Learning to Fly
Lessons for the Resuscitation Community From the Aviation Industry

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The systematic review and meta-analysis by Wallace et al.1 evaluates several important cardiopulmonary resuscitation (CPR) metrics (ie, chest compression depth and rate, no-flow fraction, and ventilatory rate) with the stated purpose of estimating their associations with survival. In the end, the authors only identified chest compression depth as significantly associated with survival, but with a difference of only 2.4 mm between those who survived and those who did not. Additionally, no other metric was found to be significantly associated with survival.


What should we make of the findings reported by Wallace et al.,1 and are we to believe CPR mechanics truly lacks importance? The absence of significant associations between chest compression rate, no-flow fraction, and ventilatory rate and survival may be attributable to certain limitations inherent in meta-analyses, including (1) ecological fallacy, (2) assumption of independence of variables, and (3) type II error.

There is a tremendous amount of minute-to-minute variability during the resuscitation of someone in cardiac arrest. A patient with a mean chest compression rate of 100 per minute, but with a range of 0 to 150 compressions per minute, will have periods of time in which there is significantly lower- and higher-than-optimal compression rates. Previous research has found that cardiac arrest patients have <70 chest compressions performed per minute in up to 21.7% of the total resuscitation effort.2 Aggregating minute-to-minute compression rate variability to a mean and range for each individual patient loses the granularity that is required to understand and potentially predict the likelihood of a successful resuscitation. These means and ranges for individual patients are then pooled at the study level to generate a mean and range for the survivors versus nonsurvivors. In the meta-analysis, the study-level means and ranges for the 2 groups were then pooled to generate estimates of association between the 4 CPR metrics and survival. This may lead to the ecological fallacy or a scenario in which grouped data are used to make individual-level estimates; in this situation, no associations between metrics and survival may simply represent such fallacy, when in reality, significant individual-level associations exist.

It is also possible that the individual CPR quality metrics are not in fact truly independent of one another. The 4 CPR metrics included in this study have been shown in animal and human studies to have an effect on return of spontaneous circulation and survival; however, the metrics are also highly dependent on one another, with the collective sum of the parts not necessarily equaling the individual components. For example, as rate increases, at a certain threshold rate, depth is likely to decrease. No-flow fraction time may also be correlated with a lower mean rate of chest compressions. The interactions between these 4 CPR quality metrics are presumably more important than the independent effect of each, which obviously cannot be adequately accounted for in a meta-analysis.

Finally, there is also a concern for potential type II error or lack of power to detect differences. There were 10 total studies included in the meta-analysis, including 49 to 2103 patients each. For the specific CPR quality metrics, only 4 to 7 studies met a priori criteria for inclusion. It is possible that the meta-analysis was not adequately powered to identify associations when in fact they are present.

**Using Airline Success to Change Cardiac Arrest Outcomes**

The ultimate question remains, How can we optimize CPR to maximize the likelihood of return of spontaneous circulation? This challenge is analogous to one that the aviation industry has faced. How is it that over the last decade the aviation industry has reduced the number of fatalities from airplane crashes by >50%, with 1 death per 45 000 000 flights? Fundamental to this great success has been the incorporation of a multidisciplinary approach, and one that should be considered in the field of resuscitation science.

Pilots must deal with a minute-to-minute variability in wind resistance, weather conditions, temperature, and barometric pressure, among others. This highly variable environment is similar to the complexity of the human body during resuscitation. The Federal Aviation Administration collects data from 44 major airlines and conducts research to systematically analyze these data to identify common problems and their solutions. These data are used to optimize equipment and human performance to proactively address the most common issues that a pilot must face (eg, angle of landing a plane in a snowstorm with strong crosswinds).
This type of intense data analysis requires large amounts of observational data, the ability to take into account multiple variables, and the desire to create standardized processes to improve the safety of air travel by the entire industry.

We challenge the resuscitation science community to take this same approach. It may be that a large-scale effort to systematically collect standardized data on CPR quality will allow us to determine the optimal process to provide safe, effective, and efficient CPR. We must then be willing to use these data in a process of rapid process improvement to ensure that every patient who experiences cardiac arrest will have a systematic, standardized approach to resuscitation.

Although organizations like the American Heart Association and International Liaison Committee on Resuscitation systematically review the best available evidence every 5 years, we believe it is time for a new approach to answer the ultimate question of how can we optimize CPR to maximize the likelihood of return of spontaneous circulation. The current 5-year cycle of guideline revision is based on analyzing the best available evidence on hundreds of topics; however, this process of guideline creation may actually hinder rapid advancements and improvement in resuscitation.

New advances in the field (eg, hands-only CPR, cardiorespiratory resuscitation) that fall outside the guideline revision cycle are not incorporated into the guidelines for up to 4 years after the landmark studies.

We propose a paradigm shift in the field of resuscitation science based on the lessons learned from the aviation industry. To improve our understanding of how CPR may positively affect resuscitation efforts, we believe it is time for (1) large-scale, centralized collection of prospective CPR metric data; (2) linkage of these data to appropriate resuscitation-centered outcomes (ie, return of spontaneous circulation); (3) systematic, rigorous, and rapid analyses; and (4) use of the results to drive resuscitation process improvements at the community and emergency medical services agency levels. These changes admittedly will not come easily, but we believe this is the only way to truly answer the important questions Wallace et al outlined in their article. The field of resuscitation science has a lot to learn from the aviation industry; increasing survival by 50% in the next decade would translate to thousands of lives being saved every year, and understanding CPR quality sits at the center of this achievement.

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**References**


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