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CLINICAL PAPER

Recorded heart sounds for identification of ventricular tachycardia☆

Richard Kobza, Markus Roos, Stefan Toggweiler, Michel Zuber, Paul Erne*

Division of Cardiology, Kantonsspital Luzern, Spitalstrasse, CH-6000 Luzern 16, Switzerland

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Summary
Background: The ECG discrimination of ventricular tachycardia (VT) vs. supraventricular tachycardia (SVT) is both important and often difficult. In this study, we tested the hypothesis that recorded digital cardiac acoustical data reflect hemodynamic changes that can be used for VT detection.
Methods: We studied 57 subjects (42 males, mean age 57, range 24—83 years) who had undergone electrophysiological testing for known and suspected cardiac arrhythmias. Acoustic cardiography (Audicor®, Inovise Medical, Inc.) was performed during each subject's electrophysiological study. We evaluated the ability of S1 intensity and S1 variability to discriminate between VT and supraventricular rhythm.
Results: The 57 subjects had 17 episodes of VT and 76 episodes of supraventricular rhythm—including 22 episodes of SVT. VT had a lower S1 intensity and higher S1 variability than supraventricular rhythm (2.63 ± 1.78 mV vs. 4.70 ± 5.03 mV and 0.45 ± 0.24 vs. 0.21 ± 0.11, respectively). Conversely, left bundle branch block, right bundle branch block or SVT did not affect either S1 intensity or its variability. Ventricular pacing increased S1 variability but did not affect S1 intensity. The sensitivity of S1 variability for detecting VT was 50% at 100% specificity.
Conclusion: VT is associated with both decreased S1 intensity and increased beat-to-beat S1 variability. The electronic recording and digital processing of digital heart sound data is useful for identifying VT and may facilitate the differential diagnosis of clinically important tachyarrhythmias, particularly in emergency situations where advanced techniques such as electrophysiology studies are not available.

Introduction

It is often difficult, particularly in acute emergency settings, to distinguish ventricular tachycardia (VT) from supraventricular tachycardia (SVT). The reported poor diagnostic performance by both human readers and automated ECG algorithms developed specifically for this purpose support the assertion that this task is currently difficult.[1] The

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* Corresponding author. Tel.: +41 41 205 52 08; fax: +41 41 205 22 34.
E-mail address: paul.erne@ksl.ch (P. Erne).

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Table 1 Demographics

Group	N	Age (years)	Male (%)	LV EF (%)	CMP (%)	CAD (%)	Aortic stenosis (%)
All patients	57	57 ± 13	74	52 ± 18	14	28	2
VT	17	54 ± 11	88	40 ± 14	24	53	6
SVT	22	52 ± 16	50	66 ± 12	0	5*	0
LBBB	9	61 ± 12	100	25 ± 11	22	0	11
RBBB	3	73 ± 6	100	44 ± 13	0	0	0
Paced	13	57 ± 12	92	34 ± 13	38*	23	0

VT: ventricular tachycardia; SVT: supraventricular tachycardia; LBBB: left bundle branch block; RBBB: right bundle branch block; LV EF: left ventricular ejection fraction; CMP: cardiomyopathy; CAD: coronary artery disease.
* $P < 0.05$ compared to all the patients.

inadequacy of the body surface ECG for identifying VT reliably has led to the use of invasive procedures and therapeutic trials with pharmacological agents.[2]

The identification of VT as the underlying mechanism of a tachyarrhythmia has depended heavily on ECG evidence of the presence of atrioventricular (AV) dissociation.[3] It can also depend upon the detection of fusion beats and the reader's opinion of whether the morphology of the QRS complex is typical of a known pattern of abnormal intraventricular conduction.[3] Unfortunately, the ECG demonstration of AV dissociation is often problematic, since it can be difficult to identify P waves, especially at high heart rates. Also, fusion beats are frequently absent during the recorded episode of tachyarrhythmia. Finally, judging whether the QRS morphology is sufficiently characteristic of either right or left bundle branch block or a ventricular rhythm that merely emulates one of those patterns is highly subjective. This decision is especially difficult when the reader is not highly experienced in electrocardiography and/or does not have a full 12-lead set of ECG data, i.e., during most episodes of cardiac monitoring and in situations involving paramedics or first-responders. Therefore, in many applications the sole use of the ECG for detecting VT is often unreliable. Electrocardiographic artifact can also lead to the erroneous detection of VT.[4,5]

However, VT, regardless of its ECG morphology, often exhibits hemodynamic features that may improve one's ability to distinguish it from SVT. For example, since VT is associated with greater ventricular dyssynchrony than SVT, less forceful ventricular contraction at similar heart rates is usually exhibited.[6] This diminished forcefulness of ventricular contraction manifests as a reduced intensity of the first heart sound (S1) because of the decreased kinetic energy imparted to the mitral leaflets. In addition, the AV dissociation that characterizes most cases of VT produces beat-to-beat variations in S1 intensity.[7]

Based on these considerations, we tested the hypothesis that recorded cardiac acoustical data are useful for distinguishing VT from supraventricular rhythms.

Table 2 Comparisons of diagnostic parameters with vs. without VT

Parameter	VT	N	Mean (±95% CI)
All episodes of VT, all ejection fractions			
S1 intensity	Absent	76	4.6 (3.6, 5.9)
S1 intensity	Present	17	2.4 (1.7, 3.6)
S1 variability	Absent	76	0.21 (0.19, 0.23)
S1 variability	Present	17	0.45 (0.32, 0.59)
All episodes of VT, ejection fraction <60%			
S1 intensity	Absent	44	4.4 (3.1, 5.6)
S1 intensity	Present	13	2.4 (1.4, 3.3)
S1 variability	Absent	44	0.24 (0.20, 0.27)
S1 variability	Present	13	0.43 (0.28, 0.59)
One episode of VT per patient, all ejection fractions			
S1 intensity	Absent	42	5.0 (3.4, 6.7)
S1 intensity	Present	11	2.5 (1.4, 3.7)
S1 variability	Absent	42	0.21 (0.18, 0.25)
S1 variability	Present	11	0.47 (0.28, 0.67)

CI: confidence interval; VT: ventricular tachycardia.

Table 3 Comparisons of patients with vs. without conditions other than VT

Parameter	LBBB	N	Mean (±95% CI)
Left bundle branch block			
S1 intensity	Absent	80	4.7 (3.6, 5.9)
S1 intensity	Present	9	2.9 (1.5, 4.3)
S1 variability	Absent	80	0.24 (0.21, 0.28)
S1 variability	Present	9	0.35 (0.23, 0.48)
Parameter	**VP**	**N**	**Mean (±95% CI)**
Ventricular pacing			
S1 intensity	Absent	76	4.4 (3.3, 5.5)
S1 intensity	Present	13	5.1 (2.3, 8.0)
S1 variability	Absent	76	0.20 (0.18, 0.23)
S1 variability	Present	13	0.42 (0.33, 0.52)
Parameter	**Tachycardia**	**N**	**Mean (±95% CI)**
Tachycardia (supraventricular rhythms only)			
Heart rate	Absent	55	75 (72, 78)
Heart rate	Present	22	147 (132, 160)
S1 intensity	Absent	55	3.5 (2.6, 4.4)
S1 intensity	Present	22	6.9 (4.3, 9.6)
S1 variability	Absent	55	0.20 (0.17, 0.22)
S1 variability	Present	22	0.23 (0.18, 0.28)

CI: confidence interval; LBBB: left bundle branch block; VP: ventricular pacing.