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A Heads-Up on Salvaging Nonshockable Cardiac Arrest Cases*

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The fascinating, potentially practice-changing article by Bachista et al (1) published this month in the issue of *Critical Care Medicine* not only suggests an evolving physiologically based strategy to augment the life-saving effects of traditional cardiopulmonary resuscitation (CPR) but could be significant in other levels as well.

Since the inception of modern resuscitation efforts for cardiac arrest patients 6 decades ago, including closed-chest cardiac compressions (2), there has been little new to offer those with nonshockable presentations. Although automated external defibrillators constitute a true advance in saving lives, less than 25% of out-of-hospital cardiac arrest (OHCA) patients have a shockable presentation and not even all of those are salvageable (3, 4). Despite rapid 9-1-1 response, well-performed basic CPR, advanced airway/pulmonary oxygenation tools, adrenaline infusion, and a number of other suggested interventions over the years, survival rates for nonshockable cases have remained fairly dismal, particularly for the 70% of nonshockable cases found in asystole (1, 5, 6).

These investigators have raised an intriguing possibility for significant life-saving, nicely demonstrating how additional application of noninvasive CPR adjuncts that help to lower intracranial pressure and augment venous return may profoundly improve survival with good neurologic function (7, 8). When emergency medical services (EMS) crews applied these devices within a quarter hour of 9-1-1 call receipt (~80% of cases), there was a greater than 10-fold improved association with intact survival (1). For most EMS systems, application within 15 minutes is a very achievable goal, particularly in urban areas, and not surprisingly the earlier the intervention, the better the results. Although early extracorporeal membrane oxygenation techniques have improved survival in some systems, most advocates still reserve this intervention for ventricular fibrillation rather than for nonshockable cases. Not only does this study focus on that previously excluded group, but also the interventions are noninvasive and can be readily applied by most trained responders.

This is not a randomized controlled trial (RCT) and some will understandably suggest that only large RCTs should change practice. This has proven to be extraordinarily challenging—one might say nearly impossible—particularly in areas like OHCA research. These investigators have provided an innovative method of better addressing this frustrating stalemate. Although RCTs have always been considered the gold standard for testing interventions, most well-designed OHCA RCTs have been disappointingly unable to document effective interventions largely because significant effect modifiers, a litany of confounding variables, or small numerators (9–11), have plagued them.

*See also p. 170.

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Nonetheless, based on a half-century of OHCA studies, all of the pivotal outcome-related variables and their relative weights have been well-defined (12), presumptively creating an optimal environment for propensity scoring. Not only does propensity-score matching attempt to accomplish the goals of an RCT, but also this study also demonstrates that OHCA investigations can be less labor-intensive, less expensive, and potentially provide, more rapidly, the sought-after answers to investigational questions in this challenging realm of research complicated by numerous factors (9, 11). As was the case for basic CPR itself in the 1960s, there will understandably be those who will still insist on tradition of RCTs, but the evolving data strengthen the case for using the methodology employed here for future OHCA interventions.

This study suggests a profound impact of a new intervention on patients who have continued to experience poor outcomes despite substantial efforts to improve them. Although the traditional practice of supine chest compressions may be lifesaving, it likely only generates 15–25% of normal blood flow in many cases, reflected clinically by a low end-tidal carbon dioxide. As laboratory studies have demonstrated, this limitation is largely because of inherent backpressure on the venous system with each chest compression resulting in increases in intracranial pressure (ICP) and accompanying elevations in intrathoracic pressure that stifle right heart filling (1, 7, 8). Therefore, the application of these noninvasive devices and their ability to amplify conventional CPR depends on how they are able to alter CPR physiology as we have understood it for over a half-century.

The initial testing of the concept for this ICP-lowering/enhanced preload strategy was suggested a decade ago in trials that tested the combination of active compression-decompression (ACD) CPR and an impedance threshold device (ITD). According to these studies, in the laboratory, the two adjuncts alone more than double the blood flow to the brain (7, 8). In the RCT, it resulted in 50% improvements in 1-year survival with good neurologic function (7, 13). What was notable was that the addition of the gradual elevation of the head and thorax after ACD/ITD priming had a synergistic effect that normalized blood flow through the brain in the laboratory. As the authors reference in the text, it also normalizes or near-normalizes end-total carbon dioxide levels, even in asystolic patients, which should prompt further investigation with other measurements (e.g., cerebral oximetry).

Although these advances in resuscitation have been exciting, the interventions are still adjuncts that enhance the basic intervention of chest compressions first published (but not necessarily rapidly adopted) in 1960 in the study by Kouwenhoven et al (2). Even without the current additional adjuncts, conventional CPR has saved countless productive lives for both adults and children. Amplified by widespread public CPR, it remains an unparalleled medical advance.

Nevertheless, in the tradition of penicillin and other serendipitous discoveries, the "founding fathers" only explored this lifesaving intervention when, during closed-chest defibrillation studies using instrumented animal models, they happened to coincidentally notice arterial pulse waves being generated whenever they pressed on the chest wall with the heavy external 1950s-style defibrillator paddles (14). Formal investigations soon followed including techniques for ventilation by others such as Drs. James Elam and Peter Safar, the latter becoming one of the founders and early Presidents of the *Society of Critical Care Medicine*.

Other pioneers in resuscitation medicine such as Dr. Leonard Cobb and Fire Chief Gordon Vickery in Seattle helped to promulgate widespread CPR training. In Seattle, more than half of the population was trained by 1980, and survival results for shockable OHCA cases and drowning became striking whenever bystanders performed the procedure. That effect has been reproduced throughout the world, especially in nations that encourage and support CPR training for all adults. Despite its physiological limitations, basic CPR as first described 6 decades ago remains one of the greatest discoveries in the house of medicine.

With that foundation, the current study, involving additional application of adjuncts to enhance CPR in nontraumatic OHCA, seeks to advance us to a whole new level of saving lives with good neurologic recovery. Even with bystanders performing CPR, survival odds with good neurologic status are quite low in nonshockable cases. Nearly half of the nonshockable OHCA cases involve an unwitnessed OHCA presenting to EMS responders with asystole. This scenario infers long arrest intervals before treatment and significant neurologic insult. Therefore, the findings here provide hope for improved chances of survival for the many cases of nonshockable OHCA. Even if overall rates of survival with good neurologic function remain relatively low, the number of persons with nonshockable OHCA presentations exceeds 800 a day in the United States alone, translating into the potential for salvaging many dozens of lives every day.

In recent presentations of this subject, it was reported that one of the survivors from this technique, a healthcare provider familiar with permanent ischemic brain damage in his role as a retriever of organs for transplantation, came up with the name, "neuroprotective CPR," knowing the very lengthy time his brain experienced without heartbeat. That moniker not only reflects the laboratory experience but also some other very preliminary reports indicating that most of these survivors have Cerebral Performance Category scores of 1 (i.e., a return to fully normal function).

As a closing comment, the authors assert that this strategy must be implemented correctly, with the right tools in the right sequence, or it will not work. In addition, the authors state that when first-in responders, including those with specialized backpacks to facilitate delivery to the scene, use a true pit crew approach and the interventions positioned to the task when opened, the outcomes appear to be the best. They also appropriately infer that this augmented CPR strategy will likely be even more effective in hospital emergency departments, ICUs, and catheterization laboratories, where it can be implemented even more rapidly. In turn, other targeted stand-by sites could be those where one might find an automated external defibrillator positioned such as sports venues, gymnasiums, and lifeguard areas. Although not yet recommended for the average layperson to elevate the head, that consideration or use of a manual ACD pump is being entertained in current studies.

Looking toward the future, critical care practitioners have clear advantages in studying this evolving avenue of research. Patients may already be monitored hemodynamically, including indwelling catheters at the time of arrest, allowing documentation of effects. Recent preclinical data demonstrate improved cerebral perfusion with head-up positioning versus supine position postresuscitation (15). Clinical confirmation would have tremendous implications for all critical care patients. Furthermore, critical care clinicians are often the medical directors who manage EMS systems in many jurisdictions globally and, as such, may be the leaders in furthering the next level of research both in and out-of-hospital.

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Dr. Colwell has disclosed that he does not have any potential conflicts of interest.

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