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Short communication

Inconsistent shock advisories for monomorphic VT and Torsade de Pointes – A prospective experimental study on AEDs and defibrillators☆

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ABSTRACT

Background: Cardiovascular disease and sudden cardiac arrest are the leading causes of death in the United States. Early defibrillation is key to successful resuscitation for patients who experience shockable rhythms during a cardiac arrest. It is therefore vital that the shock advisory of AEDs (automated external defibrillators) or defibrillators in AED mode be reliable and appropriate. The goal of this study was to better understand the performance of multiple lay-rescuer and hospital professional defibrillators in AED mode in their analysis of ventricular arrhythmias. The measurable objectives of this study sought to quantify:

1. No shock advisory for sinus rhythms at any rate.
2. Recognition and shock advisory for ventricular fibrillation (VF).
3. Recognition and shock advisory for monomorphic ventricular tachycardia (VT).
4. Recognition and shock advisory for Torsades de Pointes (TdP).

Methods: This is a prospective evaluation of two AEDs and four semi-automatic, hospital professional defibrillators. This study represents post-marketing evaluation of FDA approved devices. Each defibrillator was connected to multiple rhythm simulators and presented with simulated ECG waveforms 20 consecutive times at various rates when possible.
Results: All four defibrillators and both AEDs tested consistently recognized normal sinus rhythm (NSR) from all rhythm sources, and did not recommend a shock for NSR at any rate (from 80 to 220 bpm). All four defibrillators and both AEDs recognized VF from all rhythm sources tested and recommended a shock 100% of the time. Variations were found in the shock advisory rates among defibrillators when testing simulated VT heart rates at or below 150 bpm. One AED tested did not consistently advise a shock for monomorphic VT or TdP at any tested rate.
Conclusion: Lay-rescuer AEDs and professional hospital defibrillators tested in AED mode did not reliably recommend a shock for sustained monomorphic VT or TdP at certain rates, despite the fact that it is a critical component of the currently recommended treatment. These findings require further examination of the risk benefit analysis of shocking or not shocking rhythms such as TdP or pulseless VT.
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1. Introduction

Cardiovascular disease continues to be the leading cause of death in the U.S.[1] Each year, approximately 424,000 individuals experience an unexpected, out-of-hospital cardiac arrest.[2] Ventricular tachycardia (VT) and ventricular fibrillation (VF) have been found to be the initial rhythm in about 23% of cases.[3,4]

To battle these statistics, automated external defibrillators (AEDs) have become ubiquitous in public spaces. Current American Heart Association (AHA) guidelines recommend that AEDs provide a shock to VF and unstable VT, including the rarely witnessed form of polymorphic VT, Torsade de Pointes (TdP).[5]

With AED technology being relied upon to deliver life-saving shocks, waveform recognition and reliable shock advisories are

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Table 1
Semi-automatic defibrillators, AEDs and Rhythm Simulators used in testing are pictured below.

Semi-automatic defibrillators

Physio-Control LIFEPAK® 15

Physio-Control LIFEPAK® 20

Philips MRX

Zoll R Series Plus

Automatic external defibrillators (AEDs)

Philips HeartStart AED

Zoll Plus AED

Rhythm simulators

Zoll 3-lead ECG

Symbio CS1201

SimMan3G Manikin®

imperative. Equally important is that rescuers understand the strengths and weaknesses of AED performance.

The goal of this study was to better understand the performance of multiple lay-rescuer AEDs and professional defibrillators in AED mode, in their analysis of ventricular arrhythmias. The measurable objectives of this study sought to quantify:

1. No shock advisory for sinus rhythms at any heart rate.
2. Recognition and shock advisory for VF.
3. Recognition and shock advisory for monomorphic VT.
4. Recognition and shock advisory for TdP.

2. Methods

A prospective evaluation of two AEDs and four semi-automatic defibrillators was performed.

The results were verified by either a second investigator present during testing, or by reviewing video recordings. Either a GoPro® Hero or an Apple Ipad® was used for filming.

Rhythms tested:

Normal sinus rhythm (NSR)
Ventricular fibrillation (VF)
Torsade de Pointes (TdP)
Ventricular tachycardia (VT)

2.1. Equipment: (see Table 1)

The semi-automatic defibrillators were tested in AED mode. The lay-rescuer AEDs only operate in automatic mode.

2.2. Procedure: (see Fig. 1)

Phase 1: The SimMan3G® manikin was connected to each defibrillation device. Using the manikin's proprietary software and rhythm simulator, each device was presented with the following rhythms, 20 times at each tested rate:

NSR – 80 bpm then 120–220 bpm (in increments of 10)
VF – coarse and fine
VT – 140–240 bpm (in increments of 10)
TdP – 140–220 bpm (in increments of 10)

Phase 2: The Symbio CS1201 simulator was connected to each defibrillator except for the Zoll AED, as there is no adaptor that allowed for that connection. The following rhythms were presented at a fixed rate 20 times each:

NSR – 80 bpm
VT Fast – 185 bpm
VT Slow – 140 bpm
TdP – 195 bpm

Phase 3: There is no adaptor that allowed for the AEDs to connect to the Zoll 3-lead rhythm simulator, so it was only connected to the four defibrillators and presented the following rhythms at fixed rates, 20 times each:

NSR – 80 bpm
VF
VT Hi – 185 bpm
VT Lo – 140 bpm
TdP – 135 bpm

3. Results

None of the four defibrillators recommended a shock for NSR at any tested rate. All devices recognized VF from all rhythm sources tested and recommended a shock 100% of the time.

3.1. Recognition of monomorphic VT (Table S2)

No device consistently recommended shocks at rates of 150 bpm or below. Above 150 bpm, shock advisory rates were 95–100% on each device except for the Philips AED.

The Philips AED did not provide shock advisories until 200 bpm and above. From 200 to 220 bpm, shock advisories were between 5 and 15%.