

Diagnostic Value of Single Versus Dual Chamber Electrograms Recorded from an Implantable Defibrillator*

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Abstract. Introduction: The clinical utility of ventricular electrograms in comparison to atrial and ventricular electrograms in diagnosing the type of tachycardias recorded by an implantable defibrillator has not been addressed from the standpoint of a clinician's diagnostic accuracy and confidence in that diagnosis.

Methods: Fifty-two tachycardia episodes recorded from dual chamber defibrillators were divided into two tests. The initial test contained only information from the ventricular electrogram and the second test contained information from both the atrial and ventricular electrograms. For each test, the reviewers were asked to provide the specific diagnosis, the originating chamber of origin of the tachycardia, and the confidence of their responses for each question. McNemar's test for matched pairs was used to determine accuracy and an analysis of variance to determine reviewer confidence.

Results: The overall accuracy for both the specific diagnosis (61% vs. 79%; $p < 0.001$) and the chamber of origin (76% vs. 90%; $p < 0.001$) improved when both the atrial and ventricular electrograms were available for review. Reviewer confidence appeared to correlate with diagnostic accuracy.

Conclusions: The data clearly show the favorable impact of dual chamber defibrillators on the diagnostic accuracy and confidence of clinicians faced with a clinical tachycardia recorded from an implantable defibrillator. Such improvements may translate into more focused and appropriate therapeutic interventions.

Key Words. defibrillator, tachycardia, diagnosis

Introduction

During clinical electrophysiologic testing, multiple endocardial catheters are used to record electrograms and determine a tachycardia's mechanism [1]. Implantable defibrillators provide either ventricular, or atrial and ventricular electrograms. The clinical utility of ventricular, or atrial and ventricular electrograms in diagnosing the type of tachycardias recorded by an implantable

defibrillator has not been addressed from the standpoint of a clinician's diagnostic accuracy and confidence. Presumably, the combination of atrial and ventricular electrogram recordings provide incremental diagnostic information, compared to only a ventricular electrogram recording. Therefore, the purpose of this study was to compare a group of clinicians' diagnostic accuracy and confidence in determining the type of tachycardias recorded by an implantable defibrillator when provided with a ventricular electrogram alone or with atrial and ventricular electrograms.

Methods

Study Design

Dual chamber electrogram recordings were obtained during clinical follow-up and then pre-selected with the intent of finding a variety of clinical tachycardias for analysis. A consensus diagnosis was made by two investigators (MHK & SAS) using standard techniques [2]. These reviewers used all available clinical information including electrocardiograms, rhythm strips, results of electrophysiology testing, and the patient history. Five additional electrophysiologists reviewed the 52 selected tachyarrhythmia episodes

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which included 8 examples of sinus tachycardia, 11 of atrial fibrillation/flutter, 4 of paroxysmal supraventricular tachycardia, 23 of ventricular tachycardia, 3 of ventricular fibrillation, and 3 of double tachycardias.

The 52 recorded tachycardia episodes were divided into 2 tests, each containing 52 tests of either single chamber or dual chamber electrograms. The tests were coded and randomized so that the sequence of episodes was different for each test. The initial test presented only the ventricular and/or shock electrogram and the marker channels. The atrial electrogram and atrial marker channel were not available for review in the initial test. Delivered therapies were also shown. Twelve of the 52 tachycardia episodes contained only the ventricular electrogram rather than both the shock and ventricular electrogram together. Tachycardia onset and/or termination was available in 32 of the 52 episodes. Electrogram morphology in sinus or supraventricular rhythm was not always available. After completion of the ventricular electrogram test, a waiting period of one month was used prior to the administration of the dual chamber electrogram test that contained the atrial and ventricular electrograms. For each test, the reviewers were asked to provide: (1) a specific diagnosis, (2) the originating chamber for the arrhythmia in question (atrial, ventricular, or both), and (3) the confidence of their responses for the previous 2 questions. Confidence ratings were based on a 5-point Likert scale: 1 = not certain, 2 = somewhat certain, 3 = certain, 4 = very certain, 5 = absolutely certain.

Patient Characteristics

Thirty-nine patients (29 men, 10 women) with a mean age of 59 ± 17 years at the time of defibrillator implant were the source of the arrhythmias used in this investigation. All recordings were obtained from Guidant dual chamber defibrillators (St. Paul, MN). These arrhythmias occurred 109 ± 155 days after the defibrillator was implanted.

Statistical Analysis

The McNemar's test for matched pairs was used to determine overall accuracy across all examiners and within each examiner. A p value < 0.05 was considered statistically significant. Reviewer confidence was analyzed using an analysis of variance to determine if confidence differed across examiners overall, when the ventricular electrogram only determination for the specific diagnosis and chamber of origin was correct or incorrect, and when the atrial and ventricular electrogram determination for the specific diagnosis

and chamber of origin was correct or incorrect. Multiple comparisons required a significance level of $p \leq 0.01$ to be considered statistically significant. Scheffe's method of adjustment was used when performing pairwise analysis. A logistic regression analysis was performed to assess the relationship between confidence and accuracy, and between tachycardia cycle length and the specific diagnosis.

Results

Main Findings

The overall accuracy in obtaining the diagnosis with the ventricular electrogram only (single chamber) was 61%, compared to 79% with both the atrial and ventricular electrograms (dual chamber) ($p < 0.001$; Table 1). The proportion of correct determinations differed based on the specific diagnosis (Table 1).

A significant improvement in diagnosing the chamber of origin (supraventricular, ventricular, or both (double tachycardia)) of the tachycardia was observed with the dual chamber electrograms in comparison to the single chamber electrograms. The overall accuracy increased from 76% with the ventricular electrogram to 90% when both electrograms were used ($p < 0.001$; Table 2). Selected cases demonstrating a benefit of the atrial lead are shown in Figures 1 and 2.

Table 1. Comparison of diagnostic accuracy with single versus dual chamber electrograms

Diagnosis (%)	Single lead accuracy	Double lead accuracy	P value
Overall	158/260 (61)	206/260 (79)	<0.001
Sinus tachycardia	18/40 (45)	26/40 (65)	0.046
Atrial fibrillation	47/55 (85)	50/55 (91)	0.40
Paroxysmal SVT	1/20 (5)	12/20 (60)	<0.001
Ventricular tachycardia	78/115 (68)	97/115 (84)	<0.001
Ventricular fibrillation	14/15 (93)	14/15 (93)	NS
Double tachycardia	0/15 (0)	7/15 (47)	<0.0001

NS: Not significant.

SVT: Supraventricular tachycardia.

Table 2. Comparison of diagnostic accuracy in diagnosing the tachycardia's chamber of origin with single versus dual chamber electrograms

Diagnosis (%)	Single lead accuracy	Dual lead accuracy	P value
Overall	197/260 (76)	233/260 (90)	<0.001
Supraventricular only	97/115 (84)	107/115 (93)	0.03
Ventricular only	100/130 (77)	119/130 (92)	<0.001
Double tachycardia	0/15 (0)	7/15 (47)	N/A

N/A: Not applicable due to small sample size.

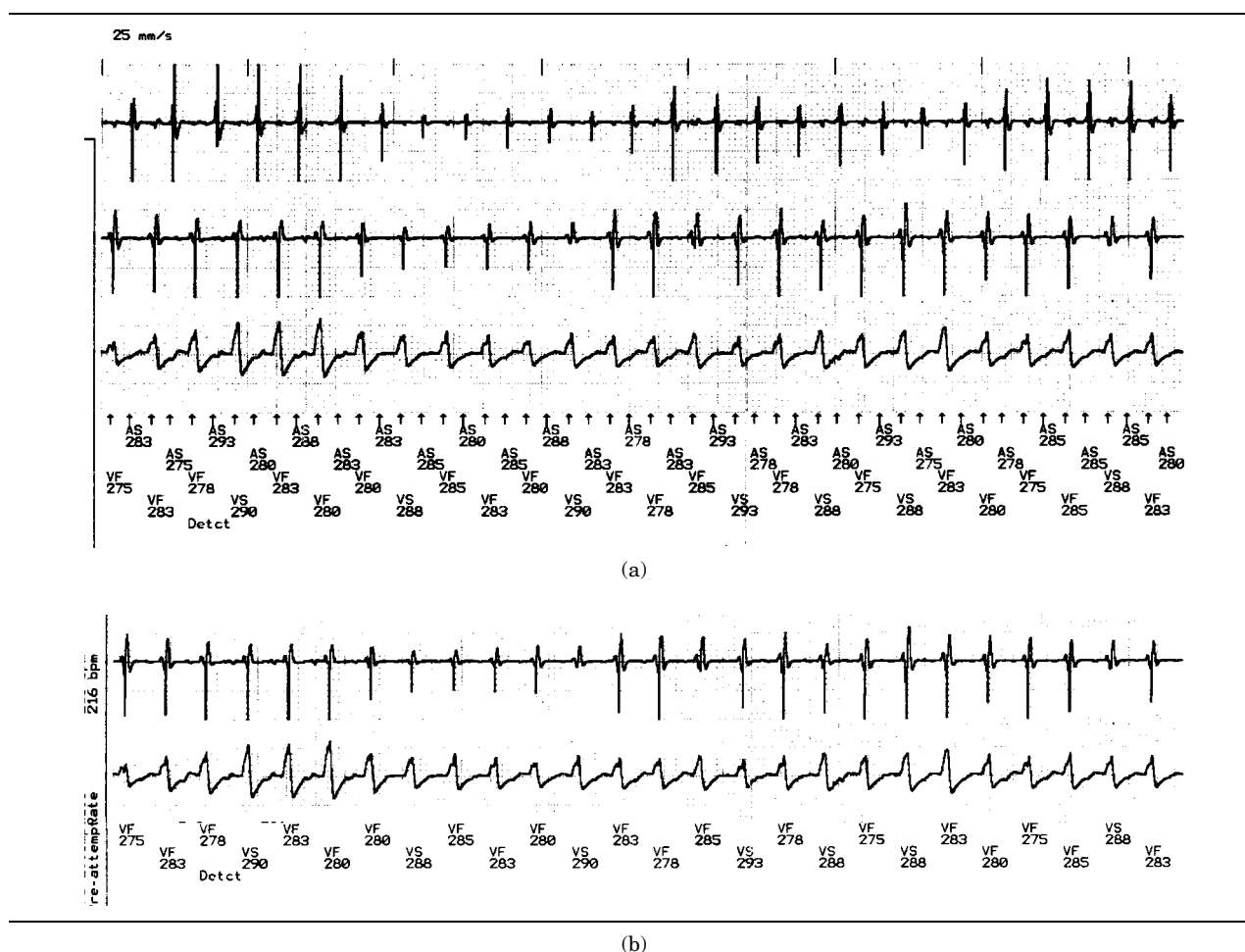


Fig. 1. (a) Sinus tachycardia / AV tracing. (b) Tachycardia diagnosis? / V tracing.

Confidence of the Reviewer

Across all reviewers, the mean confidence was significantly greater when the reviewer was, in fact, correct. For the specific diagnosis and determination of the chamber of origin with the ventricular electrogram, the odds of an accurate specific diagnosis doubled (odds ratio 2.0) and increased by 61% (odds ratio 1.6), respectively, with each unit increase in confidence along the 5-point Likert scale ($p < 0.0001$ for both). For the specific diagnosis with the atrial and ventricular electrograms, the odds of an accurate diagnosis were 67% greater (odds ratio = 1.67) with each unit increase in

confidence along a 5-point Likert scale ($p < 0.01$), but the odds of an accurate diagnosis of the chamber of origin of tachycardia did not correlate with confidence levels ($p = 0.3$).

Mean confidence in the diagnosis for both the ventricular only and atrial and ventricular electrograms are shown on Table 3. In the analysis of tachycardia cycle length for both the ventricular only and the atrial and ventricular electrograms, the odds of an accurate specific diagnosis, after adjustment for all reviewers, increased only for sinus tachycardia. Specifically, the odds increased by 1.2% with each millisecond increase

Table 3. Reviewers' confidence in their diagnosis when using single versus dual chamber electrograms based on 5-point Likert scale

	Specific diagnosis mean confidence (standard deviation)	P value	Chamber of origin mean confidence (standard deviation)	P value
Single lead (correct/incorrect)	3.4 (1.1)/2.8 (1.0)	<0.001	3.3 (1.1)/2.8 (1.0)	0.0004
Dual lead (correct/incorrect)	4.2 (1.0)/3.7 (1.1)	<0.01	4.2 (1.0)/3.9 (1.2)	0.3

Thus, the question of the dual chamber defibrillator's effectiveness in preventing inappropriate therapies is unanswered.

Despite this lack of definitive data on the performance of dual chamber detection algorithms in preventing inappropriate therapies, data from the present study suggest that when physicians have access to dual chamber electrograms, it is a very useful tool for determining the type of tachycardia that was treated by the implantable defibrillator.

Limitations

The major limitation of this study is that the evaluated tachycardias did not occur consecutively. Instead the recordings reflect a selected variety of clinical arrhythmias across a wide range tachycardia cycle lengths. The reviewers' ability to obtain the correct diagnosis was limited by the lack of information about the patient and the absence of an arrhythmia summary detailing comments such as the tachycardia onset, stability, and cycle length. This information, however, was available on the marker channels and could be inferred indirectly. Other factors which could have limited the clinicians' diagnostic accuracy included the lack of uniform availability of electrograms showing tachycardia onset and termination, no ventricular shock electrogram, and the inability to compare the electrograms in sinus or supraventricular rhythm.

Clinical Implications

The data contained herein clearly demonstrate the favorable impact of dual chamber defibrillators on the diagnostic accuracy and confidence in determining the diagnosis of a clinical arrhythmia. An improved diagnostic accuracy when interpreting stored electrograms from an implantable defibrillator should translate to an improved and more focused therapeutic approach. This finding sug-

gests that among patients with an indication for an implantable defibrillator, a dual chamber implantable defibrillator should be considered for patients in sinus rhythm. Additionally, a single lead implantable defibrillator system that provides atrial and ventricular electrograms may offer all of the advantages of a dual chamber implantable defibrillator without the extra lead and incremental costs associated with a conventional dual chamber implantable defibrillator.

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