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ORIGINAL ARTICLE

DETECTION OF ATRIAL FIBRILLATION IN PATIENTS WITH COMPLETE HEART BLOCK TREATED WITH DIFFERENT MODES OF PACEMAKER

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ABSTRACT

Background: Atrial fibrillation (AF) and complete heart block (CHB) are significant cardiac conditions often managed with pacemaker implantation. Pacemaker mode may influence the detection and incidence of AF, a common and potentially severe complication in patients with CHB. This study evaluated the association between pacemaker mode (dual-chamber DDD vs. single-chamber VVI) and the incidence of AF in patients with CHB.

Materials & Methods: A cross-sectional study was conducted from January 2021 to December 2021 among 114 CHB patients who received either DDD or VVI pacemakers at the Ibn Al-Bittar Specialized Center for Cardiac Surgery and Al-Nasiriyah Heart Center. Convenience sampling method was employed. Demographic and clinical data, including pacemaker type, duration of implantation, and comorbidities, were collected from medical records and structured interviews. AF incidence was assessed using electrocardiography (ECG) and pacemaker interrogation data. Statistical analysis was performed using chi-square and Fisher's exact tests, with a p-value < 0.05 considered significant.

Results: Among the 114 patients (56 DDD, 58 VVI), 14% (n=16) developed AF. AF incidence was significantly higher in patients with VVI pacemakers (21%) compared to those with DDD pacemakers (7%) (p-value=0.034). No significant differences in AF incidence were observed between pacemaker modes based on gender, age, or the presence of comorbidities such as hypertension, diabetes, or smoking history (p-value>0.05).

Conclusion: In summary, while DDD pacemakers may offer a protective effect against AF compared to VVI pacemakers, this study underscores the complexity of AF management in patients with CHB, indicating that a multifaceted approach is necessary to optimize outcomes.

KEY WORDS: Atrial fibrillation; Complete heart block; Mode of pacemaker.

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INTRODUCTION

Atrial fibrillation (AF) and complete heart block (CHB) are two distinct cardiac conditions that significantly impact patient health, often requiring careful management.[1] Atrial fibrillation is the most common type of arrhythmia, characterized by uncoordinated electrical activity in the atria, leading to irregular heartbeats.[2] This condition increases the risk of severe complications such as stroke, heart failure, and thromboembolism.[3] On the other hand, CHB, also known as third-degree atrioventricular block, is a life-threatening condition where the electrical signals between the atria and ventricles are completely disrupted, necessitating intervention to restore effective heart rhythm.[4,5] The primary treatment for CHB is pacemaker implantation, which helps maintain proper ventricular function and ensures adequate cardiac output.[6]Korle-Bu Teaching Hospital, Accra, Ghana. Reviewed 243 patients who had intra-cardiac repair of congenital heart disease known to predispose to post-operative complete heart block from January 1993 to December 2008 was carried out with computation of the frequency of complete heart block according to the intra-operative diagnoses. Six out of 242 patients (2.5% Pacemakers, pivotal in managing CHB, come in various modes, including single-chamber, dual-chamber,

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and biventricular configurations.[7] Each mode offers distinct advantages and limitations, influencing the overall cardiac function and potentially affecting the incidence and detection of AF.[8] Understanding how different pacemaker modes impact the detection of AF is essential for optimizing patient outcomes and tailoring therapeutic strategies.[9]

Single-chamber pacemakers typically stimulate the right atrium or right ventricle, whereas dual-chamber pacemakers stimulate both the atrium and the ventricle, allowing for more synchronized cardiac activity.[10]hypertrophic obstructive cardiomyopathy (HOCM These differences in pacemaker functionality can influence the sensitivity and accuracy of detecting AF episodes in patients with CHB.[11]using EGMs, 8 (18%

The ability to accurately detect AF in patients with CHB is crucial because of the high risk of thromboembolic events and other complications associated with undiagnosed AF.[12] Modern pacemaker technologies have evolved to include sophisticated algorithms and sensors capable of detecting arrhythmic events, including AF. However, the efficiency of AF detection may vary depending on the type of pacemaker used.[13] Dual-chamber pacemakers, for instance, might offer better detection rates of AF due to their ability to monitor atrial activity more closely than single-chamber devices. In contrast, single-chamber pacemakers may provide limited information on atrial arrhythmias, potentially missing episodes of AF.[14]

This study aimed to explore the detection of atrial fibrillation in patients with complete heart block treated with different pacemaker therapy modes. By comparing the efficacy of various pacemaker modes in identifying AF, we seek to provide valuable insights into improving diagnostic accuracy and patient management.

MATERIALS AND METHODS

Study Design and Participants: This descriptive and analytical cross-sectional study was conducted from January 2021 to December 2021 at the Rhythm Management Clinics of the Ibn Al-Bittar Specialized Center for Cardiac Surgery and Al-Nasiriyah Heart Center. The study included 114 patients who had undergone permanent pacemaker implantation for complete heart block (CHB), either as newly implanted or previously implanted devices. Patients were selected using convenience sampling based on eligibility criteria and willingness to participate. Written informed consent was obtained from all participants before inclusion in the study.

Inclusion Criteria:

- Patients aged 21–89 years with permanent pacemakers implanted for CHB.
- Patients with no history of atrial fibrillation (AF) before pacemaker implantation.

Exclusion Criteria:

- Patients with pre-existing AF prior to pacemaker implantation.
- Patients diagnosed with heart failure (clinical or echocardiographic evidence).
- Those with significant valvular heart disease or thyroid disorders.
- Patients with pacemakers programmed with an AF suppression mode at the time of enrollmen

Data Collection: Patient demographic and clinical information was collected through structured interviews and medical record reviews. Data included age, gender, pacemaker type, comorbidities (e.g., hypertension, diabetes), and lifestyle factors (e.g., smoking). Pacemaker interrogation and electrocardiography (ECG) were used to assess the presence of AF. Clinical evaluations also included transthoracic echocardiography.

AF episodes were identified using ECG findings and pacemaker interrogation data, following the methodology of Said et al. (2024).[15] Patients diagnosed with AF were reassessed one month later to confirm findings through repeat ECGs.

Pacemaker Modes Categorization: Pacemakers were classified as dual-chamber (DDD) or single-chamber ventricular (VVI) for analysis. Patients with DDD pacemakers were programmed with atrioventricular (AV) delays ranging from 120 ms to 200 ms.

Sample Size Calculation: The required sample size was calculated using the formula for estimating proportions:

$$n = Z^2 \times p \times (1-p)/e^2$$

Assumptions:

- Confidence level: 95%
- Margin of error: 5%
- Prevalence of AF in pacemaker patients: 20%

The calculated sample size was 114 patients.

Statistical Analysis: Data analysis was performed using SPSS version 21. Categorical variables, including AF presence and pacemaker mode, were compared using chi-square or Fisher's exact tests. Subgroup analyses were conducted to evaluate differences in AF incidence based on age, gender, duration of pacemaker implantation, and comorbidities (e.g., hypertension, diabetes, smoking). A p-value of < 0.05 was considered statistically significant.

RESULTS

The study enrolled 114 patients, nearly equally distributed between pacemaker modes: 49% (n=56) with DDD pacemakers and 51% (n=58) with VVI pacemakers. The majority of participants were above 60 years of age (58.8%, n=67), while the remaining were under 60 years (41.2%, n=47). Males constituted 56% (n=64) of the sample, and females

comprised 44% (n=50). Table 1 summarizes the demographic and clinical characteristics.

Table 1: Demographic and Clinical Characteristics of Patients

Variable	Sub-Division	Frequency (%)
Pacemaker Type	DDD	56 (49%)
	VVI	58 (51%)
Age	Under 60 years	47 (41.2%)
	Above 60 years	67 (58.8%)
Gender	Male	64 (56%)
	Female	50 (44%)
Duration of Implantation	Less than 4 years	55 (48.2%)
	More than 4 years	59 (51.8%)
Hypertension	Hypertensive	61 (53.5%)
	Non-hypertensive	53 (46.5%)
Diabetes Mellitus	Diabetic	18 (15.8%)
	Non-diabetic	96 (84.2%)
Smoking	Smoker	41 (36%)
	Non-smoker	73 (64%)
Ischemic Heart Disease	History of IHD	13 (11.4%)
	No history of IHD	101 (88.6%)

Among the 114 patients, 14% (n=16) developed AF, while 86% (n=98) were free of AF. The incidence of AF was significantly higher in patients with VVI pacemakers (21%, n=12) compared to those with DDD pacemakers (7%, n=4) (p = 0.034). Table 2 presents the findings.

The results showed that although there is a higher rate of AF in male patients with VVI pacemakers compared to those with DDD pacemakers, the difference does not reach statistical significance (p-value=0.07). Also, although the incidence of AF was higher in female patients with

VVI pacemakers compared to those with DDD pacemakers, the difference is not statistically significant (p-value= 0.16) (Table 3).

One hundred fourteen patients (64 male, 50 female) patients in our study ranged from 21 to 89 years old, with a mean ± SD (58.58 ± 15.535) years. The difference in AF incidence between VVI and DDD pacemaker modes in patients under 60 was not statistically significant (p-value=0.107). The difference in AF incidence between pacemaker modes in this older age group was also not statistically significant (p-value=0.740) (Table 4).

Table 5 shows the frequency distribution of patients with AF based on pacemaker mode, categorized by implantation duration (< 4 years and > 4 years). The results indicated no significant difference in AF occurrence between pacemaker modes within each duration group (p-values=0.175, 0.288).

Table 2: Association Between Pacemaker Mode and AF Incidence

Pacemaker Mode	AF Presence (%)	AF Absence (%)	Total (%)	p-value
DDD	4 (7%)	52 (93%)	56 (100%)	0.034
VVI	12 (21%)	46 (79%)	58 (100%)	

Table 3. Comparison of AF incidence between VVI and DDD Pacemaker Modes in male and female patients.

Gender	Pacemaker Mode	AF	Non-AF	Total	p-value
Male	VVI	9	21	30	0. 07
Male	DDD	4	30	34	
Female	VVI	3	25	28	0.16
Female	DDD	0	22	22	

Table 4. Comparison of AF incidence according to a pacemaker in patients under and over 60 years old.

Age group	Pacemaker Mode	AF	Non-AF	Total	p-value
< 60 years	VVI	3	4	7	0.107
< 60 years	DDD	1	30	31	
> 60 years	VVI	9	42	51	0.740
> 60 years	DDD	3	22	25	

Table 5: Frequency distribution of patients with AF according to Pacemaker Mode based on duration of implantation

Implantation Duration	Pacemaker Mode	AF	Non-AF	Total	p-value
< 4 years	VVI	4	18	22	0.175
< 4 years	DDD	2	31	33	
> 4 years	VVI	8	28	36	0.288
> 4 years	DDD	2	21	23	

Table 6. Comparison of AF Incidence in hypertensive, diabetic, and smoking patients by Pacemaker Mode

Patient Group	Pacemaker Mode	AF	Non-AF	Total	p-value
Hypertensive	VVI	5	25	30	0.276
Hypertensive	DDD	2	25	27	
Diabetic	VVI	3	9	12	0.269
Diabetic	DDD	0	6	6	
Smoker	VVI	6	15	21	0.134
Smoker	DDD	2	16	18	

Table 6 presents the distribution of AF incidence by pacemaker mode in hypertensive, diabetic, and smoking patients. The analysis showed no statistically significant differences in AF incidence across pacemaker modes in any of these patient groups (p-value > 0.05) (Table 6).

DISCUSSION

The present study aimed to evaluate the incidence of AF in patients with CHB and the association between AF occurrence and pacemaker mode (DDD vs. VVI).

The results demonstrated a statistically significant difference in AF incidence between patients with DDD pacemakers and those with VVI pacemakers. Specifically, AF was more prevalent in patients with VVI pacemakers (21%) compared to those with DDD pacemakers (7%). This aligns with the understanding that DDD provides better atrial and ventricular activity synchronization, which may reduce the likelihood of atrial arrhythmias, including AF. The ability of DDD pacemakers to monitor atrial activity may also improve the early detection of AF, contributing to the lower observed AF incidence in this group.

The result is similar to the study done by Sweeney et al. They found that the incidence of AF in VVI-pacing mode patients was up to 29%.[16] also, a study by Majewski J et al.[17] showed that in the VVI group, the incidence of AF was significantly higher than in the DDD group, 30.3%, and 3.33%, respectively. The increased incidence of AF in VVI mode is related to changes in the hemodynamic consequences of VVI pacing during sinus rhythm, which are more prominent if the atrial contraction is against closed atrioventricular valves. It leads to a strong increase in atrial pressure and regurgitation into the pulmonary veins. These may lead to considerable distension of pulmonary veins, representing a potent trigger for AF. As focal electrical activity in the pulmonary veins and acute atrial stretch have been recognized as two of the most important AF triggers in patients with and without structural heart disease, there is also evidence of an increased rate of atrial ischemia and inflammatory change due to atrial contraction against closed atrioventricular valves.[18]

In patients with DDD mode due to AV synchrony, there is no evidence of increasing atrial pressure or pulmonary vein distention that may trigger the development of AF. However, changes in the duration of AV delay in patients with DDD pacemakers could affect the development of AF, which explains why AF is more common in DDD patients than in the general population.[19-22]

The age subgroup analysis did not reveal a significant difference in AF incidence between pacemaker modes for patients under 60 and over 60. These findings suggest that pacemaker mode alone may not be a determining factor for AF in relation to age and that the benefits of DDD over VVI pacemakers in reducing AF risk may be independent of patient age, same as the result of the study done by Jordaens et al. [23] this shows that in both groups of patients, only the mode of pacemaker affected the development of atrial fibrillation as the age hadn't effect in developing more AF in VVI group.

In the present study, the occurrence of AF was not significantly related to the history of ischemic heart disease (which had been diagnosed invasively or non-invasively in our patients) as in the study done by Allan et al. [24]from 3.84% per year to 2.8% per year

($p = 0.016$. This also shows the significance of the mode of pacing in AF occurrence.

Also, as in previously mentioned studies, there was no obvious difference in gender relation to the development of AF compared to pacemakers' modes. Although it was not statistically significant in our study, there was a statistically higher occurrence of AF in male gender patients (15%). In comparison, it was (6%) in females, as also in the study by Stuart et al.[25] the rate of AF was higher in the male gender. This could be related to the fact that cardiovascular diseases are usually more prevalent in the male gender than in females.[26]

Our study, as the survey done by Grimm et al.[27] includes patients with risk factors of AF, including hypertension, DM, and smoker patients. There was not a statistically significant difference in the number of patients who developed AF regarding diabetes mellitus, hypertension, and smoking in both VVI and DDD mode pacing (although there was a statistically non-significant higher prevalence of these risk factors among patients who developed AF). The absence of difference in the range of occurrence of these risk factors among the pacing modes in our study emphasizes the significance of the pacing mode effect on AF occurrence rather than the mentioned risk factors alone.

The present study's limitations include a small sample size, constrained by the limited study period, and incomplete data from other patients at the CRM unit, which led to their exclusion. Additionally, Holter monitoring was not utilized.

CONCLUSION

The present study highlights the importance of pacemaker mode in the detection and prevention of AF in patients with CHB. The results suggest that DDD pacemakers may offer superior outcomes regarding AF risk compared to VVI pacemakers. However, clinical decision-making must also consider individual patient characteristics and comorbidities. Future research should investigate other factors that may interact with pacemaker mode to influence AF development, such as pacemaker programming settings, patient adherence to follow-up care, and the role of advanced pacemaker technologies in detecting asymptomatic AF.

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CONFLICT OF INTEREST
Authors declare no conflict of interest.
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AUTHORS' CONTRIBUTION

The following authors have made substantial contributions to the manuscript as under:

Conception or Design:	HMM
Acquisition, Analysis or Interpretation of Data:	HMM
Manuscript Writing & Approval:	HMM

All the authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.