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Arrhythmogenicity of anti-tachycardia pacing programming parameters in patients with structural heart disease and implantable defibrillators

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ABSTRACT

Background: Anti-tachycardia pacing therapy (ATP) is an effective, painless therapy for ventricular tachycardia (VT) termination. However, some patients experience VT acceleration that might degenerate into ventricular fibrillation (VF), leading to shock therapy. The aim of the study was to investigate the incidence of VT acceleration in patients with structural heart disease and implantable defibrillators and its relation to the ATP programming parameters.

Methods: A total of 448 monomorphic VT episodes in 60 patients with structural heart disease and an ICD implant were reviewed after being retrieved from the programmers. The patients' clinical data and the episodes' details were analysed.

Results: ATP therapy was successful in terminating the VT in 70% of the analysed episodes. The incidence of VT acceleration in our studied patients was 8.5%. Patients with accelerated VT had a lower ejection fraction compared to patients with ATP-successful episodes. In the accelerated episodes, ramp pacing and scanning were frequently turned on. When VT-accelerated episodes were compared to ATP-successful ones, the number of ATP bursts was higher and the adaptive cycle length was shorter.

Conclusions: Ventricular tachycardia acceleration by ATP therapy is likely to occur in patients with a severely impaired ejection fraction. Scanning, ramp pacing, and the number of ATP bursts delivered had a significant effect on VT acceleration. Scanning and ramp pacing are better to be turned off, and a lesser number of ATP bursts with a longer adaptive CL should be delivered.

Keywords: *VT acceleration – Ramp pacing- Scanning-Ventricular tachycardia- ATP therapy- ICD therapy*

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BACKGROUND

Implantable cardioverter defibrillators (ICDs) therapy reduced total mortality in patients with structural heart disease and impaired ejection fraction who were at high risk of fatal ventricular arrhythmia resulting in sudden arrhythmic death (1). The two types of therapy provided by the ICDs are shock therapy, which is an effective but painful therapy, and painless ATP therapy (2) . A significant number of patients who receive ICD shocks have anxiety and depression, which affect their quality of life badly and lead to poor outcomes and increased mortality (3) .

Scar-related myocardial reentry is the main mechanism of sustained monomorphic VT in patients with structural heart disease (4) and reentrant tachycardia is susceptible to pace termination, which makes ATP therapy effective (5). In addition to being a painless therapy, it is simple to programme and reduces battery drain (6). The drawbacks of ATP therapy include being unsuitable for hemodynamically unstable patients, polymorphic VT or Vf. ATP may also result in VT acceleration, which may degenerate into VF (7). The aim of the study is to evaluate the proarrhythmic effect of ATP programming parameters on VT acceleration.

METHODS

The study is prospective and analytical; it included patients with structural heart disease and an ICD implant who had VT episodes treated by ATP therapy. The data retrieved from the programmers was used in the outpatient device follow-up clinic for offline analysis. The study complied with the Declaration of Helsinki, and the study protocol was approved by the local research committee. All patients signed informed written consent.

The exclusion criteria included polymorphic VT/VF episodes as diagnosed by the intracardiac far-field EGM, supraventricular episodes that were falsely labelled as VT and treated accordingly, inappropriate TP therapy due to lead noise, non-sustained VT episodes, and episodes that exceed the device memory. The data collected were the demographic data, the clinical diagnosis, the indication of ICD implantation, the left ventricle systolic function assessed by the ejection fraction, and the antiarrhythmic medications received. The retrieved episodes were analysed with regard to the ATP programming parameters and the response after ATP therapy. The VT acceleration is a decrease in the VT cycle length by more than 10%, or the transformation to Vf. ATP success is the restoration of sinus rhythm following ATP therapy, while ATP failure is the exact opposite. Few episodes terminated spontaneously or slowed down below the detection rate.

STATISTICAL ANALYSIS

Recorded data were analyzed using the statistical package for social sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA). The mean standard deviation (SD) was used to express quantitative data. Qualitative data were expressed as frequency and percentage. The confidence interval was set to 95%, with a 5% acceptable margin of error. So, a P-value of 0.05 was considered significant.

RESULTS

Following the exclusion criteria, a total of 60 patients were included, with 448 retrieved episodes. The patients' ages ranged from 38 to 80 years old (mean = 56.609.44 SD). The male gender predominated the study groups; there were 54 (90%) males and 6 (10%) females. Among the included patients in our study, ischemic cardiomyopathy (ICM) was the most prevalent preimplantation diagnosis, representing 41 out of 60 patients (68.3%), followed by dilated cardiomyopathy (DCM) in 16 patients (26.7%), arrhythmogenic right ventricular cardiomyopathy (ARVD) in 2 patients (3.3%), and one patient with hypertrophic obstructive cardiomyopathy (HOCM). Most of the study group (56 patients, or 93.3%) received defibrillation therapy for secondary prevention of sudden cardiac death. All the studied patients had impaired left ventricular ejection fraction (except the two patients with ARVC; they had impaired RV systolic function). The mean EF% of the patients was 35.037.72 SD (range 21–62%).

The response to ATP therapy is summarized in table (1). Beta blockade therapy was the most commonly prescribed anti-arrhythmic drug therapy in our study, with 53 patients (88.3%) receiving it either as a monotherapy (36.7%) or in a combination therapy with other anti-arrhythmic drugs (51.6%), followed by Amiodarone (48.3%) in a combination therapy, 15% receiving Ivabradine, and 10% receiving Sotalol. Digoxin was the least drug prescribed (3.3%).

Among the ATP programming parameters, the number of ATP bursts showed a statistically significant difference between the accelerated episodes and the ATP success episodes (mean = 3.66 ± 2.22 SD) vs. (mean = 1.57±1.10 SD) respectively, (P value <0.001). Also, the burst adaptive cycle length showed a statistically significant difference between the accelerated episodes and the ATP success episodes, (mean = 83.55±2.92 SD) vs. (mean = 84.55±2.78 SD) respectively, (P value 0.039). Scanning with a scan step of -10 msec was on more frequently in the accelerated episodes compared to the ATP success episodes (55.3%) vs (24.0%) respectively, (P value: <0001). Ramp pacing was on more frequently in the accelerated episodes compared to the ATP success episodes (23.7%) and (4.5%) respectively, (P value: < 0.001). The number of stimuli in each burst did not differ between the two groups. Table (2)

TABLE 1: The response to ATP therapy

Response to ATP therapy	**Total (n=448)**
ATP success	313 (70. %)
VT Acceleration by ATP therapy	38 (8.5%)
HV therapy after ATP failure	88 (19.6%)
VT deceleration below the detection rate	6 (1.3%)
Spontaneous termination	3 (0.60%)

ATP, anti-tachycardia therapy; VT, ventricular tachycardia; HV, high voltage; n, number.

TABLE 2: Comparison between ATP acceleration and ATP success episodes according to the VT characters and the ATP programing parameters

ATP programing parameters	**VT acceleration episodes *(n=38)***	**ATP Success episodes *(n=314)***	**p-value**
VT CL			
Mean±SD	318.82±27.39	334.82±47.16	0.041*
Range	258-378	236-488	
Mean VTCL			
Mean±SD	318.71±25.92	337.19±27.68	0.027*
Range	260- 370	338-492	
No. of ATP bursts			
Mean±SD	3.66±2.22	1.57±1.10	<0.001**
Range	1-9	1-7	
Number of stimuli in each burst			
Mean±SD	8.50±0.98	8.23±1.12	0.157
Range	5-10	5-13	
Burst adaptive CL			
Mean±SD	83.55±2.92	84.55±2.78	0.039*
Range	80-88	75-88	
			p-value
Scanning			
No	17 (44.7%)	238 (76.0%)	<0.001**
Yes	21 (55.3%)	75 (24.0%)	
Ramp			
No	29 (76.3%)	299 (95.5%)	<0.001**
Yes	9 (23.7%)	14 (4.5%)	

ATP, antitachycardia pacing; VT, ventricular tachycardia; CL,cycle length; n, number; SD, standard deviation
*Using: t-Independent Sample t-test; x^2: Chi-square test. p-value>0.05 NS; *p-value <0.05 S; **p-value <0.001 HS*

DISCUSSION

Defibrillation therapy is highly effective in terminating life threatening arrhythmic events (8).Trans venous and subcutaneous ICDs are able to monitor the heart rhythm continuously and do discrimination process to deliver therapy in response to programmed detection criteria. Although being effective they result in a physical and psychological damages (9).

Aiming at providing a painless therapy and as an adjuvant to ICD shocks, anti-tachycardia pacing (ATP) has been demonstrated to be effective with no increase in mortality and improve patients' quality of life (10).

In the present study, we investigated the role of ATP programming parameters in VT acceleration in patients with structural heart disease who received ATP therapy for terminating monomorphic VTs. We retrospectively reviewed 448 ATP episodes in 60 patients, whose clinical characteristics and episode details were evaluated, and these were our main findings: The percentage of VT accelerated episodes was 8.5%, the ATP success rate was 70%, and a greater impairment of the left ventricle ejection was found in the patients who had accelerated episodes. Among the ATP programming parameters, the number of ATP bursts, ramp pacing, and scanning showed a high statistically significant difference between accelerated VT episodes and the ATP success episodes. A shorter burst adaptive cycle length showed a statistically significant difference between accelerated VT episodes and successful ATP episodes.

In small randomised studies (11) (12) (13) (14). , the efficacy of ramp pacing and scanning was tested; the VT termination success rate ranged from 65-90% and the VT acceleration rate ranged from 3.7-21% regardless of pacing mode. In the current study, the success rate was 70%, and the acceleration rate was 8.5%. VT acceleration was observed more frequently in patients with greater impairment of the function. In Hammil et al. (15) they found that the ATP success rate is higher in patients with a higher EF and that VT acceleration is more likely to happen in patients with a greater impairment of the LV ejection fraction.

The effect of antiarrhythmic drugs on VT acceleration was not adequately studied as they were continuously changed during the course of the disease. According to Peter et al. (16) there is no link between the occurrence of VT acceleration and specific AAD. In the current study, we found that ramp pacing was more frequently activated in VT accelerated episodes (23.7%) than in ATP-success episodes (4.5%) (P value 0.001). Scanning with a scan step of -10 msec was also used more frequently in VT-accelerated episodes (55.3% vs. 24%; P = 0.001). In Hammil et al.,(15) they found that VT acceleration was associated with short pacing adaptive cycle length with either burst pacing (P = 0.02) or auto-decremental pacing (P = 0.03). In auto-decremental pacing, VT acceleration occurs with an increased number of pulses.

In a comparison (17) between the different ATP pacing sequences for fast VT termination, fifteen pulse ATP bursts was more effective in terminating VT in patients without heart failure history and mildly impaired ejection fraction (OR 5.21, 95%CI 1.39–19.50, p=0.014). On the contrary, eight pulses of ATP were more effective in terminating VT in patients with a previous history of heart failure and NYHA functional class I- II. In a recent study (18), burst pacing with a greater number of stimuli was associated with VT acceleration, especially in VT CL less than 347 msec.

Limitations

Randomization was not applied; a larger number of patients would be better for sampling, and the programming parameters were empirical according to the implanting physician.

CONCLUSIONS

Ventricular tachycardia acceleration by ATP therapy is likely to occur in patients with a severely impaired ejection fraction. Scanning, ramp pacing, and the number of ATP bursts had a significant effect on VT acceleration. Scanning and ramp pacing are better to be turned off, and a lesser number of ATP bursts with a longer adaptive CL should be delivered.

Source of funding

No funding was received.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest for this article.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The author declares that she has no competing interests

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No funding was received.

List of Abbreviations

Abbr.	Full term
AAD	Anti-arrhythmic drug
ATP	Anti-tachycardia pacing
ECG	Electrocardiogram
EGM	Electrograms
EPS	Electrophysiologic study
LV	Left ventricle
SD	Standard deviation
SCD	Sudden cardiac death
SPSS	Statistical Package for Social Sciences
VT CL	Ventricular tachycardia cycle length
VT	Ventricular tachycardia
VF	Ventricular fibrillation

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