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Review Article

# Adult Basic Life Support: Update from the Recent Guidelines on Cardiopulmonary Resuscitation

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## Abstract

Sudden cardiac death is the most prevalent yet preventable clinical problem. It is estimated that about 300,000 to 400,000 deaths occur annually due to cardiovascular causes with 63% occurring due to sudden cardiac deaths. The most important determinant of survival among these patients is the prompt and effective delivery of basic life support at the site or by the first bystander. Although there has been a decline in overall cardiovascular morbidity and mortality but the incidence of sudden deaths from cardiovascular causes has remained constant. Currently the basic life support not only includes cardiopulmonary resuscitation but also defibrillation using automated external defibrillators. The latest guidelines for cardiopulmonary resuscitation published in 2010 by the American Heart Association (AHA) have made substantial changes to the basic life support strategy. The conventional stepwise approach A-B-C has been changed to C-A-B. This mandates the decrease in time to deliver first compression. Look, listen and feel has been omitted to avoid unnecessary delay of the chest compressions. The pulse check parameter has also been diminished for healthcare providers. This review covers the management of cardiopulmonary resuscitation, and scrutinizes current practices and data supporting the use of CPR.
**Key words:** Adult basic life support, recent guidelines 2010, a review.

## Introduction

Sudden cardiac death causes almost 63% deaths[1]. Survival in such patients is dependent on prompt and effective delivery of basic life support at the site[1-4]. Sudden cardiac arrest is often the first manifestation of coronary artery disease (CAD), accounting for up to 50% mortality in United States and other developed countries. The incidence of sudden cardiac death is 55 per 100,000 persons or 5.6% mortality per year[2,3]. Although a decline in overall mortality due to cardiovascular causes has been noted but the incidence of sudden death from cardiovascular disease has remained constant[5].

Cardiac arrest leads to unexpected and sudden interruption of effective cardiac pumping function. This results from either ventricular asystole, pulseless ventricular tachycardia (VT) or ventricular fibrillation (VF)[6].

### History of CPR

In 1960, 14 patients survived a cardiac arrest after application of closed chest cardiac massage[7]. In the same year, a combination of chest compressions and rescue breathing was introduced. Two years later, direct-current monophasic waveform defibrillation was used[8]. In 1966 the American Heart Association developed the first cardiopulmonary resuscitation (CPR) guidelines which, are followed after periodic updates[9]. During the past 50 years, the fundamentals of early recognition and activation of early CPR, early defibrillation, and early access to emergency medical care have saved hundreds of thousands of lives around the world. These saved lives demonstrated the importance of resuscitation, research and clinical translation.

In the current era basic life support not only includes cardiopulmonary resuscitation (CPR) but also defibrillation using automated external defibrillators.

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### Basic life support

Basic life support (BLS)[10-12] includes:

1. Recognition of signs of sudden cardiac arrest (SCA), heart attack, stroke and foreign body airway obstruction.
2. Cardiopulmonary resuscitation (CPR) and defibrillation.

There has been striking differences in survival outcomes from cardiac arrest across different systems of care, with some systems reporting up to 5-fold higher survival rates than others[13-17]. Although electrical therapy, like automated external defibrillators (AEDs), has contributed to increased survival from cardiac arrest but no initial intervention can be delivered to the victim of cardiac arrest unless bystanders are trained, ready, willing and able to deliver defibrillation in a timely fashion. Moreover, to

be successful, the actions of bystanders and other care providers must occur with a system that coordinates and integrates each facet of care into a comprehensive program that focuses on survival to discharge from the hospital. The recent 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation (CPR) and Emergency cardiovascular care marks the 50th anniversary of modern CPR. In these 2010 guidelines, scientists and healthcare providers have identified factors which have the greatest potential impact on survival. On the basis of strength of the available evidence, they developed recommendations to support the interventions that showed most promising outcomes. There was a unanimous support for continued emphasis on high-quality CPR, with compressions of adequate rate and depth. Thus allowing complete chest recoil, minimizing interruption in chest compressions and avoiding excessive ventilations. High-quality CPR is the cornerstone of a system of care that can optimize outcomes which lie beyond the return of just spontaneous circulation. Return to previous quality of life and functional state of health is the ultimate goal of a resuscitation system of care[18]. Recent guidelines are based on the latest and comprehensive reviews of literature on resuscitation.

**Task force**

The 2010 guidelines were formulated by 356 resuscitation experts from 29 countries, who reviewed, analyzed, evaluated, debated and discussed the researches and hypotheses through interactive meetings for 36-months before the 2010 consensus conference. The experts produced 411 scientific evidence reviews on 277 topics in resuscitation and emergency cardiovascular care. The process included structured evidence evaluation, analysis and cataloging of the literature[18].

Current guidelines also confirm the safety and effectiveness of many approaches. It introduces new treatments based on intensive evidences, evaluations and consensus of experts. Yet these guidelines do not apply to all rescuers and all victims in all situations. The leader of a resuscitation task may need to adapt applications of these recommendations according to the prevailing circumstances[18].

The guidelines published in 2005 by the American Heart Association are based on the International Consensus Conference on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with treatment recommendations. These include a substantial change to the practice of Basic Life Support[19].

This review summarizes the key modifications in the updated guidelines and highlights the most important practical changes to CPR from the year 2000 to 2010.

**Approaches**

**Shock-first versus CPR first approach**

It was considered important in 2005 guidelines to distinguish between witnessed (known duration of cardiac arrest) and unwitnessed arrest. If a cardiac arrest is witnessed and CPR is begun immediately, shock can be given as soon as the defibrillator is available. In an unwitnessed cardiac arrest, it is recommended to give two minutes of CPR first and then give shock[19]. Cobb and colleagues showed that in patients in whom response intervals exceeded 4 minutes, delivery of 90 seconds of CPR before defibrillation resulted in a 27% survival rate to discharge compared with a 17% survival rate in the group receiving defibrillation first by emergency medical technicians ($p$-value= 0.01). They also showed an overall improvement in neurologic status in the CPR first group independent of response time[20]. A randomized trial by Wik and colleagues also showed similar results[21]. However, one randomized trial did not show such a survival benefit[22]. For patients with unwitnessed arrest, immediate defibrillation was recommended in the year 2000 but this was changed in 2005 to give 5 cycles of CPR before defibrillation. This has been retained in recent 2010 guidelines.

In prolonged ventricular fibrillation, CPR provides benefit by depleting high-energy phosphate molecules to cardiac myocytes. CPR improves the metabolic status of the heart by providing a critical amount of perfusion to the heart.

**Compression-ventilation ratio**

The compression ventilation ratio was also addressed in 2005 and changed from 15:2 to 30:2. In 2010, compression- ventilation ratio of 30:2 was retained. In the new strategy the compressions were to be given before ventilations unlike previously when ventilations were given before chest compressions[18]. Compressions before ventilations increase the chances of survival by providing early blood flow to vital organs and therefore, increasing the chances of giving unnecessary CPR to unconscious victims who are infect not suffering from cardiac arrest.

**One shock versus three shocks**

No evidence has proven that one shock is better than three stacked shock. However, checking the pulse and analyzing the rhythm, in the three stacked shock protocol, causes unnecessary delay in delivering CPR as each time when a patient receives a shock, there is a delay of 40 seconds to resume CPR[23]. Two other studies have also shown delay of 17 to 38 second in the postshock CPR[24,25]. Delays of 15-20 second in CPR in the three stacked shocks is a predictor of poor neurologic outcomes[26,27]. Interruption of CPR results in low cardiac perfusion pressures[28,29]. In more than 60% of patients after cardiac arrest the initial rhythm after the delivery of shock was either asystole or a non-reperfusing rhythm[23-25,30]. Therefore, immediate CPR is strongly recommended after the first shock[19]. A total of five cycles of CPR should be given before the rhythm is checked. The pulses

are checked if the rhythm is other than asystole or a pulseless electrical activity. The time of second shock is standardized after five cycles of CPR, and should not be more than 2 minutes.

Sequence of defibrillation shocks was modified in 2005 from 3 stacked shocks to one shock only followed by immediate CPR and defibrillation after 5 cycles of CPR[31,32]. This sequence has remained unchanged in 2010 guidelines[19].

**Monophasic versus biphasic defibrillators**

Biphasic waveforms have been shown to be more effective than monophasic waveforms[23-35]. None provides survival benefit over the other[23,33,34]. The American heart association recommends 360J for the monophasic waveform and 200J for the biphasic waveform just for the sake of ease and to prevent unnecessary delays in selection of the joules. Superiority of either escalating or fixed subsequent doses of energy has not been tested yet with different waveforms. However, if higher energy levels are available in the device at hand, they may be considered if the initial shocks are unsuccessful in terminating the arrhythmia. In the last 5 to 10 years many randomized trials have compared biphasic with monophasic cardioversion in atrial fibrillation[36-38]. Cardioversion of adult atrial flutter and other supraventricular tachycardias generally requires less energy; an initial energy of 50 J to 100 J is often sufficient[39]. If the initial shock fails, increase the dose in a stepwise fashion[40]. Adult cardioversion of atrial fibrillation with monophasic waveforms should begin at 200J and increase in a stepwise fashion where necessary.

**CPR duration before defibrillation**

To give the victim the best chance of survival, 3 actions must occur within the first few moments of a cardiac arrest[41].

**(1) Activation of the EMS system[42], (2) Provision of CPR and (3) Operation of a defibrillator[43]**

One controversial area is whether delivering a longer period of CPR before defibrillation improves outcomes in cardiac arrest or not. In early studies, survival was shown to be improved but in 2 recent randomized controlled trials CPR performed before defibrillation did not affect the outcome[44,45]. As a rule if two rescuers are present, one should start CPR and second should call EMS and obtain the defibrillator for use.

**Role of automated external defibrillator (AED)**

AED's are safe, simple and effective devices designed to be used by the general public and by first responders. The layperson and first responders can perform defibrillation even at home[46,47]. Studies have shown that laypersons and first responders can be trained for defibrillation techniques. Use of AED for in-hospital cardiac arrest has led to a 2.6-fold increase in survival from cardiac arrest[48]. A study reported 34% survival at discharge for in-hospital patients with cardiac arrest caused by ventricular tachycardia or ventricular fibrillation[49].

**CPR by lay rescuers**

During the past 5 years large observational studies have provided important information about the positive impact of bystander CPR on survival in an out-of-hospital cardiac arrest. For most of the adults with out-of-hospital cardiac arrest, bystander CPR with chest compressions only (Hands-Only CPR) appears to achieve similar outcomes as those from conventional CPR (compressions with rescue breathing)[50, 51].

"A-B-C" changed to "C-A-B"

The latest development in the Guidelines for CPR is a change in the basic life support (BLS) sequence of steps from "A-B-C" (Airway, Breathing, Chest compressions) to "C-A-B" (Chest compressions, Airway, Breathing) for adults and pediatric patients (children and infants, excluding the newborns).

The experts have also agreed to the importance to reduce time to first chest compressions. The 2010 Guidelines for CPR recommend this change for the following reasons:

1. The vast majority of cardiac arrests occur in adults, and in these patients the critical initial elements of CPR are EARLY chest compressions and EARLY defibrillation[18].
2. By changing the sequence to C-A-B, chest compressions will be initiated earlier and ventilation will be minimally delayed until completion of the first cycle of chest compressions (30 compressions should be accomplished in approximately 18 seconds).
3. Most rescuers find rescue breaths delivery more difficult than chest compressions.
4. It is reasonable for healthcare providers to tailor the sequence of rescue actions to the most likely cause of arrest. For example, if a lone healthcare provider sees a victim collapsing suddenly, the provider should assume that the victim has suffered a sudden VF cardiac arrest and must provide CPR. But for a presumed victim of drowning or other likely asphyxial arrest, the priority would be to provide about 5 cycles (about 2 minutes) of conventional CPR (including rescue breathing) before activating the emergency response system[18].

**New key changes in the guidelines for CPR**

1. In order to avoid time delay "Look, Listen and Feel" has been removed from the stepwise approach to BLS. The recent guidelines stress on the immediate activation of the emergency response system and starting chest compressions for any unresponsive

adult victim who has either no breathing or abnormal breathing (i.e., only gasps).
2. Hands-Only (compression only) CPR has been encouraged for the untrained lay rescuer who hesitate giving rescue breaths due to the fear of contacting contagious diseases. Hands-Only CPR is easier to perform even by those who have no training. Results are similar to conventional CPR.
3. New recommendations stress on chest compressions before giving rescue breaths (C-A-B rather than A-B-C) [18].
4. There is an increased focus on methods to ensure that high-quality CPR is performed, i.e. push hard and fast on a hard surface at a rate of 100 per minute with minimum interruptions and allow equal time for recoil of chest. The recommended depth of compression for adult victims has increased from a depth of 1 and 1/2 to a depth of at least 2 inches.
5. Many tasks performed by healthcare providers during resuscitation attempts can be performed concurrently by an integrated team of highly trained rescuers. A lone rescuer can start alone and call for help, resulting in the arrival of additional team members by that time[18].
6. The importance of pulse check has been decreased for the healthcare providers. Detection of a pulse can be difficult, and even highly trained healthcare providers often incorrectly assess the presence or absence of a pulse when the blood pressure is very low or absent. The lay rescuer should not attempt to check for a pulse and should assume that cardiac arrest is present if an adult suddenly collapses, is unresponsive, and is not breathing or not breathing normally (ie, only gasping).

**Key points of continued emphasis for the 2010 guidelines for CPR**

1. Responsiveness should be checked first for early recognition of cardiac arrest.
2. Training should focus on alerting potential rescuers to the unusual presentations of sudden cardiac arrest such as gasping respiration and seizure.
3. Minimize interruptions during effective chest compressions until termination of resuscitative efforts.
4. Minimize the importance of pulse check by healthcare providers. Healthcare providers should take no more than 10 seconds to determine if a pulse is present or not[18].

**Stabilization of the Patient with ACS**

A packaged system of care for patients with ST elevation myocardial infarction (STEMI) has been suggested in 2010 guidelines. This system stresses on taking 12-lead electrocardiograms (ECGs) before reaching the hospital, triage to percutaneous coronary intervention (PCI) capable center, and comprehensive care for patients following cardiac arrest with confirmed STEMI. A well-organized approach to STEMI care also requires integration of community, EMS, physician, and hospital resources[52-58]. A 12-lead ECGs before reaching the hospital decreases time to primary percutaneous coronary intervention (PCI) and guides patient transfer to specific hospitals when PCI is the most likely option[59-66]. Early ECG diagnosis by EMS team causes timely activation of the cardiac catheterization laboratory by the EMS team or ED physician leading to significant reductions in time to reperfusion. The ACS guidelines have also made new recommendations for triage of patients to PCI centers after cardiac arrest. Performing routine cardiac catheterization as part of standardized post-cardiac arrest protocols has also been considered reasonable in the new guidelines. Early PCI will cause less or no neurological damage and improve functional recovery. It is also recommended to carry out emergent angiography and prompt revascularization in patients with out-of-hospital cardiac arrest. The ECG may be insensitive or misleading following cardiac arrest, and coronary angiography in subjects with arrest of presumed ischemic cardiac etiology may be reasonable, even in the absence of a clearly defined STEMI.

**Adult Stroke**

Approximately 795,000 people suffer a new or repeat stroke each year, and stroke remains the third leading cause of death worldwide. A collection of effort in stroke patients should include public education, 911(or any other) dispatch, pre-hospital diagnosis and triage and a stroke care system in hospitals. As with STEMI patients, pre-arrival hospital notification by the transporting EMS unit significantly increase the percentage of patients with acute stroke who receive fibrinolytic therapy. The 2010 AHA Guidelines for CPR recommend that every hospital with an Emergency Department have a written plan that is communicated to EMS systems describing how patients with acute stroke are to be managed in that institution. Triage of patients with acute stroke directly to designated stroke centers is a new Class I recommendation. Another new Class I recommendation is admission of the stroke patient to a dedicated stroke unit managed by a multidisciplinary team experienced in stroke care**.** Since the publication of the 2005 AHA Guidelines for CPR, additional data have emerged extending the time window for administration of IV recombinant tissue plasminogen activator (rtPA) to select patients with acute ischemic stroke. These guidelines now recommend IV rtPA for patients who meet the eligibility criteria for the National Institute of Neurological Disorders and Stroke (NINDS) or the Third European Cooperative Acute Stroke Study (ECASS-3) if rtPA is administered by physicians in the setting of a clearly defined protocol with a knowledgeable team and

institutional commitment. However, it is important to emphasize the continued time-dependent reperfusion window and that earlier treatment is better and is associated with improved outcome. Patients ineligible for standard IV fibrinolytic therapy may be considered for intra-arterial fibrinolytic therapy or mechanical revascularization only at selected centers with specialized capabilities. Finally these guidelines recommend admission to a stroke unit within 3 hours of presentation to the ED. Recent studies establish that stroke unit care is superior to care in general medical wards, and positive effects of stroke unit care can persist for years. The benefits from treatment in a stroke unit are comparable to the beneficial effects achieved with IV rtPA. Overall stroke care has progressed dramatically. Improvements in education, prehospital management, hospital system development, and acute treatments have lead to significant improvements in patient outcomes[18].

**Special Situations**

Cardiac arrest in special situations may require special treatments or procedures beyond those provided during standard BLS. Because of difficulty in conducting randomized clinical trials in these areas or their infrequent occurrence, these unique situations call for an experienced provider to go "beyond basics" using clinical consensus and extrapolation from typical circumstances. Topics with these potentially unique features include asthma, anaphylaxis, pregnancy, morbid obesity, pulmonary embolism, electrolyte imbalance, ingestion of toxic substances, trauma, accidental hypothermia, drowning, electric shock or lightning strikes, and special procedural situations affecting the heart, including PCI, cardiac tamponade, and cardiac surgery[18].

On the 50th anniversary of modern-era CPR, it is acknowledged that, despite measurable progress aimed at its prevention, cardiac arrest, both in and out of the hospital, continues to be a major public health challenge. Over these 50 years, scientific knowledge about arrest pathophysiology and resuscitation mechanisms has increased substantially. In the ongoing commitment to ensure optimal community-based care for all victims of cardiac arrest, it must be continued to effectively translate the science of resuscitation into clinical care and improved resuscitation outcomes[18].

BLS training facilities are lacking in developing countries including Pakistan. Even the most concerned personnel lack the specialty as a professional and attendance in the BLS courses is also less frequent. There are Emergency Medical Services available in our country but in a primitive state. There is a need to educate skills of BLS to train health care providers and relatives of those patients who suffer or are at high risk for coronary artery disease. There is also a need to refresh/update on a large scale the current BLS system to the personnel who are an integral part in the healthcare system professions.

## References


1. Zipes DP, Wellens HJ. Sudden cardiac death. Circulation 1998;98:2334-51.
2. Holmberg M, Holmberg S, Herlitz J. Effect of bystander cardiopulmonary resuscitation in out-of-hospital cardiac arrests patients in Sweden. Resuscitation. 2000; 47: 59-70.
3. Caffrey SL, Willoughby PJ, Pepe PE, Becker LB. Public use of automated external defibrillators. N Engl J Med 2002; 347: 1242-7.
4. Hallstrom AP, Ornato JP, Weisfeldt M. Public-access defibrillator and survival after out-of- hospital cardiac arrest. N Engl J Med 2004; 351: 637-46.
5. Zheng ZJ, Croft JB, Giles WH, Mensah GA; Sudden Cardiac death in United States, 1989 to 1998. Circulation 2001; 104; 2158-63.
6. Chandra-Strobos N, Weisfeldt ML. Cardiopulmonary resuscitation and the subsequent management of the patient. In: Fuster V, Alexander RW, O'Rourke RA, Roberts R, King SB, Nash IS, et al, editors. Hurst's The heart. 11th ed. New York: McGraw-Hill; 2004:p.1030.
7. Kouwenhoven WB, Jude JR, Knickerbocker GG. Closed-chest cardiacmassage. JAMA 1960;173:1064-7.
8. Lown B, Neuman J, Amarasingham R, Berkovits BV. Comparison ofalternating current with direct electroshock across the closed chest. Am J Cardiol 1962;10:223-33.
9. Cardiopulmonary resuscitation: statement by the AdHoc Committee on cardiopulmonary resuscitation, of the division of medical sciences, National Academy of Sciences, National Research Council. JAMA.1966;198:372-9.
10. Robert WH, John EB, Vinay MN, William MM, Robert EO, Micheal RS, et all. 2005 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation 2005; 112;19-34.
11. Zheng ZJ, Croft JB, Giles WH, Mensah GA; Sudden Cardiac death in United States, 1989 to 1998. Circulation 2001; 104; 2158-63.
12. Reynold MR, Josephson ME. Sudden cardiac death. In: Fuster V, Alexander RW, O'Rourke RA, editors. Hurst's. The heart, 11th ed. New York: Mc Graw Hill; 2004. P.1051-78.
13. Nichol G, Thomas E, Callaway CW, Hedges J, Powell JL, AufderheideTP, et al .Regional variation in out-of-hospital cardiac arrest incidence and outcome. JAMA. 2008;300:1423-31.
14. Mogayzel C, Quan L, Graves JR, Tiedeman D, Fahrenbruch C, HerndonP. Out-of-hospital ventricular fibrillation in children and adolescents: causes and outcomes. Ann Emerg Med 1995;25:484-91.
15. Donoghue AJ, Nadkarni V, Berg RA, Osmond MH, Wells G, Nesbitt L,Stiell IG. Out-of-hospital pediatric cardiac arrest: an epidemiologicreview and assessment of current knowledge. Ann Emerg Me. 2005;46:512-22.
16. Samson RA, Nadkarni VM, Meaney PA, Carey SM, Berg MD, BergRA. Outcomes of in-hospital ventricular fibrillation in children. N EnglJ Med 2006;354:2328-39.
17. Atkins DL, Everson-Stewart S, Sears GK, Daya M, Osmond MH, Warden CR, et al. Epidemiology and outcomes from out-of-hospitalcardiac arrest in children:

the Resuscitation Outcomes ConsortiumEpistry-Cardiac Arrest. Circulation. 2009;119:1484-91.
18. Field JM, Hazinski MF, Sayre MR, Chameides L, Schexnayder SM, Hemphill R, et al. Part 1: Executive summary: 2010 American Heart Association guidelines for Cardiopulmonary resuscitation and emergency cardiovascular care. Circulation. 2010;122 suppl-3: S640-S656.
19. Robert WH, John EB, Vinay MN, William MM, Robert EO, Micheal RS, et all.2005 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation 2005; 112;19-34.
20. Cobb LA, Fahrenbruch CE, Walsh TR, Copass MK, Olsufka M, Breskin M, et al. Influence of cardiopulmonary resuscitation prior to defibrillation in patients with out-of-hospital ventricular fibrillation. JAMA 1999;281:1182-8.
21. Wik L, Hansen TB, Fylling F, Steen T, Vaagenes P, Auestad BH, et al. Delaying defibrillation to give basic cardiopulmonary resuscitation to patients with out-of-hospital ventricular fibrillation: a randomized trial. JAMA. 2003;289:1389-95.
22. Jacobs IG, Finn JC, Oxer HF, Jelinek GA. CPR before defibrillation in patients with out-of-hospital cardiac arrest: a randomized trial. Emerg Med Australas.2005;17:39-45.
23. van Alem AP, Chapman FW, Lank P, Hart AA, Koster RW. A prospective, randomized and blinded comparison of first shock success of monophasic and biphasic waveform in out-of-hospital cardiac arrest. Resuscitation. 2003;58:17-24.
24. Berg MD, Clard LL, Valenzuela TA, Kern KB, Gerg RA. Post-shock chest compression delays with automated external defibrillator use. Resuscitation.2005;64:287-91.
25. Carpenter J, Rea TD, Murray JA, Kudenchuk PJ, Eisenberg MS. Defibrillation waveform and psot-shock shythm in out-of-hospital ventricular fibrillation cardiac arrest. Resuscitation 2003;59:189-196.
26. Yu T, Weil MH, Tang W, Sun S, Klouche K, Povoas H, et al. Adverse outcome of interrupted precordial compressions during automated defibrillation. Circulation 2002;106:368-72.
27. Waalenwijn RA, Tijssen JG, Koster RW. Bystander initiated actions in out-of-hospital cardiopulmonary resuscitation: results from the Amsterdam Resuscitation Study (ARRESUST). Resuscitation 2001;50:273-9.
28. Kern KB, Gilwig RW, Berg RA, Sanders AB, Ewy GA. Importance of continuous chest compressions during cardiopulmonary resuscitation: improves outcome during a simulated single lay-rescuer scenario. Circulation. 2002; 105:645-9.
29. Berg RA, Sanders AB, Kern KB, Gilwig RW, Heidenreich JW, Porter ME, et al. Adverse hemodynamis effects of interrupting chest compressions for rescue breathing during cardiopulmonary resuscitation for ventricular fibrillation cardiac arrest. Circulation.2002;105:2270-3.
30. White RD, Russell JK. Refibrillation, resuscitation and survival in out-of-hospital sudden cardiac arrest victims treated with biphasic automated external defibrillators. Resiscitation. 1999;41:133-44.
31. Myerburg RJ, Interian AJ, Mitrani RM, Kessler KM, Castellanos A. Frequency of sudden cardiac death and profile of risk. Am J Cardiol 1997;80:10-9.
32. Juikuri JV, Castellanos A, Myerburg RJ. Sudden death due to cardiac arrhythmias. N Engl J Med 2001;345:1473-82.
33. Martens PR, Russell JK, Wolcke B, Paschen H, Kuisma M, Gliner BE, et al. Optimal Response to Cardiac Arest study: defibrillation waveform effects. Ressuscitation. 2001;49:233-43.
34. Schneider T, Martens PR, Paschen H, Kuisma M, Wlocke B, Gliner BE, et al. Multicenter, randomized, controlled trial of 150-J biphasic shocks compared with 200-360 J monophaisc shocks in the resuscitation of out-of-hospital cardiac arrest victims. Pptimized Response to Cardiac Arrest(ORCA) Investigators. Circulation2000;102:1780-7.
35. Schwarz B, Bowdle TA, Jett GK, Mair P, Lindner KH, Aldea GS, et al. Biphasic shocks compared with monophasic damped sine wave shocks for direct ventricular fibrillation during open heart surgery. Anesthesiology 2003;98:1063-9.
36. Page RL, Kerber RE, Russell JK, Trouton T, Waktare J, Gallik D, et al. Biphasic versus monophasic shock waveformfor conversion of atrial fibrillation: the results of an international randomized,double-blind multicenter trial. J Am Coll Cardiol. 2002;39:1956-63.
37. Scholten M, Szili-Torok T, Klootwijk P, Jordaens L. Comparison =monophasic and biphasic shocks for transthoracic cardioversion of atrial fibrillation. Heart. 2003;89:1032–4.
38. Glover BM, Walsh SJ, McCann CJ, Moore MJ, Manoharan G, DalzellGW, et al. Biphasic energy selection for transthoracic cardioversion of atrial fibrillation. The BEST AF Trial. *Heart.* 2008;94:884-7.
39. Reisinger J, Gstrein C, Winter T, Zeindlhofer E, Hollinger K, Mori M,Schiller A, Winter A, Geiger H, Siostrzonek P. Optimization of initial energy for cardioversion of atrial tachyarrhythmia with biphasic shocks. Am J Emerg Med 2010;28:159-65.
40. Kerber RE, Martins JB, Kienzle MG, Constantin L, Olshansky B, Hopson R, et al. Energy, current, and success in defibrillation and cardioversion: clinical studies using an automated impedance-based method of energy adjustment. Circulation 1988;77:1038-46.
41. Larsen MP, Eisenberg MS, Cummins RO, Hallstrom AP. Predicting survival from out-of-hospital cardiac arrest: a graphic model. *Ann EmergMed*. 1993;22:1652-58.
42. Valenzuela TD, Roe DJ, Cretin S, Spaite DW, Larsen MP. Estimating effectiveness of cardiac arrest interventions: a logistic regression survival model. Circulation. 1997;96:3308-3313.
43. Swor RA, Jackson RE, Cynar M, Sadler E, Basse E, Boji B, et al. Bystander CPR,ventricular fibrillation, and survival in witnessed, unmonitored out-of-hospital-cardiac arrest. Ann Emerg Med. 1995;25:780-4.
44. Baker PW, Conway J, Cotton C, Ashby DT, Smyth J, Woodman RJ, et al. Defibrillation or cardiopulmonary resuscitation first for patients with out-of-hospital cardiac arrests found by paramedics to be in ventricular fibrillation? A randomised control trial. *Resuscitation.* 2008;79:424-31.
45. Jacobs IG, Finn JC, Oxer HF, Jelinek GA. CPR before defibrillation in out-of-hospital cardiac arrest: a randomized trial. Emerg Med Australas 2005;17:39-45.
46. Weisfeldt ML, Kerber RE, McGlodrick RP, Moss AH, Nichol G, Ornato JP, et al. American Heart Association's

report on the Public Access Defibrillation Conference December 8-10. Circulation. 1995;92: 2740-7.
47. Nichol G, Hallstrom AP, Oranto JP, Riegel B, Stiell IG, Valenzuela T, et al. Potential cost-effectiveness of public access defibrillation in the united states. Circulation 1998;97:1315-20.
48. Zafari AM, Zarter SK, Geggen V, Wilsom P, Taylor RA, Reddy K, et al. A program encouraging early defibrillation results in inprove in-hospital resuscitation efficacy. J Am Coll Cardial 2004;44:846-52.
49. Peberdy MA, Kaye W, Ornato JJP, Larkin GL, Nadkarni V, Mancini ME, et al. cardiopulmonary resuscitation of adults in the hospital" a report of 14720 cardiac arrests from the National Registry of Cardiopulmonary Resuscitation. Resuscitation 2003;58:297-308.
50. Valenzuela TD, Roe DJ, Crerin S, Spaite DW, Larsin MP. Estimating effectiveness of cardiac arrest interventions" a logistic regression survival model. Circulation 1997;96:3308-13.
51. Assar D, Chamberlain D, Colquhoun M, Donnelly P, Handley AJ, Leaves S, et al. Randomized controlled trials of staged teaching for basic life support. 1. Skill acquisition at bronze stage. Resuscitation 2000;45:7-15.
52. Karagounis L, Ipsen SK, Jessop MR, Gilmore KM, Valenti DA, Clawson JJ, et al. Impact of field-transmitted electrocardiography on time to in-hospital thrombolytic therapy in acute myocardial infarction. Am J Cardiol. 1990;66:786-91.
53. Kereiakes DJ, Gibler WB, Martin LH, Pieper KS, Anderson LC. Relative importance of emergency medical system transport and the prehospital electrocardiogram on reducing hospital time delay to therapy for acute myocardial infarction: a preliminary report from the Cincinnati Heart Project. Am Heart J 1992;123(4 Pt 1): 835- 40.
54. Banerjee S, Rhoden WE. Fast-tracking of myocardial infarction by paramedics. J R Coll Physicians Lond 1998;32:36-8.
55. Melville MR, Gray D, Hinchley M. The potential impact of prehospital electrocardiography and telemetry on time to thrombolysis in a United Kingdom center. Ann Noninvasive Electrocardiol 1998;3:327-32.
56. Millar-Craig MW, Joy AV, Adamowicz M, Furber R, Thomas B. Reduction in treatment delay by paramedic ECG diagnosis of myocardial infarction with direct CCU admission. Heart 1997;78:456-61.
57. Brainard AH, Raynovich W, Tandberg D, Bedrick EJ. The prehospital12-lead electrocardiogram's effect on time to initiation of reperfusion therapy: a systematic review and meta-analysis of existing literature. Am J Emerg Med 2005;23:351-6.
58. Morrison LJ, Brooks S, Sawadsky B, McDonald A, Verbeek PR. Prehospital 12-lead electrocardiography impact on acute myocardial infarction treatment times and mortality: a systematic review. Acad Emerg Med 2006;13:84-9.
59. Adams GL, Campbell PT, Adams JM, Strauss DG, Wall K, Patterson J, et al. Effectiveness of prehospital wireless transmission of electrocardiograms to a cardiologist via hand-held device for patients with acute myocardial infarction (from the Timely Intervention in Myocardial Emergency, North East Experience [TIME-NE]). Am J Cardiol 2006;98:1160-4.
60. Afolabi BA, Novaro GM, Pinski SL, Fromkin KR, Bush HS. Use of the prehospital ECG improves door-to-balloon times in ST segment elevation myocardial infarction irrespective of time of day or day of week.Emerg Med J 2007;24:588-91.
61. Terkelsen CJ, Lassen JF, Norgaard BL, Gerdes JC, Poulsen SH, Bendix K, et al. Reduction of treatment delay in patients with ST-elevation myocardial infarction: impact of pre-hospital diagnosis and direct referral to primary percutanous coronary intervention. Eur Heart J 2005;26:770-7.
62. Wall T, Albright J, Livingston B, Isley L, Young D, Nanny M, et al. Prehospital ECG transmission speeds reperfusion for patients with acute myocardial infarction. N C Med J 2000;61:104-8.
63. Dhruva VN, Abdelhadi SI, Anis A, Gluckman W, Hom D, Dougan W, et al. ST-Segment Analysis Using Wireless Technology in Acute Myocardial Infarction (STAT-MI) trial. J Am Coll Cardiol 2007;50:509-13.
64. Sekulic M, Hassunizadeh B, McGraw S, David S. Feasibility of early emergency room notification to improve door-to-balloon times forpatients with acute ST segment elevation myocardial infarction. Catheter Cardiovasc Interv 2005;66:316-9.
65. Swor R, Hegerberg S, McHugh-McNally A, Goldstein M, McEachin CC. Prehospital 12-lead ECG: efficacy or effectiveness? Prehosp EmergCare 2006;10:374-7.
66. Campbell PT, Patterson J, Cromer D, Wall K, Adams GL, Albano A, et al. Prehospital triage of acute myocardial infarction: wireless transmission of electrocardiograms to the on-call cardiologist via a handheld computer. J Electrocardiol 2005;38:300-9.