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The Dynamic Relationship Among Atrial Pacing, Premature Atrial Beats, Mode Switching, and Atrial High-Rate Episodes in Patients with Sick Sinus Syndrome

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Abstract

Objectives: This study aimed to explore the association between atrial pacing percentage, frequency of premature atrial beats, and mode-switch episodes and the occurrence of atrial high-rate episodes (AHREs) in patients with sick sinus syndrome (SSS) who underwent dual-chamber pacemaker (DDDR) implantation.

Materials and Methods: This prospective, single-center, observational study included 60 patients with SSS and Medtronic DDDR pacemakers. Patients with pre-existing atrial fibrillation, ischemic stroke, heart failure, chronic renal failure, or insufficient follow-up data were excluded. Key parameters, such as atrial pacing percentage, premature atrial beats, mode-switch episodes, and AHREs, were evaluated at 1, 3, and 6 months and at 1 and 2 years after implantation.

Results: The mean age of the participants was 65.5 years, with 53.3% of them being male. During the first 3 months, atrial pacing percentage showed an inverse correlation with AHREs (83.7±19.8% at 1 month and 85.2±19.9% at 3 months; p=0.026 and p=0.046, respectively). mode-switch episodes and premature atrial beats were significantly associated with AHREs within the first 6 months (mode-switch episodes: 11.2±4.3 at 1 month, 11.4±3.2 at 3 months, and 6.7±3.1 at 6

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months; p=0.015, p=0.033, p=0.041; premature atrial beats: 6.8±2.3% at 1 month, 7.1±2.1% at 3 months, and 7.2±1.9% at 6 months; p=0.015, p=0.022, p=0.031). AHRE prevalence increased progressively from 9.7±2.3% at 1 month to 18.1±4.1% at 3 months and 23.3±5.9% at 6 months. However, these associations diminished after 6 months, persisting less significantly at 1 and 2 years. Receiver operating characteristic curve analysis determined a 94.5% atrial pacing percentage cut-off at 1 month, with a sensitivity of 68% and specificity of 82% [area under the curve (AUC): 0.806, p<0.001], and a 94% cut-off at 3 months, with sensitivity and specificity of 68% and 90%, respectively (AUC: 0.801, p<0.001). For mode-switch episodes, a 1.5 cut-off value at both 1 and 3 months yielded sensitivities of 73% and 74% and specificities of 99% and 98%, respectively (AUC: 0.890 and 0.895, p<0.001).

Conclusion: This study highlights a time-dependent relationship between pacing parameters and AHREs in patients with SSS. The early post-implantation periods showed significant correlations, which diminished over time. These findings underscore the importance of regular monitoring for optimal management of SSS patients with DDDR pacemakers.

Keywords: Atrial high-rate episodes, sick sinus syndrome, atrial pacing, atrial premature beat, mode switch episodes

Introduction

Atrial high-rate episodes (AHREs) are asymptomatic atrial tachyarrhythmias identified through cardiac implantable electronic devices (CIEDs). These episodes were observed in individuals without a documented history of atrial fibrillation (AF) or AF on standard electrocardiograms. Although AHREs are associated with an increased risk of thromboembolism, this risk is generally lower than that observed in clinical AF. Notably, a higher AHRE burden is correlated with an elevated thromboembolic risk, which may progress over time and potentially precede the development of clinical AF[1,2].

Sinoatrial node dysfunction, commonly referred to as sick sinus syndrome (SSS), can result in various cardiac anomalies. These irregularities may cause symptoms such as palpitations, fatigue, dizziness, syncope, and reduced tissue perfusion. SSS primarily affects individuals aged 65 years and older with a history of cardiac conditions, with an estimated prevalence of 1-2% in this demographic, impacting both genders equally[3].

SSS is characterized by a disruption in sinoatrial node activity, leading to electrocardiographic manifestations, such as sinus bradycardia, sinus arrest, and sinoatrial block. These abnormalities are often accompanied by episodes of supraventricular tachyarrhythmias, forming a condition known as "tachy-brady syndrome". In cases with significant clinical impact, pacemaker implantation is typically required. SSS is one of the leading indications for pacemaker implantation, accounting for 30%-50% of such procedures in the United States[4].

Permanent pacemakers are recommended for patients with sinus node dysfunction accompanied by symptomatic bradycardia or chronotropic incompetence. Dual-chamber pacemakers (DDDRs) are often preferred in these cases because of their ability to address the increased likelihood of atrioventricular (AV) block[5].

The relationship between atrial pacing algorithms and the prevention of AHREs remains an ongoing research. SSSs and AF frequently coexist and influence each other in a complex manner. This study aimed to explore the association between atrial pacing percentages, early atrial beat frequencies, mode-switching episodes, and the occurrence of AHREs over a long-term follow-up period in patients diagnosed with SSS who have received DDDRs and have no prior diagnosis of AF.

Materials and Methods

This prospective, single-center observational study included a cohort of 60 patients who met the inclusion criteria. Participants were selected from individuals diagnosed with SSS who underwent DDDR pacemaker

implantation. All pacemakers used in the study were Medtronic devices, with the AHRE detection feature activated in each device.

To maintain a uniform study population, only patients with a confirmed diagnosis of SSS and DDDR pacemaker implantation using Medtronic devices were included. Individuals with a prior diagnosis of AF and those with a history of ischemic stroke, heart failure, or chronic renal failure were excluded. Patients with incomplete follow-up data were also excluded from the analysis.

The atrial leads in these pacemakers are capable of detecting atrial electrical activity and identifying pre-specified events, including AHREs. AHREs were defined as episodes lasting at least 5 minutes with an atrial rate exceeding 175 beats per minute (bpm) (Figure 1). AF was categorized into three types: paroxysmal AF (self-terminating within 7 days), persistent AF (lasting more than 7 days but less than 1 year), and permanent AF (persisting for over 1 year). All detected AHREs were independently reviewed by two clinicians, and classification decisions were made through mutual agreement. The devices continuously monitored atrial rhythm and automatically recorded relevant data, including arrhythmia events.

Mode switching was defined as the pacemaker's transition from tracking mode to non-tracking mode during episodes of atrial tachyarrhythmia, with a return to tracking mode following the termination of the arrhythmia. Atrial premature beats (APBs) were defined as extra beats originating from atrial regions other than the sinus node preceding a normal heartbeat.

Demographic and clinical data, including age, sex, and comorbid conditions, were documented for all participants. A structured follow-up protocol was designed to assess AHRE trends over time, with evaluations conducted at 1, 3, and 6 months, as well as at 1 and 2 years after implantation. The parameters assessed during each follow-up were AHRE percentage, atrial pacing percentage, number of APBs, mode-switch episodes, and AF status.

The primary endpoint of this study was to investigate the relationship between atrial pacing percentage, APB frequency, and mode-switch episodes and the occurrence of AHREs in patients with SSS implanted with DDDR pacemakers.

The ethical principles outlined in the Declaration of Helsinki were strictly adhered to throughout the study. Approval for this research was given by the ethics committee under the Protocol on the Conduct of Research Conducted Between Osmaniye Provincial Health Directorate and the Owner of the Scientific Research (approval no.: E-77378720-605.01-224398439, date:

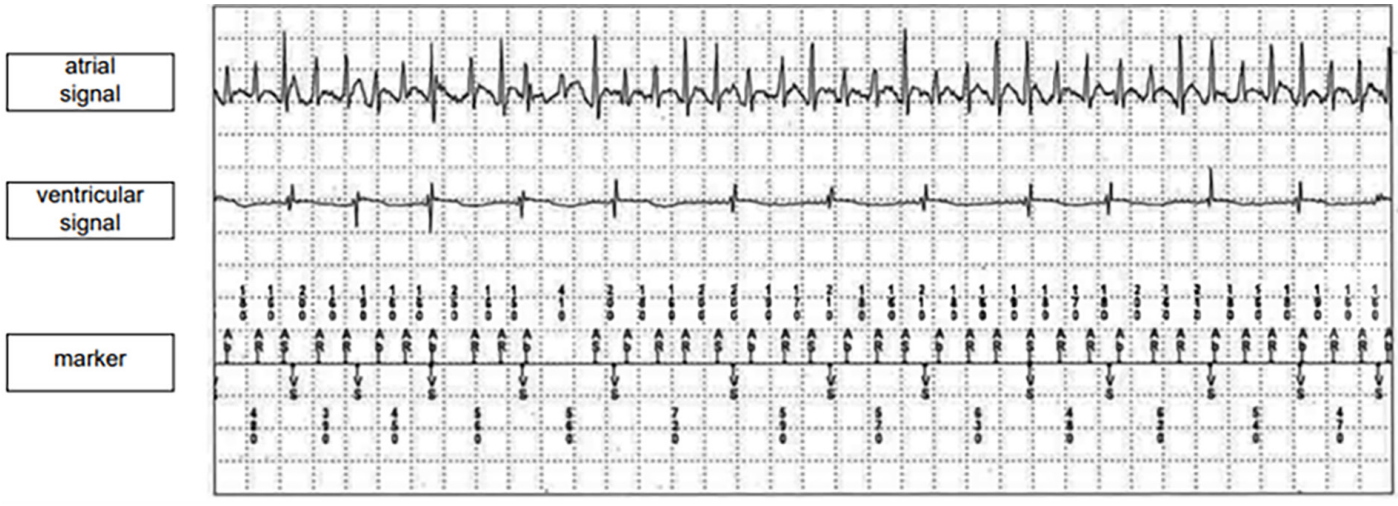


Figure 1. AHRE example recorded from patient
AHRE: Atrial high-rate episode

13.09.2023). All participants provided written informed consent before study enrollment.

Statistical Analysis

Descriptive statistics were used to summarize patients' demographic and clinical characteristics, with results presented as means, standard deviations, frequencies, and percentages. Categorical variables, such as AHRE presence and mode changes, were analyzed using chi-square or Fisher's exact test. For continuous variables, including atrial and ventricular pacing percentages, independent t-tests were used for data with normal distributions.

To examine the influence of device events on AHRE development, a multivariate Cox regression analysis was conducted. Additionally, receiver operating characteristic (ROC) curve analysis was performed to determine the impact of atrial pacing frequency and mode-switch episodes on AHRE occurrence. Statistical significance was set at a p-value of <0.05. All statistical analyses were performed using IBM SPSS version 25 (Chicago, IL, USA).

Results

The study enrolled a total of 60 patients, with a mean age of 65.5 years (±7.3). Male participants comprised 53.3% of the group (32 individuals). Hypertension was reported in 48.3% of the participants, and coronary artery disease was noted in 30.0%. Regarding antiarrhythmic therapy, 61.7% (37 patients) were prescribed beta-blockers, 23.3% (14 patients) were treated with calcium channel blockers, 5.0% (3 patients) used propafenone, 3.3% (2 patients) were on sotalol, and 11.7% (7 patients) received amiodarone (Table 1).

At the end of the 2-year follow-up, 38 patients were diagnosed with atrial AF. Of these, 27 were initiated on direct oral anticoagulants and 3 were prescribed warfarin. Three patients with a CHA_2DS_2-VASc score of 1 were started on acetylsalicylic acid, and no antiplatelet or anticoagulant therapy was initiated for five patients with a CHA_2DS_2-VASc score of 0. During the monitoring period, ischemic stroke occurred in five patients, and one patient receiving warfarin experienced a hemorrhagic stroke.

Device data from all participants who underwent pacemaker implantation for sick SSS were thoroughly analyzed. Each participant had a Medtronic pacemaker with a DDDR. The average lower rate limit of the pacemakers was 61.2 bpm (±3.6). At the end of the follow-up period, 63.3% (38 patients) developed AF.

The atrial pacing percentage, APBs, mode-switch episodes, and AHREs were evaluated at specified intervals-1, 3, and 6 months, as well as 1 and 2 years after implantation-and are summarized in Table 2.

Cox regression analysis identified a significant inverse association between atrial pacing percentage and AHRE occurrence during the 1st and 3rd months (p=0.026 and p=0.046, respectively). However, this relationship was not observed at 6 months, 1 year, or 2 years. Additionally, a significant association was found between mode-switch episodes, APBs, and AHREs during the initial 1st, 3rd, and 6th months (p=0.015, p=0.033, and p=0.041 for mode-switch episodes; p=0.014, p=0.022, and p=0.031 for APBs). These associations diminished by the 1st and 2nd years of follow-up (Table 3).

ROC curve analysis was performed for the 1st and 3rd months to evaluate the predictive impact atrial pacing

Table 1. Patient characteristics and antiarrhythmic drugs

Patient characteristics	(n=60)
Age (years) (mean±SD)	65.5 ± 7.3
Sex (male) (%)	32 (53.3)
Active smoker (%)	29 (48.3)
DM (%)	13 (21.7)
HT (%)	28 (46.7)
CAD (%)	18 (30.0)
Valvular disease*(%)	13 (21.7)
Hyperlipidemia (%)	19 (31.7)
Antiarrhythmic drugs	
Beta-blocker	37 (61.7)
Calcium channel blocker	14 (23.3)
Propafenone	3 (5.0)
Sotalol	2 (3.3)
Amiodarone	7 (11.7)

*CAD: Coronary artery disease, DM: Diabetes mellitus, HT: Hypertension, SD: Standard deviation. *moderate to severe valve regurgitation or valve stenosis*

percentage and mode-switch episodes on AHREs. In the 1st month, an atrial pacing percentage cut-off value of 94.5% yielded a sensitivity of 68% and a specificity of 82% [area under the curve (AUC): 0.806, p<0.001]. This cut-off remained consistent in the 3rd month at 94%, with a sensitivity of 68% and a specificity of 90% (AUC: 0.801, p<0.001). Regarding mode-switch episodes, the 1st month cut-off value was 1.5, achieving 73% sensitivity and 99% specificity (AUC: 0.890, p<0.001). The same cutoff was maintained in the 3rd month, with 74% sensitivity and 98% specificity (AUC: 0.895, p<0.001) (Figure 2).

Discussion

In this study, we explored the complex relationship between atrial pacing, mode-switch episodes, premature atrial contractions, and the occurrence of AHREs in patients with SSS who received DDDR. During the first 3 months following pacemaker implantation, an inverse association was observed between atrial pacing percentage and AHREs. However, this link diminished over longer follow-up periods. Similarly, mode-switch episodes and the frequency of premature atrial beats were significantly correlated with AHREs during the initial six months, but these associations were no longer evident beyond that timeframe. These findings emphasize the importance of the early post-implantation period in AHRE development in this patient group.

AF is a well-documented comorbidity in individuals with SSS[6]. However, the causal relationship between AF and SSS remains debated-whether AF is a precursor to SSS or SSS predisposes patients to AF. AF induces structural and functional changes in the sinus node at cellular and molecular levels, which may contribute to SSS. Mechanisms such as sinus node dysfunction, AF, and electrical remodeling are thought to play a role in initiating AF, supporting previous research in this area[7,8]. Additionally, evidence suggests that AHREs detected by CIEDs serve as predictors for future AF episodes, although the specific prevalence and predictors of AHREs in SSS patients with pacemakers remain less defined[9,10].

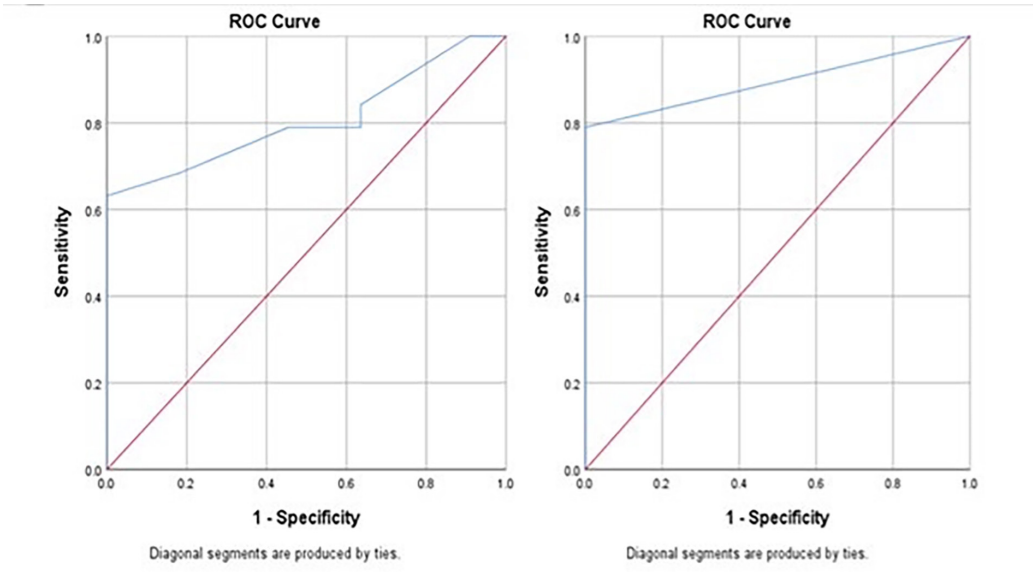
Table 2. Data obtained in follow-up from the pacemakers

Mean pacemaker lower rate limit (bpm) (mean±SD)	**61.2±3.6**
Atrial pacing percentage (mean ± SD)	
First month	83.7±19.8
Third month	85.2±19.9
Sixth month	84.7±23.1
First-year	86.5±22.3
Second year	87.4±20.7
Atrial premature beat percentage (mean±SD)	
First month	6.8±2.3
Third month	7.1±2.1
Sixth month	7.2±1.9
First-year	6.9±2.3
Second year	7.0±2.1
Mode switch episode (mean±SD)	
First month	11.2±4.3
Third month	11.4±3.2
Sixth month	6.7±3.1
First-year	2.4±1.9
Second year	2.1±1.1
Atrial high-rate episode (mean±SD)	
First month	9.7±2.3
Third month	18.1±4.1
Sixth month	23.3±5.9
First-year	29.2±6.3
Second year	35.8±8.1
Patients diagnosed with atrial fibrillation n (%)	38 (63.3)

SD: Standard deviation, bpm: Beats per minute

Table 3. Effects of device events on the development of Atrial High-Rate Episodes

Multivariable cox regression analysis			
Device events	**Hazard ratio**	**95% Confidence interval**	**p-value**
Atrial pacing percentage			
First month	0.984	0.971-0.998	**0.026**
Third month	0.986	0.973-0.999	**0.046**
Sixth month	0.989	0.978-1.000	0.059
First year	0.990	0.978-1.001	0.085
Second year	0.989	0.976-1.002	0.095
Atrial premature beat percentage			
First month	1.040	1.013-1.078	**0.014**
Third month	1.038	1.006-1.072	**0.022**
Sixth month	1.035	1.007-1.064	**0.031**
First year	1.040	0.974-1.110	0.241
Second year	1.037	0.909-1.183	0.590
Mode switch episode			
First month	1.020	1.004-1.036	**0.015**
Third month	1.015	1.001-1.030	**0.033**
Sixth month	1.012	1.001-1.024	**0.041**
First year	1.031	0.983-1.082	0.210
Second year	1.012	0.980-1.046	0.461



Risk Factor	AUC (95% CI)	Cutoff	P Value	Sensitivity	Specificity
Atrial pacing percentage					
First month	0.806	94.5	<0.001	0.68	0.82
Third month	0.801	94.0	<0.001	0.68	0.90
Mode switch episode					
First month	0.890	1.5	<0.001	0.73	0.99
third month	0.895	1.5	<0.001	0.74	0.98

AUC: Area Under the Curve, CI: Confidence Interval

Figure 2. Representation of the effect of atrial pacing frequency and mode-switching episodes in terms of the development of AHRE by ROC analysis
AHRE: Atrial high-rate episode, AUC: Area under the curve, CI: Confidence interval, ROC: Receiver operating characteristic

The sinus node is involved in the pathogenesis of both SSS and AF. Mechanistic theories, such as the "wavelength of re-entry" and "focal source hypothesis," underscore the role of electrical remodeling and sustained re-entry in arrhythmogenesis[11,12]. In SSS, slowed atrial conduction often leads to compensatory pauses and activation of ectopic atrial foci, which may trigger AHREs. Multifocal atrial rhythms, which are often observed before AHRE onset, further illustrate the interplay between sinus node dysfunction and atrial arrhythmias[13].

Our analysis revealed that atrial pacing was inversely associated with AHRE development during the initial 3 months of follow-up, although this protective effect waned over time. Additionally, mode-switch episodes and premature atrial contractions were strongly associated with AHREs during the first six months but showed no significant correlation was observed in subsequent follow-up periods. These temporal patterns highlight the dynamic nature of these relationships and suggest the need for targeted monitoring and management in the early post-implantation period.

DDDR pacemakers are instrumental in optimizing cardiac function by preserving AV synchrony and preventing bradycardia-induced tachyarrhythmias. Studies have suggested that higher pacing rates in such devices may allow for greater beta-blocker dosing, potentially

reducing the incidence of AHREs[14-16]. However, the potential impact of elevated pacing percentages and ventricular pacing on long-term AHRE risk requires further investigation. Current guidelines advocate the use of DDDR that maintain AV synchrony as the preferred approach for managing SSS[17-19].

Mode-switching algorithms designed to detect and respond to atrial tachyarrhythmias play a pivotal role in preventing inappropriate atrial pacing and tracking during arrhythmic events. The frequency of mode-switch episodes is a reliable marker of AHRE burden given the sensitivity and specificity of modern pacemaker algorithms. Despite their effectiveness, occasional atrial sensing disruptions due to AHREs may occur, but these are typically resolved through tracking algorithms[20].

Premature atrial contractions, which were once considered benign, are now recognized as significant risk factors for AF. The observed association between AHREs and early atrial contractions in our study underscores their role as precursors to arrhythmias like AF. These findings emphasize the importance of early detection and intervention for managing atrial arrhythmias and preventing progression to more severe conditions[21,22].

Study Limitations

This study has several limitations that should be considered. First, the sample size was relatively small, which may limit the generalizability of our findings to a broader population. Second, this was a single-center study, and potential variations in clinical practices or patient populations at other institutions were not considered. Third, although the follow-up period was sufficient to observe the early and mid-term dynamics of AHREs, longer follow-up may be required to understand the full trajectory of AHRE development and its clinical implications. Additionally, the study did not account for potential confounding factors such as variations in comorbid conditions, medication adherence, or changes in pacemaker settings over time. Future studies with larger multicenter cohorts and longer follow-up periods are necessary to validate and expand upon these findings.

Conclusion

Our study highlights the dynamic interplay between atrial pacing percentage, mode switch episode, and premature atrial beats in relation to the development of AHREs in patients undergoing SSS post-DDDR implantation. The initial 3 months after implantation demonstrated a significant inverse relationship between atrial pacing percentage and AHREs, alongside notable associations between mode switch episode and APBs with AHREs during the first six months. However, these relationships weakened over time, suggesting that early monitoring and intervention are crucial in mitigating the risk of AHREs in this patient population. Our findings underscore the importance of ongoing research to further elucidate the mechanisms and long-term implications of AHREs in patients with SSS.

Ethics

Ethics Committee Approval: The ethical principles outlined in the Declaration of Helsinki were strictly adhered to throughout the study. Approval for this research was given by the ethics committee under the Protocol on the Conduct of Research Conducted Between Osmaniye Provincial Health Directorate and the Owner of the Scientific Research (approval no.: E-77378720-605.01-224398439, date:13.09.2023).

Informed Consent: The need for patient consent for enrollment and publication was waived because of the retrospective design.

Footnotes

Authorship Contributions

Surgical and Medical Practices: Yaylak B, Süleymanoğlu C, Concept: Polat F, Süleymanoğlu C, Design: Yaylak B, Süleymanoğlu C, Data Collection and/or Processing: Polat F, Süleymanoğlu C, Analysis and/

or Interpretation: Yaylak B, Polat F, Literature Search: Yaylak B, Polat F, Writing: Polat F.

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References

1. Boriani G, Vitolo M, Imberti JF,et al. What do we do about atrial high rate episodes? Eur Heart J Suppl. 2020;22(Suppl O):O42-O52.
2. Toennis T, Bertaglia E, Brandes A, et al. The influence of atrial high-rate episodes on stroke and cardiovascular death: an update. Europace. 2023;25:euad166.
3. Adán V, Crown LA. Diagnosis and treatment of sick sinus syndrome. Am Fam Physician. 2003;67:1725-32.
4. Jensen PN, Gronroos NN, Chen LY, et al. Incidence of and risk factors for sick sinus syndrome in the general population. J Am Coll Cardiol. 2014;64:531-8.
5. Ferrer MI. The sick sinus syndrome in atrial disease. JAMA. 1968;206:645-6.
6. Yang PS, Kim D, Jang E, et al. Risk of sick sinus syndrome in patients diagnosed with atrial fibrillation: a population-based cohort. J Cardiovasc Electrophysiol. 2021;32:2704-14.
7. Jansen HJ, Bohne LJ, Gillis AM, et al. Atrial remodeling and atrial fibrillation in acquired forms of cardiovascular disease. Heart Rhythm O2. 2020;1:147-59.
8. Polat F, Ko AL. Comparison of patients with atrial fibrillation without structural heart disease and normal population in terms of urine catecholamines. Turk Kardiyol Dern Ars. 2023;51:168-73.
9. Mahajan R, Perera T, Elliott AD, et al. Subclinical device-detected atrial fibrillation and stroke risk: a systematic review and meta-analysis. Eur Heart J. 2018;39:1407-15.
10. Healey JS, Connolly SJ, Gold MR, et al. Subclinical atrial fibrillation and the risk of stroke. N Engl J Med. 2012;366:120-9.
11. Kezerashvili A, Krumerman AK, Fisher JD. Sinus node dysfunction in atrial fibrillation: cause or effect? J Atr Fibrillation. 2008;1:30.
12. Lee S, Khrestian CM, Sahadevan J, et al. Reconsidering the multiple wavelet hypothesis of atrial fibrillation. Heart Rhythm. 2020;17:1976-83.
13. Antzelevitch C, Burashnikov A. Overview of basic mechanisms of cardiac arrhythmia. Card Electrophysiol Clin. 2011;3:23-45.
14. Dretzke J, Toff WD, Lip GY, et al. Dual chamber versus single chamber ventricular pacemakers for sick sinus syndrome and atrioventricular block. Cochrane Database Syst Rev. 2004;2004:CD003710.
15. Elsokkari I, Abdelwahab A, Parkash R. Polymorphic ventricular tachycardia due to change in pacemaker programming. HeartRhythm Case Rep. 2017;3:243-7.
16. Ziff OJ, Samra M, Howard JP, et al. Beta-blocker efficacy across different cardiovascular indications: an umbrella review and meta-analytic assessment. BMC Med. 2020;18:103.
17. Dawood M, Elsharkawy E, Abdel-Hay MA, et al. Effects of cardiac pacemakers on left ventricular volumes and function assessed by 3D echocardiography, Doppler method, and global longitudinal strain. Egypt Heart J. 2021;73:16.
18. Krzemień-Wolska K, Tomasik A, Wojciechowska C, et al. Prognostic factors in patients with an implanted pacemaker after 80 years of age in a 4-year follow-up. Gerontology. 2018;64:107-117.
19. Xie JM, Fang F, Zhang Q, et al. Atrial dysfunction and interatrial dyssynchrony predict atrial high rate episodes: insight into the distinct effects of right atrial appendage pacing. J Cardiovasc Electrophysiol. 2012;23:384-90.
20. Israel CW. Mode-switch-algorithmen: programmierbarkeit und nutzen [mode-switching algorithms: programming and usefulness]. Herz. 2001;26:2-17.
21. de Voogt WG, van Hemel NM, van de Bos AA, et al. Verification of pacemaker automatic mode switching for the detection of atrial fibrillation and atrial tachycardia with Holter recording. Europace. 2006;8:950-61.
22. Farinha JM, Gupta D, Lip GYH. Frequent premature atrial contractions as a signalling marker of atrial cardiomyopathy, incident atrial fibrillation, and stroke. Cardiovasc Res. 2023;119:429-39.