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Outcomes of Patients Who Have Incidental Non-Sustained Ventricular Tachycardia Identified on Cardiac Implantable Electronic Device Interrogation

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Abstract: Background: Non-sustained ventricular tachycardia (NSVT) is an arrhythmia prevalent in both structurally normal and abnormal hearts. Methods: We conducted a single-center retrospective clinical audit of patients followed-up in a device clinic with one or more incidental NSVT episodes recorded on their device between November 2017 and August 2018 and followed up patients for outcomes until January 2019. Results: A total of 83 patients were included in the analysis with one or more episodes of NSVT on device interrogation. Those identified to have NSVT were more likely to be male (74.7%) and there was a mean of 14.2 beats per episode and a mean of 3.7 episodes for each patient. Only 24.7% of patients had electrolytes checked within 4 weeks of episode detection and 18.3% had an echocardiogram post-episode. The majority of patients (73.5%) were followed up again in the pacing clinic but had no changes in medication, or other management implemented. In terms of outcomes, 81.7% of patients had no admission to hospital, mortality, or shock during the follow-up period. Conclusions: Most patients who developed NSVT did not have an extra follow-up, medication review, or investigation. Despite this, outcomes such as admission, shock, or death were uncommon.

Keywords: non-sustained ventricular tachycardia; cardiac implantable devices; outcomes

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1. Introduction

Non-sustained ventricular tachycardia (NSVT) is an arrhythmia prevalent in both structurally normal and abnormal hearts [1]. NSVT is associated with an increased risk of mortality in patients with coronary heart disease, left ventricular hypertrophy and severe heart failure [2–4]. Even in structurally normal hearts, NSVT has been associated with cardiovascular hospitalisation, stroke and death [5]. Given the adverse outcomes associated with NSVT, it is important to gain better insights on this arrhythmia.

Reliable epidemiological data about NSVT is challenging to gather for several reasons. Firstly, there is no consensus on diagnostic criteria for this ectopic ventricular rhythm and there are several definitions in the existing literature (see Table S1) [4,6–9]. Definitions vary in the duration of NSVT; some diagnostic criteria state NSVT must resolve within 30 s [7–9] while others do not define a time period [4,6]. There is also variation in the number of beats required to characterise NSVT; some definitions require at least 3 beats at a rate >100 beats per minute [4,6,7], while others require ≥3 beats at a rate ≥120 beats per minute [8]. Still, another definition requires runs of ≥16 beats with a rate ≥125 beats per minute [9]. Commonalities between the definitions are that NSVT is a

spontaneously resolving arrhythmia with wide QRS complexes. Secondly, studies using ambulatory monitoring as a method of NSVT identification may be underestimating its burden. Several studies have shown marked spontaneous variability in the frequency of ventricular arrhythmias; ambulatory monitoring would have to be performed at the right time to detect events [10–12]. This may be evidenced by an ambulatory electrocardiogram (ECG) monitoring study of post-infarction patients with previously confirmed NSVT, which found the arrhythmia to be reproduced in only 50% of patients' repeat ECGs [13]. Thirdly, patients may be asymptomatic with the arrhythmia given the transience of each NSVT episode. That being said, NSVT is a common finding in patients who present with palpitations; one study found NSVT to be prevalent in nearly 6% of patients with palpitations [14].

Cardiac devices are implanted in over 250,000 European patients every year for a plethora of indications [7]. As these implanted devices continuously monitor cardiac rhythm, identification of patients with NSVT is likely to be more reliable. Existing studies of cardiac device patients with NSVT have shown no association with mortality [15,16]. This is in contrast to evidence which suggests NSVT confers a greater risk of death in patients with structural heart disease [2–4]. Furthermore, existing studies which examined the prognostic significance of NSVT in cardiac device patients do not explore the characteristics of patients with NSVT or the management of identified episodes [15,16]. In order to better understand the characteristics of patients who have NSVT, identify how they are managed and clarify prognostic outcomes, we conducted a retrospective audit of cardiac device patients in our UK-based tertiary hospital.

2. Methods

We conducted a retrospective clinical audit and health service evaluation of patients in the device clinic at Royal Stoke University Hospital. Royal Stoke University Hospital provides tertiary-level cardiology care with four catheter laboratories and a cardiac device service that implants cardiac implantable electronic devices. Every patient who undergoes cardiac device implantation in the hospital is followed-up regularly in the device clinic. This follow-up includes symptom/rhythm correlation, interrogation of the cardiac device, identification of arrhythmias and institution of appropriate management.

The cohort for this retrospective clinical audit was obtained from patients followed-up in the device clinic between November 2017 and August 2018 with permanent pacemakers, implantable cardioverter defibrillators and cardiac resynchronisation therapy devices. These patients were identified at routine device interrogation by electrophysiology technicians. Using prior definitions as a guide, an episode of NSVT was defined as a tachyarrhythmia (heart rate >100 beats per minute) with a wide QRS lasting >3 beats and resolving within 30 s. Patients found to have one or more incidental NSVT episodes recorded on their device, irrespective of accompanying symptoms, were included in the study.

In order to ensure precise identification of outcomes, including readmission, the current study included patients whose home address was within the catchment area for the Royal Stoke University Hospital; this corresponded to addresses beginning with the postcodes ST1–ST13, ST15–ST18 and ST21. Patients with incomplete data on electronic medical records were also excluded.

Data on patient age, sex, comorbidities, echocardiography, medications, type of device, blood results, management and outcomes was collected from electronic medical records by four auditors (A.N., C.L.W., J.M., D.D.). Patients were followed up until January 2019 for the outcomes shock, readmission related to NSVT and death. Extracted data was tabulated on an Excel spreadsheet and descriptive statistics were analysed on Stata (College Station, TX, USA).

A control group was not used in this study as it would have been impractical. Given the study design included patients all had NSVT; comparison with cardiac device patients who did not have NSVT would not have been appropriate. The aim of this study was to

characterise the characteristics, outcomes and follow-up of patients who developed NSVT and therefore a control group was not used.

3. Results

Between November 2017 and August 2018, 97 patients with implanted cardiac devices were found to have one or more episodes of NSVT on device interrogation. Of these patients, five were excluded from analysis because they lived outside the catchment area of Royal Stoke University Hospital and nine were excluded due to incomplete data on electronic medical records. A total of 83 patients were included in the analysis.

Table 1 shows demographic factors and comorbidities of the 83 patients (mean age 75.1 years old) included in this analysis. The current cohort had a greater proportion of males (74.7%) and the comorbidities prevalent in these patients were hypertension (41%), ischemic heart disease (39.8%) and atrial fibrillation/flutter (33.7%). Interestingly, only 6% of patients had a documented history of ventricular arrhythmias (ventricular tachycardia or fibrillation).

Table 2 presents data on cardiac devices and pre-NSVT variables. The most common indication for device implantation was heart block/bradycardia (57.8%). Several types of cardiac device were implanted; permanent pacemaker (59%), cardiac resynchronisation therapy devices (24.1%) and implantable cardioverter defibrillator (16.9%). Table 2 shows further information about the type of device implanted. From the 68 patients who had echocardiograms before NSVT was recorded, 52.9% had left ventricular systolic impairment and 39.7% had valvular dysfunction. Of the 76 patients on medications pre-NSVT, 56.6% were on beta-blockers/diltiazem, 59.2% were on angiotensin-converting enzyme inhibitors or angiotensin receptor blockers, 47.4% were prescribed a diuretic and 43.4% were anticoagulated.

Table 3 summarises NSVT events, post-detection management and outcomes. All patients had >5 beats of NSVT with a mean of 15.9 beats per episode. The mean number of episodes in the current cohort is 3.6. 24.7% of patients had electrolytes checked within four weeks of episode detection and 18.3% had an echocardiogram post-episode. The majority of patients (73.5%) were followed up again in the pacing clinic but had no changes in medication or other management implemented. In terms of outcomes, 81.7% of patients had no admission to hospital, mortality or shock during the follow-up period.

Table 1. Patient characteristics and comorbidities (n = 83).

Variable	Value
Mean age (±SD)	75.1 ± 11.7
Median age (IQR)	77 (66–84)
Male	62 (74.7%)
Coronary artery disease	26 (31.3%)
Myocardial infarction	7 (8.4%)
Mean ejection fraction (±SD)	46.0% ± 13.8%
Cardiomyopathy	
Ischemic	15 (18.1%)
Dilated	11 (13.3%)
Hypertrophic obstructive cardiomyopathy	2 (2.4%)
Unclear	8 (9.6%)
None	46 (55.4%)
AF/atrial flutter	28 (33.7%)
Previous PCI	3 (3.6%)
Previous CABG	7 (8.4%)

Table 1. *Cont.*

Variable	Value
Valvular heart disease	13 (15.7%)
Second degree or complete atrioventricular block/sick sinus syndrome	19 (22.9%)
Previous ventricular tachycardia/fibrillation	5 (6.0%)
Cardiac arrest	5 (6.0%)
Hypertension	34 (41.0%)
Hypercholesterolemia	19 (22.9%)
Diabetes mellitus	20 (24.1%)
Chronic lung disease	21 (25.3%)
Renal disease	10 (12.1%)
Gastrointestinal disease	10 (12.1%)
Rheumatoid arthritis and connective tissue disease	5 (6.0%)
Previous stroke or TIA	11 (13.3%)
Peripheral vascular disease or aortopathy	4 (4.8%)
DVT or pulmonary embolus	6 (7.2%)
Cancer	5 (6.0%)
Depression	5 (6.0%)

SD = standard deviation, IQR = interquartile range, PCI = percutaneous coronary intervention, CABG = coronary artery bypass graft, TIA = transient ischemic attack, DVT = deep vein thrombosis.

Table 2. Device and pre-ventricular tachycardia variables.

Variable	Value
Indication for device	
Heart block/bradycardia	48 (57.8%)
Heart failure	17 (20.5%)
Ventricular arrhythmia/cardiac arrest	14 (16.9%)
AV nodal ablation	3 (3.6%)
Sick sinus syndrome	1 (1.2%)
Indication for ICD (n = 22)	
Primary prevention	13 (59%)
Secondary prevention	9 (41%)
Device	
VVI PPM	10 (12.0%)
DDD PPM	39 (47.0%)
ICD-VR	2 (2.4%)
ICD-DR	12 (14.5%)
CRT-P	12 (14.5%)
CRT-D	8 (9.6%)
Pre-VT echocardiogram	(n = 68)
Left ventricular systolic impairment	36 (52.9%)
Regional wall motion abnormalities	14 (20.6%)
Valvular dysfunction (including mild severity)	27 (39.7%)

Table 2. *Cont.*

Variable	Value
Mean pre-VT electrolytes	(*n* = 79)
Na	138.6 ± 3.3
K	4.5 ± 0.4
Ur	8.2 ± 3.9
Creatinine	93.7 ± 41.1
eGFR	67.9 ± 20.7
Previous medications	(*n* = 76)
Beta-blocker/diltiazem	43 (56.6%)
ACE-inhibitor or ARB	45 (59.2%)
Diuretic	36 (47.4%)
Digoxin	4 (5.3%)
Amiodarone/dronedarone	4 (5.3%)
Mexiletine	4 (5.3%)
Anticoagulation	33 (43.4%)

CRT-P = cardiac resynchronisation therapy-pacemaker, CRT-D = cardiac resynchronisation therapy defibrillator, VT = ventricular tachycardia, eGFR = estimated glomerular filtration rate, ACE = angiotensin converting enzyme, ARB = angiotensin receptor blocker.

Table 3. Non-sustained ventricular tachycardia event, management and outcomes.

Variable	Value
Mean NSVT episodes (±SD)	3.6 ± 3.9
Mean NSVT beats	15.9 ± 8.9
Post NSVT echocardiogram performed	15 (18.3%)
Check of U&E within 4 weeks	19 (24.7%)
Normal	13 (16.9%)
Low Na	1 (1.2%)
Low K	1 (1.2%)
Chronic kidney disease	4 (5.2%)
Management at next follow up	
Cardiology clinic no change in medications	4 (4.8%)
Cardiology clinic change in medications	2 (2.4%)
Pacing clinic no change in medication	61 (73.5%)
Pacing clinic change in medications	9 (10.8%)
No action no follow up	6 (7.2%)
No action patient admitted	1 (1.2%)
Outcomes	
Shock (*n* = 22)	4 (18.2%)
Anti-tachycardia pacing (*n* = 22)	9 (40.9%)
No readmission within 12 months	67 (81.7%)

Table 3. *Cont.*

Variable	Value
Readmission within 6 months	10 (12.2%)
Readmission within 12 months	14 (17.1%)
Readmission related to VT event	2 (2.5%)
Death	3 (3.6%)

NSVT = non-sustained ventricular tachycardia, SD = standard deviation, IQR = interquartile range, U&E = urea and electrolytes, VT = ventricular tachycardia.

4. Discussion

Our evaluation of a cohort of cardiac implantable electronic device patients with NSVT has several key findings. Firstly, most patients who developed NSVT did not develop adverse outcomes such as VT-related admission, shock or death in the follow-up period. This is the first study to consider the management of patients after identification of incidental NSVT events; 91% of patients were followed up in routine pacing or cardiology clinic, 25% had urea and electrolytes checked post-NSVT and 18% had a post-NSVT echocardiogram. Although patients were not randomised into a treatment group, all included patients were followed up for treatment and the results showed no differences in outcome regardless of the degree of clinic follow-up or medication rationalisation.

These findings suggest that NSVT may not be an adverse prognostic marker in cardiac device patients.

Previous studies, which have used ambulatory ECGs as a method of arrhythmia identification, have shown ventricular arrhythmias to be statistically significant independent predictors of mortality in patients with structural heart disease [2–4]. In addition, studies have shown that the presence of NSVT [17], frequency [18] and duration of episodes [19] may predict sudden death in patients with heart failure. These studies have several limitations, including a lack of predetermined criteria for interpretation of arrhythmias, potential sampling bias through the use of ambulatory monitoring and investigation of specific cardiac cohorts. In addition, none of these studies have considered the medical management and investigation of patients' NSVT during the follow-up period.

In this study, we add to the literature by considering the follow-up and further management patients receive after identification of incidental NSVT events. Current guidance suggests that treatment of NSVT should focus on the management of underlying cardiac problems rather than on the arrhythmia itself. When NSVT is detected in the context of existing cardiac disease, the finding of NSVT should trigger further investigation of the patient for reversible causes and prompt medication review [20]. The mechanism by which NSVT occurs in patients may be through association with ischemic heart disease; cardiac ischemia and infarction may result in fibrosis and subsequent disruption of myocardial electrical conduction [21,22].

The current study has found that adverse outcomes were rare despite incomplete follow-up of patients with NSVT. 24.7% of patients had electrolytes checked and 18.3% of patients had echocardiograms after recorded NSVT episodes. Of the 76 (91.5%) patients who were followed up in routine pacing or cardiology clinic, only 13 (17.1%) had medication changes. Of the 13 patients who had medication changes, 11 (84.6%) had bisoprolol doses up-titrated, one had anticoagulation added due to atrial fibrillation and one had amiodarone dose titrated. Two of the 13 (15.4%) patients who had medication alterations were readmitted during the period of follow-up (one for falls, one for recurrent NSVT). The current study has found a low rate of death (2.4%), shock (2.5%) or VT-related admission (2.5%) in NSVT patients during the follow-up period. Variation in the results between this study and existing research may be because of baseline demographic differences in cohorts between studies, differences in NSVT definition and method of identification and differences between prospective and retrospective data collection. The evidence is,

however, contradictory to the role of NSVT as a predictor of mortality and more study is required.

While the results of the current study are discordant with ambulatory ECG studies, the results do agree with other studies of pacemaker interrogation. A study of 119 pacemaker patients with ejection fractions >40% found NSVT to have no association with mortality [15]. Similarly, a study of incidental NSVT in pacemaker patients found NSVT to have no impact on survival [16]. The study by Jamil et al. was a large prospective study with an unselected cohort of 565 pacemaker patients with a mean follow-up of 4 years and found that NSVT is not a predictor of adverse outcomes even in higher-risk subgroups. The results of the current study echo the results of Jamil et al. and also suggest that outcomes of NSVT patients are reassuring even in the context of limited or no clinical investigation.

The current study has several limitations, including a small sample size, limited duration of follow-up and retrospective design. It is, however, an unselected cohort of cardiac device patients with a variety of disease types and severity. In addition, the results of this study are not generalisable to cohorts with structurally normal hearts. The findings of our study suggest minimal intervention is required for incidental NSVT in cardiac device patients, given the paucity of poor outcomes. That being said, further research is required to clarify the relationship between NSVT and mortality, given the contradictory findings of existing studies.

In conclusion, NSVT among patients with devices is most common in the elderly patients. Most patients who developed NSVT did not have an additional follow-up, medication review or investigation. Despite this, outcomes such as admission, shock or death were uncommon.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/hearts2030024/s1, Table S1: Definitions of nonsustained ventricular tachycardia in existing literature.

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