Defibrillators: Technical Aspects

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IMPULSE WAVES OF EXTERNAL DEFIBRILLATORS

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Defibrillation is the one most important therapy for terminating ventricular fibrillation. Many defibrillators are offered by different companies with a great variety on defibrillation impulse waveforms and impulse lengths. Up to now there does not exist an European recommendation for transthoracic defibrillation waveforms. We wondered whether the waveform could be a factor of success of real clinical defibrillation. So we tried to find out some criteria of efficacy and safety for monophasic waveforms.
From a physiological point of view, if we consider a rectangular pulse, the most efficient duration should be the time of chronaxie. If we extrapolate to all possible types of waveforms and patient resistance one can propose a maximum overall pulse duration of about 8-10 ms for most effective defibrillation. This hypothesis is confirmed by many animal studies. Consequently we want to point out that it is only the current and energy contained in the first 10 ms which is effective and that the energy content on the range of about 10 to 50 ms would be poorly effective and probably waste. This is confirmed by clinical results comparing the relative short damped sinusoidal to the long truncated exponential waveform, which demonstrated a higher success for damped sinusoidal.
Moreover, it is known that after about 50 ms many cells are again vulnerable. Therefore if an impulse has a long low-amplitude tail of current after 50 ms it may reinitiate fibrillation (so-called refibrillation).
We conclude that waveform is important for successful defibrillation and propose to evaluate and to publish universal statements for all types of waveforms for transthoracic defibrillation.

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MONOPHASIC AND BIPHASIC WAVEFORM DEFIBRILLATION EFFICACY IN OUT-OF-HOSPITAL CARDIAC ARREST

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Introduction. Shocks delivered to typical out-of-hospital VF lasting several minutes result in rhythms that are complex and dynamic. A standard definition of defibrillation including the time of post-shock rhythm assessment does not exist. This study examines the influence of post-shock time intervals on the classification of out-of-hospital defibrillation success with monophasic and biphasic shocks.

Methods. Automatic external defibrillators (AEDs) with 200-360 J monophasic damped sine (MDS) (First Medic 510 and 710 AEDs, Physio-Control, Redmond, WA) and 150 J impedance-compensating biphasic (ICB) (ForeRunner AED, Heartstream, Inc., Seattle, WA) waveforms were employed in a combined police and paramedic program in Rochester, MN. ECGs from 87 MDS pts (463 shocks) and 21 ICB pts (107 shocks) were analyzed at post-shock intervals of 3, 5, 10, 20, and 60 seconds. The last rhythm recorded by the AED was also noted.

Results. The percentage of rhythms classified as VF at each post-shock assessment time follows for all shocks. * $p \leq 0.05$ by chi-square test.

	3 sec	5 sec	10 sec	20 sec	60 sec	Last
MDS	41%	42%	48%	66%	82%	19%
ICB	10%*	17%*	26%*	36%*	53%*	0%*

Conclusions. The time of post-shock rhythm assessment significantly influences the classification of out-of-hospital defibrillation. As expected, the percentage of rhythms classified as VF increases as the post-shock time interval increases. At all assessment times, the low-energy impedance-compensating biphasic waveform resulted in lower rates of VF than the high-energy monophasic damped sine waveform.

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RANDOMIZED COMPARISON OF LOW-ENERGY BIPHASIC AND HIGH ENERGY MONOPHASIC WAVEFORMS FOR DEFIBRILLATION OF OUT-OF- HOSPITAL CARDIAC ARREST

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Introduction: Low-energy biphasic waveform has been shown to defibrillate out-of-hospital cardiac arrest at high rates compared with historical data on high-energy monophasic waveforms. The initial results of this randomized study compare the defibrillation efficacies of biphasic truncated exponential and standard monophasic damped sine waveforms.
Methods: Emergency medical response to out-of-hospital cardiac arrest was randomized either a 150 J impedance-compensating biphasic waveform defibrillator (Forerunner AED, Heartstream Inc.) or a monophasic damped sine defibrillator (LifePak 300/10, Physio-Control Corp.). 64 patients with cardiac arrest were included and 21 patients presented primary ventricular fibrillation as inital rhythm.
Results:

Defibrillation Efficacy	Biphasic	Monophasic
First Shock	6/8 (75%)	4/13 (31%)
3 or Fewer Shocks	8/8 (100%)	10/13 (77%)

Due to small sample size differences are not yet statistically significant at $p \leq 0{,}05$.
Conclusions: The inital results of this randomized study indicate, that the low-energy impedance-compensating waveform defibrillates at higher rates than the high-energy monophasic damped sine waveform.

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EFFECTIVENESS OF QUASI-SINUSOIDAL BIPHASIC WAVEFORM IN TRANSTHORACIC VENTRICULAR DEFIBRILLATION OF HUMANS

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It has been shown that for transthoracic defibrillation of short induced ventricular fibrillation (VF) and tachycardia (VT) sinusoidal biphasic waveforms are superior to monophasic impulses. We studied efficacy of biphasic impulses in patients (n=61) need defibrillation for spontaneous primary or secondary VF (n=39) and VT (n=22). The number of episodes of VF and VT was 61 and 28, respectively. The aethiology of arrhythmias was acute ischaemic heart disease. The duration of VF/VT before the first shock was about 0,5-11 min. Diameters of hand-held electrode paddles were 11/11 cm and 8/8 (4 pts). The operator selected an initial shock energy settings of 11-40 Joules (J) for VT and 11-65 J for VF (delivered on 50 Ω load). The current (I, A), transchest impedance (TTI, Ω), delivered energy (DE, J) were measured for each shock. Results (mean±SD and range): defibrillation was successful in all patients.

	I, A	DE, J	TTI, Ω
VT	12.8±3.3 (5.5-19)	34.4±23 (10-101)	59.4±16 (38-102)
primary VF	14,1±4,1 (8-23)	50±22 (15-95)	73±7 (55-81)
secondary VF	19.6±7.8 (9-43)	76.4±40 (16-193)	59.5±22 (22-117)

It is interesting that in 34 of the 39 (87%) patients with spontaneous VF, defibrillation succeeded with shocks ≤ 115 J. These results demonstrate high efficacy of transthoracic low energy biphasic shocks in defibrillation.