CARDIOLOGY CASEBOOK
A regular feature of the American Journal of Critical Care, Cardiology Casebook is intended to enhance practitioners’ knowledge and critical thinking. Stylized case studies are accompanied by self-assessment quizzes. We welcome letters to the editors regarding this feature.

CARDIOPULMONARY RESUSCITATION REVIEW: CRITICAL ROLE OF CHEST COMPRESSIONS

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A 50-year-old man suddenly collapsed while standing in the waiting area of a local hospital. A physician walking by promptly determined, by the absence of carotid pulses, that cardiac activity had ceased. He then quickly removed a Swiss Army knife that he kept in his trouser pocket, made several chest wall precordial incisions to expose the heart, which he found to be in standstill, and initiated hand compression cardiac massage (all within 3 minutes of the event). Cardiac contractions promptly returned and the patient started to breathe. The patient was immediately taken to surgery and the chest wounds were cleansed and repaired. Subsequent chest wall and pericardial infections were treated using drains and intensive parenteral antibiotics: the patient recovered and was discharged 3 weeks after the event.

This was the state of cardiac resuscitative measures in the “1950s” when it was not uncommon for physicians to carry folding knives to be used in sudden death emergencies. It was not until 1959 that Kouwenhoven and Jude1 first reported on the success of external chest compression as a procedure that could safely and effectively massage the heart and reverse sudden cardiac death. This was the stimulus for the birth of modern cardiopulmonary resuscitation (CPR).

QUESTIONS
1. The early CPR guidelines emphasized which of the following procedures?
   a. defibrillation
   b. chest compressions
   c. mouth to mouth resuscitation
   d. ECG transmission to emergency department personnel

2. The CPR guidelines in the 1990s and to the present emphasized which of these procedures?
   a. defibrillation
   b. chest compressions
   c. mouth to mouth resuscitation

3. During CPR, repeated interruptions of chest compression are routine in order to allow which of the following?
   a. assessment of the pulse and rhythm
   b. mouth to mouth resuscitation
   c. insertion of a central line
   d. intubation
   e. changing rescuers
   f. attempts at electrical defibrillation
   g. any of the above

4. Lay persons are less likely to perform CPR.
   a. true
   b. false
   c. maybe

5. Three phases are identified during a cardiac arrest event, and treatment differs for each phase. What is the sequence of the 3 phases during cardiac arrest?
   a. metabolic phase, electrical phase, hemodynamic phase
   b. electrical phase, hemodynamic phase, metabolic phase
   c. hemodynamic phase, electrical phase, metabolic phase

6. Renewed emphasis on continuous chest compressions during CPR is based on which of the following data?
   a. there is no coronary perfusion during interrupted chest compressions
   b. delays during hands off-time required for ECG rhythm analysis

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c. prolonged ventricular fibrillation (VF) leads to myocardial metabolic degradation, which lessens the probabilities of successful attempts at defibrillation unless preceded by chest compressions
d. 1.5 to 4 minutes are needed for delivery of drugs and oxygen to vulnerable tissues: continuous chest compressions improve drug and oxygen delivery
e. all of the above

7. Determinants of a successful neurological outcome during prolonged cardiac arrest are which of the following?
a. continuity of minute ventilation and oxygen saturation
b. continuity of circulatory support
c. number of chest compressions delivered/minute
d. number of breaths delivered/minute

ANSWERS
1. b. chest compressions
c. mouth to mouth resuscitation

In the early 1960s, the pioneers of CPR established 3 components of CPR, viz: closed chest cardiac massage, electrical defibrillation, and artificial ventilation. The first CPR guidelines for cardiac arrest, published in the 1970s and revised in 1980 and 1986, stressed the importance of chest compressions. Also, the early defibrillators were more complicated and the lay public found this new equipment difficult to use in a timely fashion; as a consequence, CPR procedures concentrated on chest compression and mouth to mouth resuscitation.

2. a. defibrillation

In the early 1990s, the role of electrical defibrillators gained prominence. New technological advances improved and simplified the use of defibrillators, and the emphasis on defibrillation in CPR became prime time. Compressions were considered to be only 50% of the resuscitation attempt. The 1992 CPR guidelines placed chest compressions second to defibrillation. Recently portions of the original CPR guidelines that were reaffirmed in 2000 have been reported to be “seriously flawed.” Survival rates of out-of-hospital VF patients over the past 15 years had not improved and averaged 13% to 14%. The dismal survival rates had not changed for out-of-hospital cardiac arrest victims when chest compressions were interrupted to do 2 “quick breaths.”

3. e. any of the above

Common reasons for interrupting chest compressions are repeating patient assessments, performing mouth to mouth resuscitation, inserting a central line, intubation, changing rescuers, and attempting defibrillation. The time incurred during the automatic implantable defibrillator’s (AED) “hands off, don’t touch the patient” phase is significant and can delay initiation of chest compression by as much as 1.5 to 2 minutes. The use of AEDs may result in a higher mortality than manual defibrillation, because of the inherent delay required for analyzing the rhythm following a shock before resuming compression.

4. a. true

Bystander CPR is a major element in the “chain of survival” in cardiac arrest. Survival from cardiac arrest is known to improve with bystander CPR. However, recent reports reveal a decrease in the number of lay persons performing CPR. Less than 33% of those who witness a cardiac arrest will initiate CPR after calling 911. Doing nothing while waiting for rescue personnel often ensures a dismal outcome for the victim. There is great reluctance to administer mouth to mouth resuscitation, and bystanders are more likely to perform CPR if mouth to mouth rescue breathing is not required. It is noteworthy that similar reluctance to perform mouth to mouth resuscitation has been expressed by trained basic life support instructors, nurses, and physicians as well, and though reasons differ, the responses are consistent. When bystander CPR is initiated, it takes a lay public rescuer an average of 16 seconds just to deliver the first 2 “quick breaths”; chest compressions were performed for only 18 seconds each minute. It was conceived that if fewer ventilations were performed, a greater number of chest compressions could be done that would result in greater perfusion and thus improve the outcome.

In a report on a large Welsh study, those performing compression-only-CPR did better in remembering to call for help, open the airway, and check for breathing. More important was the finding that during the average of 8 minutes until the arrival of advanced cardiac life support, the standard CPR recommendations, which call for interruptions of chest compressions to allow 2 breaths, provided 308 chest compressions, while in sharp contrast, compression-only-CPR provided 675 chest compressions (a 119% increase). The more frequent chest compressions provide greater movement and greater delivery of blood, both vital to survival.
Three phases have been identified during cardiac arrest. Specific therapeutic interventions differ in each phase and are critical for a successful outcome. The first is the electrical phase, which lasts about 5 minutes during which defibrillation is the priority. The success of early defibrillation in this phase was demonstrated in an American Airline study at Chicago’s O’Hare air terminal and also in a study in gambling casinos where security guards were trained in the use of AEDs. The use of AEDs within 3 minutes following the onset of VF resulted in the highest ever reported survival of 70%. The electrical phase is followed by the hemodynamic phase that lasts from 4 to 10 minutes, during which time circulatory support using chest compression is the priority. During the hemodynamic phase, the use of AED can be harmful. When cardiac arrest has been longer than 5 minutes, the patient has gone from the electrical to the hemodynamic phase, then starting chest compressions can attain a survival of 20% compared to 4% if during the hemodynamic phase electrical shock is given first and followed by compressions. In the first 5 minutes of VF, blood shifts from the left to the right side of the heart, leaving the left side of the heart essentially empty; the patient is then in the hemodynamic phase and the use of the AED can be harmful, the patient being in pulseless electrical activity. The third and last phase is the metabolic phase, when drugs and hypothermia can be used. In the latter 2 phases of cardiac arrest, perfusion is critical, and the use of AEDs can be deleterious, because this would delay and limit the use of chest compressions, which are critical in maintaining coronary perfusion pressure and vital to survival.

Additional findings that support the change to continual emphasis on continual chest compression include the following: improved performance in chest compressions by a mechanical device, reduction in coronary perfusion pressure after interruption of chest compression, and delays stemming from hands-off time required for rhythm analysis. CPR prior to defibrillation improves outcome when arrest-to-defibrillation intervals are greater than a few minutes (animal data); prolonged VF results in myocardial metabolic degradation, but the success of defibrillation improves when the myocardium is metabolically stable; chest compressions after administration of shocks ensure delivery of drugs and oxygen to vital organs because during the event it takes 1.5 to 4 minutes to deliver drugs and oxygen. In standard CPR, interrupting chest compressions resulted in a 40% reduction of blood flow and a comitant decrease in survival (13%). In contrast, uninterrupted compression-only-CPR resulted in an 80% neurologically normal survival rate.

The greater importance of compressions over ventilations during CPR has been reestablished. The findings from laboratory studies and simulated events indicate that adult (nonrespiratory) cardiac arrest victims are more likely to recover when they receive a higher number of chest compressions even at the expense of a reduction in the number of ventilations. The primary determinant of a successful neurological outcome is maintaining circulatory support during prolonged cardiac arrest, which is achieved by continuity of chest compressions. The pH, oxygen saturation, and the absolute levels of minute ventilation are not primary determinants of a positive neurological result. There are critical limits for ventilatory parameters and related outcomes; however, the outer limits are relatively generous and are not exceeded during the first 12 minutes of basic life support, regardless of supplemental mouth to mouth breathing. There is usually sufficient oxygen within the blood at the time of cardiac arrest, and even with limited circulation, reasonable oxygen saturation persists for 10 minutes or longer. In a recent study, the average arterial blood saturation remained above 70% during the first 10 minutes of CPR. Also with an open airway, chest compression alone can generate some ventilation of the lung, and this is in addition to the intrinsic gasping by the patient. The number of chest compressions delivered has a direct correlation with the return of spontaneous circulation and successful resuscitation. Providing uninterrupted chest compressions during CPR is critical to survival, as reported in several studies. Continous chest compressions should always be performed in nonrespiratory cardiac arrest when only one rescuer is available.

Summary

Sudden cardiac death is the most common cause of death in the developed countries of the world, accounting for more deaths each year than the total number of deaths from AIDS, lung cancer, breast cancer, and stroke. The Centers for Disease Control estimated an incidence of 450,000 sudden deaths annually.
with a 5% survival rate. Given these statistics, it is imperative that resuscitative measures be continuously updated. Accordingly, there is compelling evidence accumulating that reveals the critical role of chest compressions during CPR in improving survival rates in nonasphyxial sudden cardiac death. Bystanders are advised to do uninterrupted chest compression continuously until rescue personnel arrive or until return of cardiac contractile function.

Finally, it is worth noting that in their original report on closed chest cardiac massage in 1960, Kouwenhoven and Jude\(^1\) stated that “classical chest cardiac massage provides ventilation of the lungs and if there is one person present in the case of arrest, attention should be concentrated on the massage.”

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Cardiopulmonary Resuscitation Review: Critical Role of Chest Compressions
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