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Improved survival in the real world with revised cardiopulmonary resuscitation guidelines: Doing better out of hospital but not out of the woods yet

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Sudden cardiac arrest (SCA) is the leading cause of death in the United States and industrialized nations. In North America, the annual incidence of out-of-hospital SCA is over 0.55 per 1,000 population¹ such that 164,000 to 300,000 out-of-hospital arrests occur annually.² However, despite advances in recent decades, clinical outcomes from out-of-hospital SCA remain dismal, and survival to hospital discharge ranges from 4% to 13%.^{3–5}

Clearly, improving the management of out-of-hospital SCA is a major public health issue. In 2005, the American Heart Association (AHA) substantially revised the previous guidelines for cardiopulmonary resuscitation (CPR) and emergency cardiac care for SCA, which were published in 2000. In particular, new CPR codified the primary importance of uninterrupted mechanical chest compression, given provocative preclinical⁶ and clinical⁷ studies showing the benefits of this approach even without mouth-to-mouth respiration or assisted ventilation. Accordingly, the revised guidelines reduced the recommended number of breaths per CPR cycle but did not advocate elimination of assisted ventilation because of concerns including the generalizability of these results.⁸ New CPR also codified recent evidence that chest compressions are more effective when performed together with an impedance threshold device (ITD), which improves chest recoil, reduces intrathoracic pressure, and augments venous return.⁹ The rationale behind the numerous other changes to new CPR are described in the parent document.⁵

In this issue of *Heart Rhythm*, Aufderheide et al¹⁰ studied whether implementation of these new CPR guidelines improved outcomes in 1,605 victims of out-of-hospital SCA in five emergency medical service systems (EMS) in the United States, compared with 1,641 historical controls at these centers treated per the 2000 guidelines in the immediately preceding years. The primary endpoint was survival to hospital discharge, and secondary endpoints were the return of spontaneous circulation (ROSC), survival to hospital discharge based on initial cardiac arrest rhythm, and neurological status at time of discharge assessed by the cerebral performance score (CPS). The authors found a significant 30% relative increase (from 10.1% to 13.1%) in survival to hospital discharge and increased rate of ROSC (from 30.3% to 33.8%) in patients treated by new CPR compared with the 2000

guidelines. As expected, results varied markedly by presenting rhythm: survival to hospital discharge was 32% versus 20% in patients with ventricular tachycardia/ventricular fibrillation (VT/VF; new CPR versus prior guidelines; $P < .001$) yet unchanged (6.8% vs. 7.1%) in patients with other presenting rhythms. Notably, neurological outcomes were also improved. More patients were discharged with good (CPS score 1) or independently functioning (CPS 2) status when treated with new CPR compared with prior guidelines, although these data were unavailable in over half the patients and thus must be interpreted with caution. Groups treated by the 2005 versus 2000 guidelines did not appear to differ in demographics, time from 911 call for help to the on-scene arrival of EMS, or the incidence of bystander CPR before EMS arrival. The authors conclude that new CPR improved survival to hospital discharge and neurological function compared with the prior 2000 guidelines.

Aufderheide et al are to be congratulated for showing that new CPR guidelines can be implemented in busy real-world centers and translated into dramatically improved outcomes. These results are highly relevant to clinical practice as 60% of unexpected cardiac deaths are treated by EMS.¹¹ Particularly impressive were the survival to hospital discharge rates, which, at 32.3% in patients presenting with VT/VF, were twice as high as some prior reports,³ and the suggested improvement in neurological recovery in the survivors. These data clearly support implementation of the 2005 revised guidelines.

Nevertheless, the fact that only 13% of SCA victims survived to hospital discharge and only $\approx 60\%$ were capable of independent functioning underscores how much further the field still has to go. Aufderheide et al hint at directions for such progress. First, Table 2 identifies a continued challenge in out-of-hospital arrest: bystanders initiated CPR in fewer than half of cases. Increasing bystander CPR, by further education or methodological refinements in CPR approach,⁷ must remain a major target for improvement. Importantly, Tables 4–6 show outcome differences between centers that, while not statistically significant, may also identify areas ripe for improvement. Explanations may include intercenter variations in patient demographics, quality of bystander CPR, time from arrest to the start of CPR by professional responders, quality of CPR by life support personnel, defibrillation rates and timing, variations in guideline implementation (sites C and D implemented new CPR in the control period, likely reducing the apparent benefit of the intervention), type of hospital, and other factors. Indeed, these¹² and other authors have previously described how regional variations may influence outcome from out-of-hospital SCA. It is clear that such variations must be minimized to ensure uniformly high management standards for this lethal condition.

An important obstacle for future improvements is that the mechanism of benefit of new CPR is unclear. Aufderheide et al show improved ROSC with new CPR, yet this does not fully account for improved survival to hospital discharge or improved neurologic outcomes. Comparing the number of patients with ROSC at each site (Table 4) against each outcome (Tables 5–8) reveals no clear relationship. In addition, while the incorporation of ITDs in new CPR portends well, the fact that sites A and E did not implement ITDs yet still reported outcomes consistent with the entire study shows that additional studies must determine how ITDs may best improve outcome. Additional factors that may have contributed to benefit include minimizing the delay to ROSC and the exact pharmacologic agents used.

Notably, Aufderheide et al¹⁰ showed that outcome and improvements from new CPR were vastly superior in patients presenting with VT/VF, who accounted for only 25% of SCA victims, compared with those with pulseless electrical activity (PEA) or asystole. This agrees with prior studies.^{3,4,13} These data thus beg the question of whether the benefit noted with new CPR reflects changes in the details of CPR maneuvers or the strong emphasis on rapid defibrillation.⁵ This is particularly relevant given the advent of automated external defibrillators, which have been shown to improve survival to hospital discharge¹⁴ yet whose use was not recorded in the current study.

Finally, the authors show that effective therapy for PEA/asystolic arrests remains elusive, even with new CPR. Our institution is in the process of revising management for non-VF SCA, as part of the Resuscitation Outcomes Consortium,¹⁵ that reemphasizes the need to treat and manage underlying hypoxemic or metabolic causes of PEA or asystolic arrest.¹⁶ Numerous other promising approaches may eventually show benefit in such patients, including various devices to enhance compressions, newer diagnostic tools, and therapeutic hypothermia. Hypothermia, in particular, has shown benefit in animal studies¹⁷ and clinical reports¹⁸ yet remains underused both during and after resuscitation.¹⁹ Aufderheide et al report that induced hypothermia was applied in 15 survivors at sites A and E along with new CPR and may have contributed to improved survival and neurological outcome.^{20,21}

In summary, the management of out-of-hospital cardiac arrest remains an arduous task. Nevertheless, the field continues to make progress. Aufderheide et al have clearly shown that the most recent AHA guidelines can be implemented on a large scale in busy real-world hospitals and translated into significantly improved clinical outcomes. Although further work is needed, the current message is simple: Get with the guidelines!

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