

# The Facts about Biphasic Defibrillation

## Introduction

In reference to the SMART Biphasic waveform, Guidelines 2000 for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care, published by the American Heart Association, states "The growing body of evidence is now considered sufficient to support a Class IIa recommendation for this low energy, BTE [biphasic truncated exponential] waveform."

A Class IIa recommendation is defined as "standard of care," is "considered intervention of choice by majority of experts," and is supported by "good to very good evidence."<sup>1</sup>

At the same time, the AHA issued a similar recommendation for the general practice of low-energy biphasic defibrillation, but cautioned that "at this time no studies have reported experience with other biphasic waveforms in long-duration VF in out-of-hospital arrest. When such data becomes available, it will need to be assessed by the same evidence-evaluation process as used for the biphasic AED and this guidelines process."<sup>1</sup>

### Not All Biphasic Waveforms Are the Same

Different waveforms are designed to work at different energies. Consequently, an appropriate energy dose for one biphasic waveform may be inappropriate for a different biphasic waveform.

There is already evidence to suggest that a waveform designed for low-energy defibrillation is less effective if applied at high energies. Tang demonstrated good resuscitation performance for the SMART Biphasic waveform, but found that more shocks were required at 200 J than at 150 J.<sup>2</sup> Conversely, a waveform designed for high-energy defibrillation may not perform effectively at lower energies.

The same study showed poorer resuscitation performance for a 200 µF biphasic waveform at 200 J compared to a 100 µF biphasic waveform (SMART Biphasic) at 200 J.<sup>3</sup> Higgins showed that the 200 µF biphasic waveform performed better at 200 J than it did at 130 J.<sup>4</sup>

Consequently, to determine the proper dosing for a given waveform, it is necessary to refer to the manufacturer's recommendations and the clinical literature. The recommendations for one biphasic waveform should not be arbitrarily applied to a different biphasic waveform. It would be irresponsible to use a waveform designed for high energy with a low-energy protocol simply to satisfy the letter of the current AHA recommendation.

In the Guidelines 2000, the AHA states "Energy levels vary with the type of device and type of waveform used."<sup>1</sup> Referring to studies involving the SMART Biphasic waveform, Guidelines 2000 states, "This research indicates that repetitive lower-energy biphasic waveform shocks (repeated shocks at & 200 J) have equivalent or higher success for eventual termination of VF than defibrillators that increase the current (200, 300, 360J) with successive shocks (escalating)."<sup>1</sup>

### Energy and Current

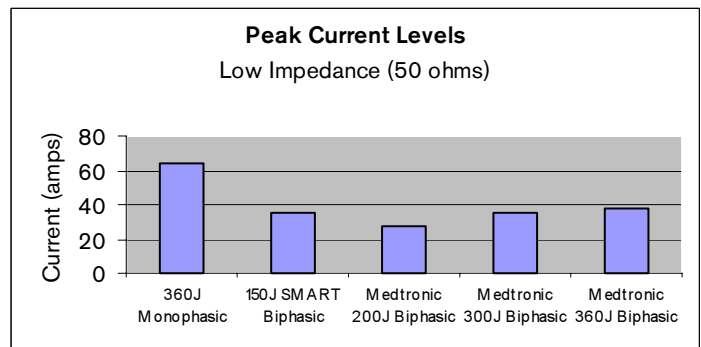
The way the energy is delivered makes a big difference in the efficacy of the waveform. Electric current has been demonstrated to be the variable most highly correlated with defibrillation efficacy. The SMART Biphasic waveform uses a 100 µF capacitor to store the energy inside the AED; the Medtronic ADAPTIV biphasic waveform uses a 200 µF capacitor. The energy stored on the capacitor is given by the equation:

$$E = \frac{1}{2} C V^2$$

The voltage and the current involved with defibrillating a patient are related to patient impedance by the equation:

$$V = I R$$

For the Medtronic biphasic waveform to attain levels of current similar to those of the SMART Biphasic waveform, it must apply the same voltage across the patient's chest. This means that to attain similar current levels, the Medtronic waveform must store twice as much energy on the capacitor and deliver much more energy to the patient; the graph below demonstrates this relationship. This is the key reason that the Medtronic biphasic waveform requires high-energy doses, whereas the SMART Biphasic waveform does not.



## Special Circumstances

It has been asserted that a patient may need more than 150 J with a biphasic truncated exponential waveform when conditions like heart attacks, high-impedance, delays before the first shock, and inaccurate electrode pad placement are present. This is not true for the HeartStart SMART Biphasic waveform, as the evidence presented in the following sections clearly indicates. On the other hand, the evidence indicates that more energy may be required for BTE waveforms other than SMART Biphasic.

### Heart Attacks

Medtronic references two animal studies using their waveform to support their claim that a patient may require more than 200 J for cardiac arrests caused by heart attack (myocardial infarction). The SMART Biphasic waveform has been tested in real-world clinical settings with human heart attack victims and has proven its effectiveness at terminating ventricular fibrillation (VF). In a prospective, randomized, out-of-hospital study, the SMART Biphasic waveform demonstrated a first-shock efficacy of 96% versus 59% for monophasic waveforms, and 98% efficacy with three shocks as opposed to 69% for monophasic waveforms.<sup>5</sup> Fifty-one percent of the patients treated with SMART Biphasic had suffered a heart attack. The published evidence clearly indicates that the SMART Biphasic waveform does not require more than 150 J for heart attack victims.

### High-Impedance Patients

High-impedance patients do not pose a problem with the low-energy SMART Biphasic waveform. Using a patented method, SMART Biphasic technology automatically measures the patient's impedance and adjusts the waveform dynamically during each shock, to optimize the waveform for each shock on each patient. As demonstrated in published, peer-reviewed clinical literature, the SMART Biphasic waveform is as effective

at defibrillating patients with high impedance (greater than 100 ohms) as it is with low-impedance patients.<sup>5</sup> The bottom line is that the SMART Biphasic waveform does not require more than 150J for high-impedance patients.

### Delay before the First Shock

The SMART Biphasic waveform is the only biphasic waveform to have extensive, peer-reviewed, published emergency resuscitation data for long-duration VF. In a randomized out-of-hospital study comparing the low-energy SMART Biphasic waveform to high-energy escalating monophasic waveforms, the average call-to-first-shock time was 8.9 +/- 3.0 minutes. Of the 54 patients treated with the SMART Biphasic waveform, 100% were defibrillated - 96% on the first shock and 98% with three or fewer shocks. Of these patients, 76% experienced a return of spontaneous circulation (ROSC), versus only 55% of the patients treated with high-energy monophasic waveforms.<sup>5</sup> In a post-market, out-of-hospital study of 100 VF patients defibrillated with the SMART Biphasic waveform, the authors concluded, "Higher energy is not clinically warranted with this waveform."<sup>6</sup> The SMART Biphasic waveform does not require more than 150 J when there are delays before the first shock.

### Inaccurate Electrode Pad Placement

It has also been claimed that higher-energy escalating shocks are more forgiving of inaccurate electrode pad placement. This is a purely speculative argument with no basis in scientific evidence. However, common sense would suggest that if a given biphasic waveform needs more energy when pads are located properly, that waveform would also need more energy when pads are placed sub-optimally. Once again, real-world data demonstrate high efficacy with the SMART Biphasic waveform in out-of-hospital studies.<sup>5,6</sup> These studies included hundreds of AED users with a range of experience and training.

### **Commitment to SMART Biphasic**

All HeartStart AED products use the 150 J SMART Biphasic waveform. The HeartStart XL, HeartStart XLT, and HeartStart MRx provide a manual mode of operation for defibrillation and cardioversion as well as an AED mode. These products provide selectable energy settings from 2 to 200 J in the manual mode of operation and a constant 150 J in the AED mode.

Some waveforms may need more than 200 J for defibrillation, but the patented SMART Biphasic waveform does not. Published clinical evidence indicates that the SMART Biphasic waveform does not require more than 150 J to effectively defibrillate, even if the patient has experienced a heart attack or has a higher-than-normal impedance, or if there have been delays before the first shock is delivered. Published clinical evidence also indicates that there is increased dysfunction associated with high-energy shocks.<sup>7,8,9,10,11</sup> With this in mind, why would you want to deliver more energy if you don't have to?

With the SMART Biphasic waveform, you don't have to deliver more than 150 J. The SMART Biphasic waveform has demonstrated its efficacy in numerous studies and, as a result, has the evidence necessary for conformance with the AHA Class IIa recommendation for low-energy biphasic defibrillation.

## References

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