Editorials

Ventilation During Cardiopulmonary Resuscitation: The Right Tool for the Job

For the moment, the ABCs of cardiopulmonary resuscitation (CPR) remain in place: *A*irway, *B*reathing, and *C*irculation, and, now, *D*efibrillation, are the alphabet of CPR. At issue is the relative importance of each. In a recent editorial, Berg eloquently reviewed the questions surrounding the importance of breathing during CPR.[1] In a nutshell, the role of ventilation during CPR depends on the cause of cardiac arrest. When arrest is secondary to asphyxia, breathing is essential for successful CPR.[2] In cases of ventricular fibrillation, defibrillation jumps to the head of the alphabet and breathing is less important.[3] When breathing is performed too vigorously during CPR, this causes a low-flow state and outcomes may be adversely affected.[4] The discussion by Berg is excellent, and I refer readers to his paper for details.

SEE THE ORIGINAL STUDY ON PAGE 1445

In this issue of RESPIRATORY CARE we consider the next letter in the CPR alphabet: E for *E*quipment and *E*ducation. Barnes et al compare ventilation in a model using traditional bag-valve-mask ventilation with a self-inflating manual resuscitator and a pneumatically powered, flow-limited, pressure-cycled, automatic resuscitator.[5] Over the last decade there have been important changes in the recommendations for ventilation during CPR.[6] Gone are the 3 rapid breaths at the beginning of resuscitation to restore lung volume and the 1,000-mL tidal volume. Instead we have long inspiratory time and slow flow (30–40 L/min) coupled with tidal volume of 400–600 mL. Both recommendations are aimed at reducing gastric inflation in the unintubated patient. Interestingly, while conventional wisdom supports these smaller tidal volumes, the “evidence” for this change is based on demonstration of “chest excursion” at that volume.[7]

Barnes et al demonstrate little difference in the 2 techniques with respect to delivered volumes and the amount of gastric inflation between the manual and automatic resuscitator. Given the model of parallel compliance (model lung and model stomach), these results are not unanticipated. This model is commonly used, and is in fact based on one developed by our group over a decade ago.[8] The work by Barnes et al here is careful and competent.

My concern relates to the recommendations by the American Heart Association (AHA) and how the education and the equipment are introduced. This predominantly deals with automatic resuscitators and portable ventilators during CPR. Based on the AHA recommendations, these devices have been developed using a fixed flow and prolonged inspiratory time. This achieves the desired effect of lower airway pressure and less gastric distention than occurs with larger volumes and shorter inspiratory times. The disconnect occurs in the current training. The basic life support course focuses on expired air techniques (eg, mouth-to-mouth or mouth-to-mask) and bag-valve-mask. The use of ventilators and automatic resuscitators is taught during advanced life support. However, during advanced life support, endotracheal intubation is commonly used to secure the airway. This results in 2 problems:

1. *Equipment.* The low flow and long inspiratory time have no advantage during ventilation of the intubated patient. In fact, the long cycle time reduces the effectiveness of compressions, important in restoring circulation and outcomes. As an example, given the new recommendations of 15 compressions to 2 ventilations, if tidal volume is 500 mL and inspiratory flow is 30 L/min (0.5 L/s), inspiratory time is 1 second. Assuming a minimum expiratory time of 2 seconds, compressions are delayed for a minimum of 4 seconds. This limits the number of compression per minute (assuming a robust 15 compressions every 10 s) to 75 compressions per minute. This falls short of the 80 compressions recommended by the AHA. This also assumes that you begin compression during the expiratory phase of the second breath.
2. *Education.* If automatic resuscitators and portable ventilators that feature low inspiratory flow are to be used during CPR, the use of these devices must be taught in basic life support. Once endotracheal intubation is achieved, slow flow has no advantages.

I believe this suggests important issues to be considered by AHA and our industry colleagues. The first is simply that use of the devices, which are designed to reduce gastric inflation during CPR in the unintubated patient, be taught to the caregivers (emergency medical technicians and others) present during that phase of resuscitation. Second, automatic resuscitators and ventilators used during CPR of ventilated patients should have the ability to abandon low flow, as the situation dictates. A recent paper in RESPIRATORY CARE by Yannopoulos et al showed that ventilation at a 15:2 ratio reduced coronary and cerebral perfusion pressures in a model of ventricular fibrillation.[9] Their findings might be altered by changes in the way ventilation is delivered.

Another important E is *Evaluation*. Devices such as those studied by Barnes et al must be tested under relevant conditions. AHA has long warned against the use of pressure-cycled devices during CPR because of the effect of compressions on delivered tidal volumes. Manufacturers of these devices often claim that, since flow is constant, their devices are not pressure-cycled. Devices such as the Oxylator, tested by Barnes et al, are simple devices that cannot provide constant tidal volumes, and in the automatic mode cannot provide a consistent rate. (Note that in the study by Barnes et al[5] the operators determined the breathing frequency.) In the automatic mode, the Oxylator is always trying to initiate inspiration, with the expiratory time and, hence, frequency being controlled by increasing expiratory resistance. Positive end-expiratory pressure is present during use of the Oxylator, as a consequence of the device's operational principle. Compressions during use of this type of device may result in triggering of a breath with each decompression and cycling of the breath with each compression. How this operation might affect ventilation, coronary and cerebral perfusion pressures, and outcomes is unknown.

Finally, I would like to congratulate Tom Barnes on his continued work toward improving our understanding of ventilation and ventilation devices for CPR. Tom has served on a number of committees with AHA, helping to guide practice through evidence-based review. His work on behalf of patients, clinicians, and the American Association for Respiratory Care deserves recognition.

Richard D Branson MSc RRT FAARC
Department of Surgery
University of Cincinnati
Cincinnati, Ohio

Correspondence: Richard D Branson MSc RRT FAARC, Department of Surgery, University of Cincinnati, 231 Albert Sabin Way, Cincinnati OH 45267-0558. E mail: richard.branson@uc.edu.

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