Gasping, Survival, and the Science of Resuscitation

Stuart Berger, MD

The study in the current issue of Circulation by Bobrow et al1 is important for a multitude of reasons. This study revolves around the concept of “gasping” as it relates to cardiac arrest. The study questions both the incidence of gasping and its impact on and relationship to survival in patients who suffer out-of-hospital cardiac arrest (OHCA).

The authors demonstrate that gasping after cardiac arrest is common, that it is most frequent soon after cardiac arrest, and that its frequency decreases over time. Additionally, the presence of gasping is associated with an increased survival to discharge from the hospital. It is interesting to note that the survival rate was not necessarily related to the institution of bystander cardiopulmonary resuscitation (CPR) because the same percentage of “gaspers” and “nongaspers” received bystander CPR. Yet among the gaspers, the authors found a 39% survival rate versus only a 9% survival rate in the nongaspers.

Although the true incidence of gasping after cardiac arrest is unclear, more perplexing is the question, what is the cause of the ostensible protective benefit of gasping? Equally important, as the authors point out, is that first responders and medical professionals recognize gasping as a symptom of cardiac arrest and institute CPR immediately rather than confuse it with normal breathing and thereby delay CPR.

Previous experimental work exists with regard to gasping and cardiac arrest. Xie et al2 studied the effects of gasping during untreated ventricular fibrillation in an animal model, showing that gasping during ventricular fibrillation increased both ventilation and cardiac output during cardiac arrest. Srinivasan et al3 studied the effects of gasping in a pig model of ventricular fibrillation and showed that spontaneous gasping decreased intracranial pressure and increased cerebral perfusion pressure. The article by Srinivasan and colleagues thus provides a second potential reason for an increased survival rate in the gasping group (better brain “protection”) and speculates on the potential benefit of devices that might enhance the physiological effects of gasping during cardiac arrest. Eisenberg commented on this subject in 2006 and noted that agonal respirations are frequent and occur in at least 55% of witnessed cardiac arrests, more commonly in ventricular fibrillation as compared with other rhythms.4 Eisenberg also pointed out that in King County, Wash, up to 20% of patients with cardiac arrest did not receive CPR because signs of life existed, primarily in the form of abnormal breathing. Eisenberg’s review and comment cautioned on the importance of being aware of the presence and significance of gasping, or agonal respirations, and not delaying CPR in such a circumstance, as Bobrow and colleagues have suggested. Manole et al5 investigated the relationship between gasping and cardiac function in both immature and maturing rats exposed to hypoxia. Their study found that anoxia-induced gasping actually transiently improved cardiac function and that more robust gasping in the immature rat group was actually associated with an increased tolerance to cardiac anoxia. Manole and Hickey6 subsequently reviewed the physiology of gasping, its prevalence and significance in cardiac arrest, and its effects on cardiac function. This review of both animal data and observational human cardiac arrest data suggested that gasping might be “auto-resuscitative” in the immature (31 of 32 infants with sudden infant death syndrome had documented gasping) and that it improves the outcome of CPR in mature mammals.

Beneficial cardiopulmonary effects of gasping therefore include (1) improved pulmonary gas exchange, (2) increased venous return to the heart, (3) increased cardiac output and cardiac contractility, and (4) increased aortic pressure and coronary perfusion pressure. Finally, Ristagno et al7 showed that gasping significantly increased carotid blood flow during untreated cardiac arrest in a pig model of ventricular fibrillation. Therefore, gasping or agonal respirations during cardiac arrest has clearly been associated with beneficial effect on gas exchange, cerebral blood flow, intracranial pressure, and cardiovascular hemodynamic responses.

OHCA is a significant public health problem in the United States, and the outcomes continue to be extremely poor despite best efforts. In a previous editorial in Circulation, Kudenchuk et al8 referenced the fact that prehospital emergency medical services personnel in the United States attend an estimated 273 000 persons with OHCA each year. Unfortunately, survival to hospital discharge is dismal, with a median survival rate of 6.4%. Some variation has been found across communities, likely related to a combination of differences in patient characteristics, bystander involvement, emergency medical services structure, quality of CPR, and hospital ratio of beds to nurses, as well as other patient-related factors.9 The explanation for the extremely poor outcomes also may include the timing of CPR and the method and quality of CPR, as well as other factors that are currently unknown or unclear. It is critical for the science of resuscitation to go forward and allow a better understanding of cardiac arrest in both children and adults so that we can improve on the dismal results described above. A better...
understanding of the pathophysiology of cardiac arrest is likely to help us improve techniques for resuscitation. The study by Bobrow et al and other studies like it should be important vehicles for understanding these issues and for allowing us the opportunity to improve recognition of cardiac arrest, improve survival with rapid and early bystander CPR efforts, and develop techniques that might improve CPR outcomes. This observation and science should drive CPR algorithms, which require continued assessment and reconsideration for change. In addition, because lay public–bystander institution of CPR is important and has clear survival benefit, dissemination of the information and results of studies such that by Bobrow and colleagues is critical.

Multiple recent areas of research have shown tremendous promise for improving survival in OHCA. Active and important areas of research include the investigation and emphasis on quality of CPR during OHCA, as well as the use of real-time automated feedback devices during CPR in order to optimize the quality of compressions. Wik et al demonstrated that chest compressions during OHCA were not delivered half of the time, and most compressions were too shallow. Kramer-Johansen et al subsequently showed that automated feedback improved the quality of CPR and that an increased compression depth was associated with an increased hospital survival. Similarly, performance debriefing with rapid and real-time audiovisual feedback has the potential to alter resuscitation training and effectiveness and improve outcomes. Edelson et al demonstrated that such rapid and real-time audiovisual feedback was associated with an increased rate of spontaneous circulation.

In addition, therapeutic hypothermia after cardiac arrest has been an important recent method to minimize postresuscitation injury after cardiac arrest. Experimental models have demonstrated both improved hemodynamic variables and a survival benefit compared with normothermic control animals. Such experimental work shows promise for use in OHCA with studies in humans currently underway.

The impedance threshold device is a US Food and Drug Administration–approved device that can be used as a hemodynamic adjunct for patients who are hypotensive after cardiac arrest. It is designed for patients in cardiac arrest who are receiving chest compressions and periodic ventilations according to American Heart Association Guidelines. Experimental work by Auferheide et al has led to recent American Heart Association guidelines that have recommended the impedance threshold device for increasing the circulation and assisting the return of spontaneous circulation. This concept and the principles of the impedance threshold device have been elegantly evaluated in animals as well as in humans with prolonged cardiac arrest undergoing standard manual CPR.

Although the survival to discharge after OHCA is generally quite poor, this may not need to be the case. A few municipalities have reported relatively higher survival rates after sudden cardiac arrest. It has been reported that the survival in Seattle, Wash, is 15%, whereas a 9% survival rate has been reported in Amsterdam, the Netherlands, and a 21% survival rate in Maribor, Slovenia. Explanations for the community-specific variability in outcomes, as alluded to earlier, might be optimized by immediate bystander activation of the emergency medical services system. This can occur only through prompt recognition of cardiac arrest and rapid institution of the American Heart Association–recommended “chain of survival”. The article by Bobrow et al again emphasizes the importance of this early recognition, awareness, and education in recognizing cardiac arrest and intervening with CPR as rapidly as possible. This emphasis is also consistent with the recent American Heart Association scientific statement suggesting that outcomes of cardiac arrest might be improved by reducing the barriers for implementation of bystander-initiated CPR. Changes in algorithms to a continuous chest compression mode, increasing the population of individuals trained to do CPR, improving the quality of CPR, and improving the lay public’s ability to recognize cardiac arrest are all maneuvers that are very likely to result in an improvement in outcomes after cardiac arrest.

The science of resuscitation has brought us a long way, but we still have farther to go in order to achieve continued increased survival after cardiac arrest. Yet outstanding work attempting to improve outcomes continues to be done. We should encourage and support the work that has been done by the outstanding investigators in the field, such as the authors of this article. As an additional example, Weisfeldt and Becker’s 3-phase time-sensitive model of CPR describes a time-sensitive progression of resuscitation physiology and will help us understand the phases of cardiac arrest. It will also help us understand important electrical and pathophysiological information in a model which suggests that the optimal treatment of cardiac arrest is phase-specific and is different for each phase. Quality of CPR and its optimization is critical in obtaining best outcomes after cardiac arrest, as discussed earlier. These important areas of research have and will continue to improve outcomes, change existing algorithms for CPR, and result in technologies that will optimize CPR quality and outcomes. This new experimental data, as well as observational human data such as that provided by Bobrow et al in this issue of Circulation, will continue pave the way for improved outcomes after cardiac arrest.

In summary, the study by Bobrow is an incredibly important study. This work reports the significance of gasping associated with cardiac arrest and notes the survival benefit. But it cautions us to be sure to understand that gasping indeed can be associated with cardiac arrest and should not prevent or delay the institution of CPR. This work also is important in the debate over continuous chest compression CPR versus the need for assisted ventilation and may argue for the former. This type of work and other studies by leaders in the field of resuscitation science will allow a better understanding of cardiac arrest and improvements in interventions, therapies, and devices for a problem that is a major public health issue not only in the United States but throughout the world.

Disclosures

None.

References


Key Words: Editorials ■ arrhythmia ■ cardiopulmonary resuscitation ■ death, sudden, cardiac ■ heart arrest ■ survival