Can a return of spontaneous circulation be achieved faster in a resuscitation algorithm that directs the duration of post-shock chest compressions according to the pre-shock value of the amplitude-spectral area?

A study of VF cardiac arrest in normal swine

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Abstract

Background: We have previously demonstrated in a swine model of cardiac arrest due to ventricular fibrillation (VF) that a return of spontaneous circulation (ROSC) following a shock is predicted by the amplitude spectral area (AMSA), a quantitative measure of the VF waveform. These prior studies were a retrospective analysis of the VF waveform prior to shocks. We now have devised a resuscitation algorithm that uses the value of AMSA in real time to direct the duration of post-shock chest compressions. We hypothesized that such an algorithm would shorten the time needed to achieve ROSC in normal swine.

Methods: VF was induced electrically in normal swine and untreated for 10 minutes. Resuscitation was commenced with 1 minute of chest compressions, resumption of mechanical ventilation, followed by the first shock and administration of epinephrine. Subsequently, animals were randomized to a traditional or waveform guided group. In the traditional group, all shocks were followed by 2 minutes of post-shock chest compressions. In the waveform guided group, AMSA was measured prior to each shock and if AMSA>20 mV-Hz then post shock chest compression duration was shortened to 1 minute. ROSC was defined as a systolic aortic pressure greater than 50 mm Hg and pulse pressure > 20 mm Hg lasting at least one minute. Time to ROSC was compared with a Kruskal-Wallis rank test. AMSA was compared between groups using regression analysis with random effects to account for multiple shocks within the same animal.

Results: A total of N=8 animals were assigned to the traditional group with 22 shocks delivered, and N=8 animals to the waveform guided group with 21 shocks delivered. Time to ROSC (from induction of VF) was 14.5 ±1.2 minutes in the traditional group and 13.5± 1.2 minutes in the waveform guided group, but was not statistically significant (P=0.2). There was a trend for higher AMSA values in the waveform guided group: 48 ± 15 versus 39 ± 16 mV-Hz (P=0.1).

Conclusions: A resuscitation algorithm that tailors the duration of post-shock chest compressions to the value of AMSA is feasible. In this small study of normal swine we found small, but non-significant, reductions in the times to achieve ROSC and higher values of AMSA in swine treated with a waveform guided approach.

Background

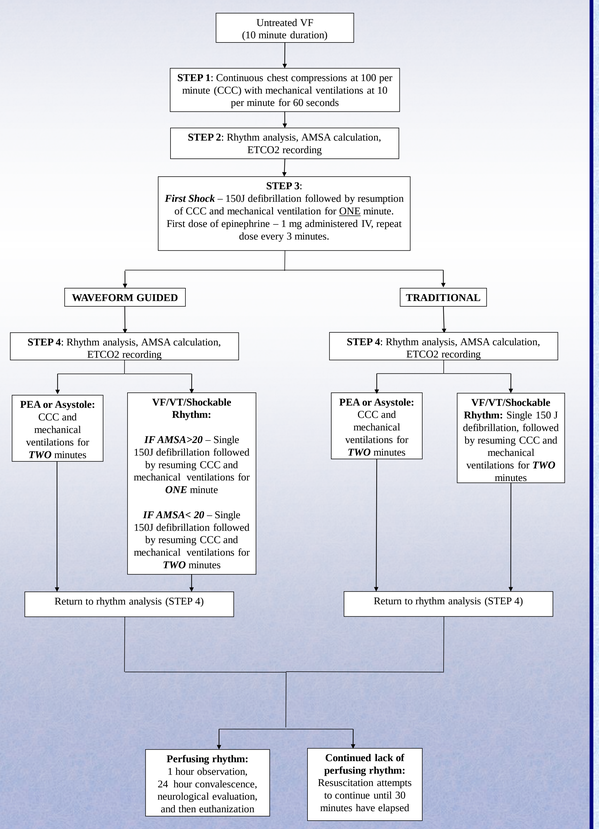
Out of hospital cardiac arrest is estimated at 295,000 cases per year in the United States, with 23% due to an initially shockable rhythm, ventricular fibrillation (VF) or pulseless ventricular tachycardia. Survival to hospital discharge for out of hospital cardiac arrest with an initial rhythm of ventricular fibrillation (VF) has improved over the past two decades, with survival of order 40% when continuous chest compressions are emphasized, and including advances in post-resuscitation care including therapeutic hypothermia. Nonetheless, the resuscitation of cardiac arrest victims with ventricular fibrillation can be markedly prolonged and require multiple shocks to ultimately attain a sustained return of spontaneous circulation (ROSC).

Analysis of the electrical waveform of ventricular fibrillation, with for example the amplitude spectrum area (AMSA), has shown promise to predict a return of spontaneous circulation (ROSC) in retrospective analyses of swine and human data.

We now have devised a resuscitation algorithm that uses the value of AMSA in real time to direct the duration of post-shock chest compressions. We hypothesized that such an algorithm would shorten the time needed to achieve ROSC in normal swine.

Methods

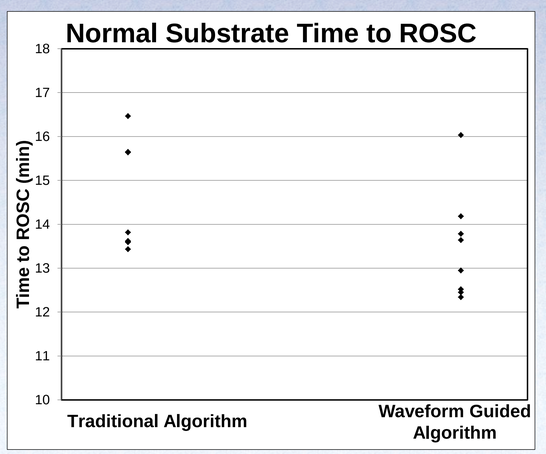
Ventricular fibrillation was induced with a 100Hz alternating current delivered through a pacing catheter in the right ventricle in normal swine and left untreated for 10 minutes. Resuscitation was commenced with 1 minute of chest compressions, resumption of mechanical ventilation, followed by the first shock and administration of epinephrine. Epinephrine was administered every 3 minutes after the first dose. Animals were then randomized to a traditional or waveform guided group. The traditional group followed the ACLS guidelines for resuscitation of all shocks followed by 2 minutes of post-shock chest compressions until ROSC is achieved or resuscitation efforts are stopped. In the waveform guided group, AMSA was measured prior to each shock and if AMSA>20 mV-Hz then post shock chest compression duration was shortened to 1 minute. ROSC was defined as a systolic aortic pressure greater than 50 mm Hg and pulse pressure > 20 mm Hg lasting at least one minute.



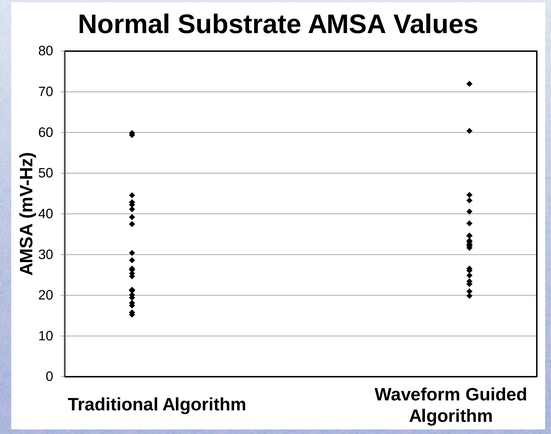
Results

A total of 8 animals (N=8) were assigned to the traditional group with 22 shocks delivered overall. A total of 8 animals (N=8) were assigned to the waveform guided group with 21 shocks delivered overall.

Time to ROSC was measured from the induction of VF. The traditional group had an average of 14.5 ±1.2 minutes to ROSC, while the waveform guided group had an average of 13.5± 1.2 minutes to ROSC. Time to ROSC was compared with a Kruskal-Wallis rank test. The difference was found to be not statistically significant with a p-value of 0.2 (p=0.2).



AMSA was compared between groups using regression analysis with random effects to account for multiple shocks within the same animal. There was a trend for higher AMSA values in the waveform guided group: 48 ± 15 versus 39 ± 16 mV-Hz (p=0.1).



Discussion

The results from this small scale pilot study are promising and show that a realtime assessment of AMSA to guide the duration of chest compressions is feasible. We found a small, but non-significant, reduction in the time to achieve ROSC in normal swine who were treated with the waveform guided approach over the traditional approach. We also found small, but non-significant, increases in the values of AMSA in swine treated with the waveform guided approach.

Conclusion

This small scale study showed a trend toward significance in both time to ROSC and AMSA values for the waveform guided approach over the traditional approach of defibrillation.

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