G, et al. Pacemaker dependency after implantation of electrophysiological devices. Europace. 2009; 11(9): 1151–1155, doi: 10.1093/europace/eup195, indexed in Pubmed: 19617204.
13. Levine PA. Pacemaker dependency after pacemaker implantation. Cardiol J. 2007; 14(3): 318–320, indexed in Pubmed: 18651480.
14. Majewski JP, Lelakowski J. Pacemaker dependency: how should it be defined? Europace. 2018; 20(10): 1708, doi: 10.1093/europace/euy010, indexed in Pubmed: 29518191.
15. Feldman S, Glikson M, Kaplinsky E. Pacemaker dependency after coronary artery bypass. Pacing Clin Electrophysiol. 1992; 15(11 Pt 2): 2037–2040, doi: 10.1111/j.1540-8159.1992.tb03017.x, indexed in Pubmed: 1279595.
16. Mar PL, Angus CR, Kabra R, et al. Perioperative predictors of permanent pacing and long-term dependence following tricuspid valve surgery: a multicentre analysis. Europace. 2017; 19(12): 1988–1993, doi: 10.1093/europace/euw391, indexed in Pubmed: 28073887.
17. Kaplan RM, Yadlapati A, Cantey EP, et al. Conduction recovery following pacemaker implantation after transcatheter aortic valve replacement. Pacing Clin Electrophysiol. 2019; 42(2): 146–152, doi: 10.1111/pace.13579, indexed in Pubmed: 30548869.