EDITORIAL COMMENT

The Truth About Shocking Ventricular Tachycardia and Ventricular Fibrillation*

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In this issue of the Journal, Zafari et al. (1) report a spectacular improvement in survival after in-hospital cardiopulmonary resuscitation (CPR), which they attribute to a program of training and an equipment upgrade. The findings may have important general implications for the practice of resuscitation both in and outside of the hospital setting.

The study, restricted to a single hospital (the Atlanta Veteran Affairs Medical Center [VAMC]), sought to measure the effect on survival from cardiac arrest of a multifaceted CPR-improvement program that included replacement of monophasic with biphasic waveform electric cardioverters throughout the hospital. Survival after the intervention improved 2.6-fold overall and by 14-fold in patients with ventricular tachycardia (VT) or ventricular fibrillation (VF). Although this outstanding result is not ambiguous, the reasons for it are.

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Equally unclear are the reasons for greater defibrillation efficacy of biphasic truncated exponential waveforms as compared with monophasic damped sine waveforms (2). The recent study of Tang et al. (3) is consistent with the hypothesis that immediate myocardial dysfunction after shock is a major cause of low survival and that the lower peak current and total energy delivered over time by the biphasic exponential reduce transient myocardial dysfunction after shock sufficiently to permit greater survival. Although this and other physiological factors may account for better survival, it remains unclear why defibrillation itself is more readily accomplished by the biphasic waveform at a given energy level.

The first difficulty in identifying the cause for the observed improvement in the efficacy of CPR in this study is that the intervention was, in fact, a set of four distinct changes in therapy: 1) replacement of all manual monophasic waveform defibrillators with biphasic waveform devices; 2) the use of automated external defibrillators (AEDs) as the biphasic waveform replacement devices throughout clinics and chronic-care areas; 3) the use of manual biphasic defibrillators as the replacements in intensive care unit (ICU) and acute-care areas; and 4) education of all medical personnel in the use of AEDs, the practice of CPR, and the critical importance of earliest-possible shock delivery.

Just how good is the biphasic waveform? Could it be primarily responsible for the extraordinary 14-fold improvement in survival from VT or VF? Unlikely. Studies performed during testing of implanted cardioverter-defibrillators in humans (4,5) have shown that the biphasic waveform holds a clear edge over monophasic shocks, but the increment in success is fractional rather than multifold for VT/VF of brief duration. Studies in animals with prolonged VF suggest that the relative reduction in energy required for successful defibrillation using a biphasic waveform is exaggerated by longer VF duration (6). However, defibrillation can still be achieved in this setting with a higher-energy monophasic pulse (7), and these higher energies surely were used when monophasic devices were in use at the Atlanta VAMC between 1995 and 2001.

How much of the improved outcome can be ascribed to AEDs? The findings suggest that they may not have been a decisive contributor. Assessment of the efficacy of AEDs in the hospital is one of the most important features of this study. Automated external defibrillators have improved the outcome of out-of-hospital arrest victims attended by emergency medical responders and have saved lives in many nonhospital settings attended by bystanders. For example, American Airlines, the first U.S. carrier to use AEDs, recently reported its 50th successful rescue attempt. Astonishingly, 56% of attempted rescues on American Airlines flights in which the AED delivered a shock have been successful (American Airlines press release, April 29, 2004). However, in large, sophisticated hospitals like the Atlanta VAMC, dozens of medical personnel are present around the clock, and manual defibrillators abound. Could AEDs add much in this setting? In the ICU and acute-care areas, manual biphasic defibrillators were used in AED mode by highly trained, experienced personnel with high staff-to-bed ratios, guaranteeing rapid, appropriate response to cardiac arrest both before and after replacement of monophasic waveform devices. I would expect little advantage in the use of AEDs, or the AED mode setting, in this situation. Yet, the improved outcomes achieved in the clinics and chronic-care wards were realized equally in the ICUs. Thus, despite the fact that AEDs were probably more readily found and transported to the patient and despite the lesser knowledge and therapeutic discretion that they required of the operator, evidence is not convincing that these features made a critical difference in the hospital setting.

The fourth discrete intervention, education on use of AEDs and modern resuscitation methods, emphasizing the importance of early response, may have contributed. However, data on the time interval from arrest to shock delivery are understandably unavailable in this study, and only crude measures of the practice of CPR before and after the
educational process are available. I am not persuaded that the education in CPR techniques, per se, played a major role; however, if it did, I would have expected to see a much greater relative improvement in outcomes outside the ICU because ICU personnel are already highly trained and experienced and, therefore, much less likely to benefit from further education.

Based on the previous arguments, in which we attempt to identify the reason for the observed dramatic improvement in survival, only the biphasic waveform emerges as a convincing contributor, but existing knowledge of the extent of its efficacy does not allow us to assign it full credit. What other factors might be involved?

This study did not include a concurrent control. The historical control strategy may have been the only study design option available, but it introduced several uncontrollable and unmeasurable influences on the primary end point. These additional factors include potential differences between the two patient cohorts in major and minor diagnoses; disease status; left ventricular function; medical therapy before arrest, during arrest, and after arrest; as well as change in the hospital itself during the seven-year period of the study. In recent years the VA hospital system has endeavored nationwide to change the nature of its inpatient services and the in-patients it serves. It has instituted aggressive quality-assurance efforts and has driven down the length of stay. The proportion of patients with chronic, end-stage disease and protracted hospital stays is down. The electronic medical record is in use. It seems very likely that these factors contributed to the improved survival of patients resuscitated in 2001 and 2002 compared with 1995 through 2000. Figure 2 of the Zafari et al. paper (1) shows 0% survival from VT or VF in all 4 years from 1996 through 1999, contrasting with 43% survival in 2001. I cannot accept the conclusion that changes in defibrillator equipment and the education of medical staff were solely responsible for such a striking difference. The nature of the cardiac arrest victims must have differed.

Both the factual observations and the explanatory uncertainties of this study can be used to improve public health. The remarkably encouraging increase in resuscitation success in general, and survival from VT and VF in particular, at the Atlanta VAMC indicate the possibility of an extraordinary opportunity to improve overall survival from cardiac arrest of the entire population. The findings of Zafari et al. (1) demand an explanation precise enough to instruct us on how to cash in on these savings in all hospitals.

Can a more rigorously controlled experiment be designed? An ideal experiment would randomize subjects prospectively to eliminate period effects. Five parallel groups could be used to assess the independent effects of biphasic waveforms shocks, AEDs, and education in CPR. One group would be treated with manual biphasic devices, a second with AEDs with monophasic waveforms, a third with AEDs with biphasic waveforms, a fourth with monophasic defibrillators supported by a new educational program in CPR, and a fifth with monophasic defibrillators without a change in education. Unfortunately, such an experiment is too cumbersome to conduct in a single hospital. Perhaps five hospitals could be identified with similar patient populations and the specified equipment. If so, the only intervention needed would be introduction of a new educational program for the fourth group. It seems unlikely that the venues for this experiment can be identified, and it will become increasingly difficult in the future to find institutions using monophasic automated or manual waveform devices as the market moves steadily toward exclusive use of the biphasic waveform. A scientifically weaker but more feasible solution might be to perform an experiment very similar to that reported by Zafari et al. (1) in another hospital that has not undergone the degree of change experienced in the VA system. That experiment could help to corroborate the current one and more accurately gauge the effect of the therapeutic interventions undertaken in it. It is equally important to gain a fundamental understanding of the salutary biophysical effects of biphasic energy delivery because this understanding may hold an important key to new preventive and interruptive therapies for VT and VF. Until we know the whole truth about shocking VT and VF, it will be hard to act on the findings reported by Zafari et al. (1).

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REFERENCES