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European Resuscitation Council Guidelines for Resuscitation 2010 Section 2. Adult basic life support and use of automated external defibrillators

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Basic life support (BLS) refers to maintaining airway patency and supporting breathing and the circulation, without the use of equipment other than a protective device.[1] This section contains the guidelines for adult BLS and for the use of an automated external defibrillator (AED). It also includes recognition of sudden cardiac arrest, the recovery position and management of choking (foreign-body airway obstruction). Guidelines for the use of manual defibrillators and starting in-hospital resuscitation are found in Sections 3 and 4.[2,3]

Summary of changes since 2005 Guidelines

Many of the recommendations made in the ERC Guidelines 2005 remain unchanged, either because no new studies have been published or because new evidence since 2005 has merely strengthened the evidence that was already available. Examples of this are the general design of the BLS and AED algorithms, the way the need for cardiopulmonary resuscitation (CPR) is recognised, the use of AEDs (including the shock protocols), the 30:2 ratio of compressions and ventilations, and the recognition and management of a choking victim. In contrast, new evidence has been published since 2005 that necessitates changes to some components of the 2010 Guidelines. The 2010 changes in comparison with the 2005 Guidelines are summarised here:

- Dispatchers should be trained to interrogate callers with strict protocols to elicit information. This information should focus on the recognition of unresponsiveness and the quality of breathing. In combination with unresponsiveness, absence of breathing or any abnormality of breathing should start a dispatch protocol of suspected cardiac arrest. The importance of gasping as sign of cardiac arrest should result in increased emphasis on its recognition during training and dispatch interrogation.
- All rescuers, trained or not, should provide chest compressions to victims of cardiac arrest. A strong emphasis on delivering high quality chest compressions remains essential. The aim should be to push to a depth of at least 5 cm at a rate of at least 100 compressions per minute, to allow full chest recoil, and to minimise interruptions in chest compressions. Trained rescuers should also provide ventilations with a compression–ventilation ratio of 30:2. Telephone-guided CPR is encouraged for untrained rescuers who should be told to deliver uninterrupted chest compressions only.
- In order to maintain high-quality CPR, feedback to rescuers is important. The use of prompt/feedback devices during CPR will enable immediate feedback to rescuers, and the data stored in rescue equipment can be used to monitor the quality of CPR performance and provide feedback to professional rescuers during debriefing sessions.
- When rescuers apply an AED, the analysis of the heart rhythm and delivery of a shock should not be delayed for a period of CPR; however, CPR should be given with minimal interruptions before application of the AED and during its use.
- Further development of AED programmes is encouraged—there is a need for further deployment of AEDs in both public and residential areas.

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Introduction

Sudden cardiac arrest (SCA) is a leading cause of death in Europe. Depending on the way SCA is defined, it affects about 350,000–700,000 individuals a year.[4,5] On initial heart-rhythm analysis, about 25–30% of SCA victims have ventricular fibrillation (VF), a percentage that has declined over the last 20 years.[6–10] It is likely that many more victims have VF or rapid ventricular tachycardia (VT) at the time of collapse but, by the time the first electrocardiogram (ECG) is recorded by ambulance personnel, their rhythm has deteriorated to asystole.[11,12] When the rhythm is recorded soon after collapse, in particular by an on-site AED, the proportion of victims in VF can be as high as 59%[13] to 65%.[14] Many victims of SCA can survive if bystanders act immediately while VF is still present, but successful resuscitation is much less likely once the rhythm has deteriorated to asystole.

The recommended treatment for VF cardiac arrest is immediate bystander CPR (combined chest compression and rescue breathing) and early electrical defibrillation. Most cardiac arrests of non-cardiac origin are from respiratory causes such as drowning (among them many children) and asphyxia. In many areas in the world drowning is a major cause of death (see http://www.who.int/water_sanitation_health/diseases/drowning/en/), and rescue breaths are even more critical for successful resuscitation of these victims.

The chain of survival

The following concept of the Chain of Survival summarises the vital steps needed for successful resuscitation (Fig. 2.1). Most of these links apply to victims of both primary cardiac and asphyxial arrest.[15]

1. *Early recognition of cardiac arrest*: This includes recognition of the cardiac origin of chest pain; recognition that cardiac arrest has occurred; and rapid activation of the ambulance service by telephoning 112 or the local emergency number. Recognizing cardiac chest pain is particularly important, since the probability of cardiac arrest occurring as a consequence of acute myocardial ischaemia is at least 21–33% in the first hour after onset of symptoms.[16,17] When a call to the ambulance service is made before a victim collapses, arrival of the ambulance is significantly sooner after collapse and survival tends to be higher.[18]
2. *Early bystander CPR*: Immediate CPR can double or triple survival from VF SCA.[18–21] Performing chest-compression-only CPR is better than giving no CPR at all.[22,23] When a caller has not been trained in CPR, the ambulance dispatcher should strongly encourage him to give chest compression-only CPR while awaiting the arrival of professional help.[24–27]
3. *Early defibrillation*: CPR plus defibrillation within 3–5 min of collapse can produce survival rates as high as 49–75%.[28–35] Each minute of delay before defibrillation reduces the probability of survival to discharge by 10–12%.[19,36]
4. *Early advanced life support and standardised post-resuscitation care*: The quality of treatment during the post-resuscitation phase affects outcome.[37–39] Therapeutic hypothermia is now an established therapy that greatly contributes to improved survival with good neurological outcome.[40–42]

In most communities, the median time from ambulance call to ambulance arrival (response interval) is 5–8 min,[13,14] or 11 min to a first shock.[43] During this time the victim's survival is dependent on bystanders who initiate BLS and use an AED for defibrillation.

Victims of cardiac arrest need immediate CPR. This provides a small but critical blood flow to the heart and brain. It also increases the likelihood that a defibrillatory shock will terminate VF and enable the heart to resume an effective rhythm and cardiac output. Chest compression is especially important if a shock cannot be delivered sooner than the first few minutes after collapse.[44] After defibrillation, if the heart is still viable, its pacemaker activity resumes and produces an organised rhythm followed by mechanical contraction. In the first few minutes after successful termination of VF, the heart rhythm may be slow, and the force of contractions weak; chest compressions must be continued until adequate cardiac function returns.[45]

Lay rescuers can be trained to use automated external defibrillators (AEDs), which are increasingly available in public places. An AED uses voice prompts to guide the rescuer, analyses the cardiac rhythm and instructs the rescuer to deliver a shock if VF or rapid ventricular tachycardia (VT) is detected. AEDs are extremely accurate and will deliver a shock only when VF (or rapid VT) is present.[46] AED function and operation are discussed in Section 3.

Several studies have shown the benefit on survival of immediate CPR, and the detrimental effect of delay before defibrillation. For every minute delay in defibrillation, survival from witnessed VF decreases by 10–12%.[19,36] When bystander CPR is provided, the decline in survival is more gradual and averages 3–4% per minute.[12,36,47] Overall, bystander CPR doubles or triples survival from witnessed cardiac arrest.[19,47,48]

Adult BLS sequence

Throughout this section, the male gender implies both males and females.

Fig. 2.1. Chain of survival.

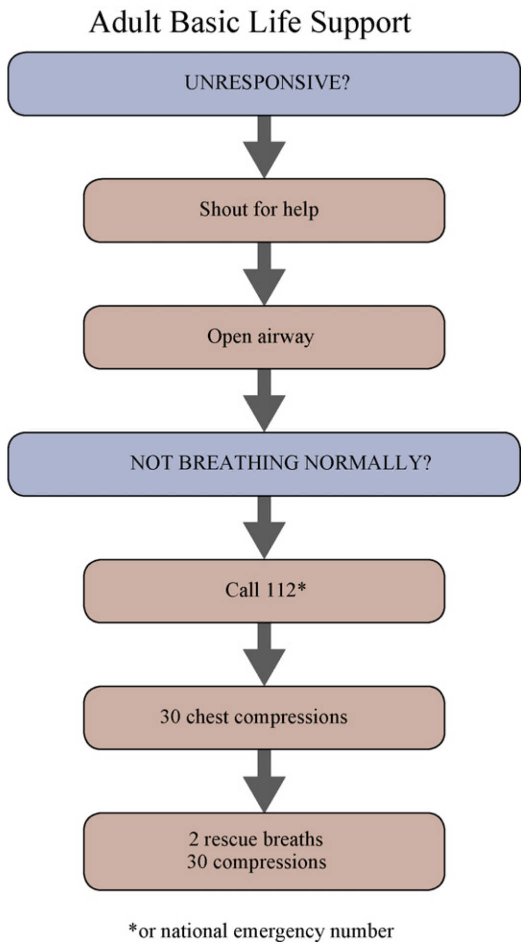

Fig. 2.2. Adult basic life support algorithm.

BLS consists of the following sequence of actions (Fig. 2.2).

1. Make sure you, the victim and any bystanders are safe.
2. Check the victim for a response (Fig. 2.3).
   - gently shake his shoulders and ask loudly: "Are you all right?"

3a. If he responds
   - leave him in the position in which you find him, provided there is no further danger;
   - try to find out what is wrong with him and get help if needed;
   - reassess him regularly.

3b. If he does *not* respond
   - shout for help (Fig. 2.4)
     - turn the victim onto his back and then open the airway using head tilt and chin lift (Fig. 2.5);
     - place your hand on his forehead and gently tilt his head back;
     - with your fingertips under the point of the victim's chin, lift the chin to open the airway.

4. Keeping the airway open, look, listen and feel for breathing (Fig. 2.6).
   - look for chest movement;
   - listen at the victim's mouth for breath sounds;
   - feel for air on your cheek;
   - decide if breathing is normal, not normal or absent

     In the first few minutes after cardiac arrest, a victim may be barely breathing, or taking infrequent, slow and noisy gasps. Do not confuse this with normal breathing. Look, listen and feel for *no more* than 10 s to determine whether the victim is breathing normally. If you have any doubt whether breathing is normal, act as if it is not normal.

Fig. 2.3. Check the victim for a response.

5a. If he *is* breathing normally
   - turn him into the recovery position (see below);
   - send or go for help—call 112 or local emergency number for an ambulance;
   - continue to assess that breathing remains normal.

5b. If the breathing is *not* normal or absent
   - send someone for help and to find and bring an AED if available; or if you are on your own, use your mobile telephone to alert the ambulance service—leave the victim only when there is no other option.

Fig. 2.4. Shout for help.

Fig. 2.5. Head tilt and chin lift.

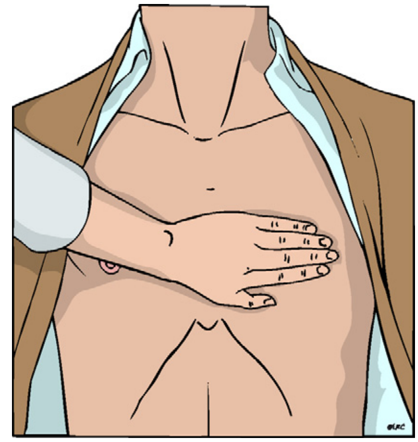

Fig. 2.7. Place the heel of one hand in the centre of the victim's chest.

- start chest compression as follows:
  - ○ kneel by the side of the victim;
  - ○ place the heel of one hand in the centre of the victim's chest; (which is the lower half of the victim's breastbone (sternum)) (Fig. 2.7);
  - ○ place the heel of your other hand on top of the first hand (Fig. 2.8);
  - ○ interlock the fingers of your hands and ensure that pressure is not applied over the victim's ribs. Keep your arms straight (Fig. 2.9). Do not apply any pressure over the upper abdomen or the bottom end of the bony sternum (breastbone);
  - ○ position yourself vertically above the victim's chest and press down on the sternum at least 5 cm (but not exceeding 6 cm) (Fig. 2.10);
  - ○ after each compression, release all the pressure on the chest without losing contact between your hands and the sternum; repeat at a rate of at least 100 min^{-1} (but not exceeding 120 min^{-1});
  - ○ compression and release should take equal amounts of time.

6a. Combine chest compression with rescue breaths.

- After 30 compressions open the airway again using head tilt and chin lift (Fig. 2.5).
- Pinch the soft part of the nose closed, using the index finger and thumb of your hand on the forehead.
- Allow the mouth to open, but maintain chin lift.
- Take a normal breath and place your lips around his mouth, making sure that you have a good seal.
- Blow steadily into the mouth while watching for the chest to rise (Fig. 2.11), taking about 1 s as in normal breathing; this is an effective rescue breath.
- Maintaining head tilt and chin lift, take your mouth away from the victim and watch for the chest to fall as air comes out (Fig. 2.12).
- Take another normal breath and blow into the victim's mouth once more to achieve a total of two effective rescue breaths. The two breaths should not take more than 5 s in all. Then return your hands without delay to the correct position on the sternum and give a further 30 chest compressions.
- Continue with chest compressions and rescue breaths in a ratio of 30:2.
- Stop to recheck the victim only if he starts to wake up: to move, open eyes and to breathe normally. Otherwise, do not interrupt resuscitation.

Fig. 2.6. Look, listen and feel for normal breathing.

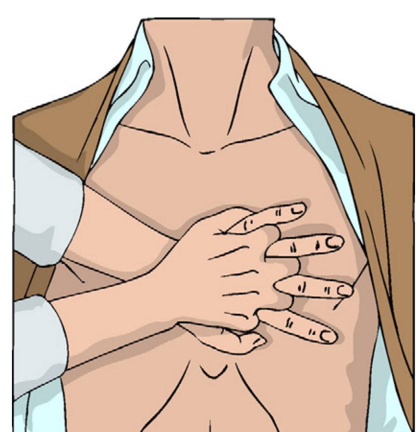

Fig. 2.8. Place the heel of your other hand on top of the first hand.

Fig. 2.9. Interlock the fingers of your hands. Keep your arms straight.

If your initial rescue breath does not make the chest rise as in normal breathing, then before your next attempt:

- look into the victim's mouth and remove any obstruction;
- recheck that there is adequate head tilt and chin lift;
- do not attempt more than two breaths each time before returning to chest compressions.

If there is more than one rescuer present, another rescuer should take over delivering CPR every 2 min to prevent fatigue. Ensure that interruption of chest compressions is minimal during the changeover of rescuers. For this purpose, and to count 30 compressions at the required rate, it may be helpful for the rescuer performing chest compressions to count out loud. Experienced rescuers could do combined two-rescuer CPR and in that situation they should exchange roles/places every 2 min.

6b. Chest-compression-only CPR may be used as follows:
- If you are not trained, or are unwilling to give rescue breaths, give chest compressions only.
- If only chest compressions are given, these should be continuous, at a rate of at least 100 min^{-1} (but not exceeding 120 min^{-1}).

7. Do not interrupt resuscitation until:
- professional help arrives and takes over; or
- the victim starts to wake up: to move, open eyes and to breathe normally; or
- you become exhausted.

Opening the airway

The jaw thrust is not recommended for lay rescuers because it is difficult to learn and perform and may itself cause spinal movement.[49] Therefore, the lay rescuer should open the airway using a head-tilt-chin-lift manoeuvre for both injured and non-injured victims.

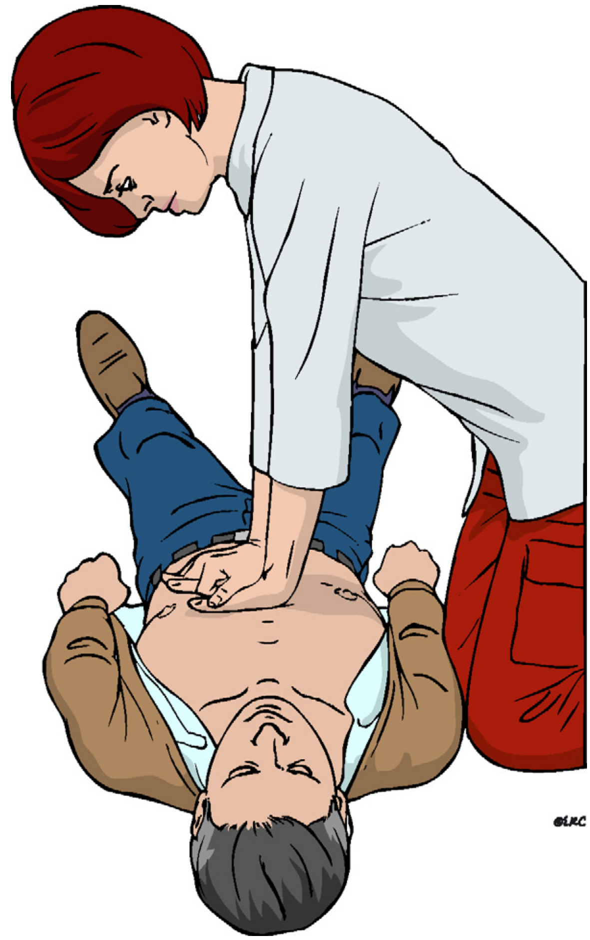

Fig. 2.10. Press down on the sternum at least 5 cm.

Recognition of cardiorespiratory arrest

Checking the carotid pulse (or any other pulse) is an inaccurate method of confirming the presence or absence of circulation, both for lay rescuers and for professionals.[50–52] There is, however, no evidence that checking for movement, breathing or coughing ("signs of a circulation") is diagnostically superior. Healthcare

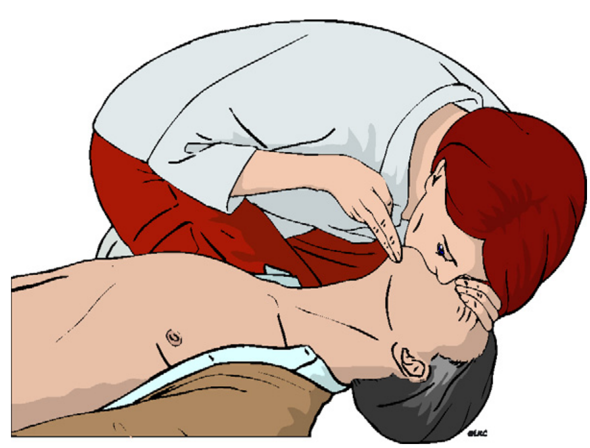

Fig. 2.11. Blow steadily into his mouth whilst watching for his chest to rise.

Fig. 2.12. Take your mouth away from the victim and watch for his chest to fall as air comes out.

professionals, as well as lay rescuers, have difficulty determining the presence or absence of adequate or normal breathing in unresponsive victims.[53,54] This may be because the airway is not open or because the victim is making occasional (agonal) gasps. When bystanders are asked by ambulance dispatchers over the telephone if breathing is present, they often misinterpret agonal gasps as normal breathing. This incorrect information can result in the bystander withholding CPR from a cardiac arrest victim.[55] Agonal gasps are present in up to 40% of cardiac arrest victims in the first minutes after onset, and are associated with higher survival if recognised as a sign of cardiac arrest.[56] Bystanders describe agonal gasps as barely breathing, heavy or laboured breathing, or noisy or gasping breathing.[57] Laypeople should, therefore, be taught to begin CPR if the victim is unconscious (unresponsive) and not breathing normally. It should be emphasised during training that agonal gasps occur commonly in the first few minutes after SCA, and that they are an indication to start CPR immediately; they should not be confused with normal breathing.

Adequate description of the victim is also of critical importance during communication with the ambulance dispatch centre. It is important for the dispatcher that the caller can see the victim, but in a small minority of cases the caller is not at the scene.[58] Information about a victim's breathing is most important, but the description of breathing by callers varies considerably. If the nature of the victim's breathing is not described or actively asked for by the dispatcher, recognition that the victim has had a cardiac arrest is much less likely than if the breathing is described as abnormal or absent.[59] If, when a caller describes an unconscious victim with absent or abnormal breathing, the dispatcher always responded as for cardiac arrest, cases of cardiac arrest would not be missed.[60]

Confirming the absence of a past medical history of seizures can increase the likelihood of recognizing cardiac arrest among victims presenting with seizure activity.[59,61] Asking about regularity of breathing can also help to recognise cardiac arrest among callers reporting seizure activity.

An experienced dispatcher can improve the survival rate significantly: if the dispatcher takes very few cardiac arrest calls per year, the survival rate is much lower than if he takes more than nine calls a year (22% versus 39%).[58] The accuracy of identification of cardiac arrest by dispatchers varies from approximately 50% to over 80%. If the dispatcher recognises cardiac arrest, survival is more likely because appropriate measures can be taken (e.g. telephone-instructed CPR or appropriate ambulance response).[25,60]

Initial rescue breaths

In primary (non-asphyxial) cardiac arrest the arterial blood is not moving and remains saturated with oxygen for several minutes.[62] If CPR is initiated within a few minutes, the blood oxygen content remains adequate, and myocardial and cerebral oxygen delivery is limited more by the reduced cardiac output than by a lack of oxygen in the lungs and arterial blood. Initially, therefore, ventilation is less important than chest compressions.[63,64]

In adults needing CPR, there is a high a-priori probability of a primary cardiac cause. To emphasise the priority of chest compressions, it is recommended that CPR should start with chest compression rather than initial ventilations. Time should not be spent checking the mouth for foreign bodies unless attempted rescue breathing fails to make the chest rise.

Ventilation

During CPR, the purpose of ventilation is to maintain adequate oxygenation and to remove CO_2. The optimal tidal volume, respiratory rate and inspired oxygen concentration to achieve this, however, are not fully known. The current recommendations are based on the following evidence:

1. During CPR, blood flow to the lungs is substantially reduced, so an adequate ventilation–perfusion ratio can be maintained with lower tidal volumes and respiratory rates than normal.[65]
2. Hyperventilation is harmful because it increases intrathoracic pressure, which decreases venous return to the heart and reduces cardiac output. Survival is consequently reduced.[66]
3. Interruptions in chest compression (for example, to check the heart rhythm or for a pulse check) have a detrimental effect on survival.[67]
4. When the airway is unprotected, a tidal volume of 1 l produces significantly more gastric distension than a tidal volume of 500 ml.[68]
5. Low minute-ventilation (lower than normal tidal volume and respiratory rate) can maintain effective oxygenation and ventilation during CPR.[69–72] During adult CPR, tidal volumes of approximately 500–600 ml (6–7 $ml\,kg^{-1}$) are recommended.

The current recommendations are, therefore, for rescuers to give each rescue breath over about 1 s, with enough volume to make the victim's chest rise, but to avoid rapid or forceful breaths. The time taken to give two breaths should not exceed 5 s. These recommendations apply to all forms of ventilation during CPR, including mouth-to-mouth and bag-mask ventilation with and without supplementary oxygen.

Mouth-to-nose ventilation is an acceptable alternative to mouth-to-mouth ventilation.[73] It may be considered if the victim's mouth is seriously injured or cannot be opened, the rescuer is assisting a victim in the water, or a mouth-to-mouth seal is difficult to achieve.

There is no published evidence on the safety, effectiveness or feasibility of mouth-to-tracheostomy ventilation, but it may be used for a victim with a tracheostomy tube or tracheal stoma who requires rescue breathing.

To use bag-mask ventilation requires considerable practice and skill.[74,75] It can be used by properly trained and experienced rescuers who perform two-rescuer CPR.

Chest compression

Chest compressions produce blood flow by increasing the intrathoracic pressure and by directly compressing the heart. Although chest compressions, performed properly, can produce systolic arterial pressure peaks of 60–80 mm Hg, diastolic pressure remains low and mean arterial pressure in the carotid artery seldom exceeds 40 mm Hg.[76] Chest compressions generate a small but critical amount of blood flow to the brain and myocardium and increase the likelihood that defibrillation will be successful.

Since the 2005 Guidelines were published, chest compression prompt/feedback devices have generated new data from victims in cardiac arrest that supplement animal and manikin studies.[77–81] Recommendations based on this evidence are:

1. Each time compressions are resumed, place your hands without delay 'in the centre of the chest'.
2. Compress the chest at a rate of at least 100 min^{-1}.
3. Ensure that the full compression depth of at least 5 cm (for an adult) is achieved.
4. Allow the chest to recoil completely after each compression, i.e. do not lean on the chest during the relaxation phase of the chest compression.
5. Take approximately the same amount of time for compression as relaxation.
6. Minimise interruptions in chest compression in order to ensure the victim receives at least 60 compressions in each minute.
7. Do not rely on feeling the carotid or other pulse as a gauge of effective arterial flow during chest compressions.[50,82]

Hand position

For adults receiving chest compressions, rescuers should place their hands on the lower half of the sternum. It is recommended that this location be taught in a simplified way, such as, "place the heel of your hand in the centre of the chest with the other hand on top." This instruction should be accompanied by demonstrating placing the hands on the lower half of the sternum on a manikin. Use of the internipple line as a landmark for hand placement is not reliable.[83,84]

Compression rate

There is a positive relationship between the number of compressions actually delivered per minute and the chance of successful resuscitation.[81] While the compression rate (the speed at which the 30 consecutive compressions are given) should be at least 100 min^{-1}, the actual number of compressions delivered during each minute of CPR will be lower due to interruptions to deliver rescue breaths and allow AED analysis, etc. In one out-of-hospital study, rescuers recorded compression rates of 100–120 min^{-1} but the mean number of compressions was reduced to 64 min^{-1} by frequent interruptions.[79] At least 60 compressions should be delivered each minute.

Compression depth

Fear of doing harm, fatigue and limited muscle strength frequently result in rescuers compressing the chest less deeply than recommended. There is evidence that a compression depth of 5 cm and over results in a higher rate of return of spontaneous circulation (ROSC), and a higher percentage of victims admitted alive to hospital, than a compression depth of 4 cm or below.[77,78] There is no direct evidence that damage from chest compression is related to compression depth, nor has an upper limit of compression depth been established in studies. Nevertheless, it is recommended that, even in large adults, chest compression depth should not exceed 6 cm.

CPR should be performed on a firm surface when possible. Air-filled mattresses should be routinely deflated during CPR.[85] There is no evidence for or against the use of backboards,[86,87] but if one is used, care should be taken to avoid interruption in CPR and dislodging intravenous lines or other tubes during board placement.

Chest decompression

Allowing complete recoil of the chest after each compression results in better venous return to the chest and may improve the effectiveness of CPR.[88,89] The optimal method of achieving this goal, without compromising other aspects of chest compression technique such as compression depth, has not, however, been established.

Feedback on compression technique

Rescuers can be assisted to achieve the recommended compression rate and depth by prompt/feedback devices that are either built into the AED or manual defibrillator, or are stand-alone devices. The use of such prompt/feedback devices, as part of an overall strategy to improve the quality of CPR, may be beneficial. Rescuers should be aware that the accuracy of devices that measure compression depth varies according to the stiffness of the support surface upon which CPR is being performed (e.g. floor/mattress), and may overestimate compression depth.[87] Further studies are needed to determine if these devices improve victim outcomes.

Compression–ventilation ratio

Animal data supported an increase in the ratio of compression to ventilation to >15:2.[90–92] A mathematical model suggests that a ratio of 30:2 provides the best compromise between blood flow and oxygen delivery.[93,94] A ratio of 30 compressions to 2 ventilations was recommended in the Guidelines 2005 for the single rescuer attempting resuscitation of an adult or child out of hospital, an exception being that a trained healthcare professional should use a ratio of 15:2 for a child. This decreased the number of interruptions in compression and the no-flow fraction,[95,96] and reduced the likelihood of hyperventilation.[66,97] Direct evidence that survival rates have increased from this change, however, is lacking. Likewise, there is no new evidence that would suggest a change in the recommended compression to ventilation ratio of 30:2.

Compression-only CPR

Some healthcare professionals as well as lay rescuers indicate that they would be reluctant to perform mouth-to-mouth ventilation, especially in unknown victims of cardiac arrest.[98,99] Animal studies have shown that chest-compression-only CPR may be as effective as combined ventilation and compression in the first few minutes after non-asphyxial arrest.[63,100] If the airway is open, occasional gasps and passive chest recoil may provide some air exchange, but this may result in ventilation of the dead space only.[56,101–103] Animal and mathematical model studies of chest-compression-only CPR have shown that arterial oxygen stores deplete in 2–4 min.[92,104]

In adults, the outcome of chest compression without ventilation is significantly better than the outcome of giving no CPR at all in non-asphyxial arrest.[22,23] Several studies of human cardiac arrest have suggested equivalence of chest-compression-only CPR and chest compressions combined with rescue breaths, but none excluded the possibility that chest-compression-only is inferior to chest compressions combined with ventilations.[23,105] One study suggested superiority of chest-compression-only CPR.[22] All these studies have significant limitations because they were based on retrospective database analyses, where the type of BLS was not controlled and did not include CPR according to Guidelines

2005 (30:2 compressions to ventilation ratio). Chest compression alone may be sufficient only in the first few minutes after collapse. Professional help can be expected on average 8 min or later after a call for help, and chest compression only will result in insufficient CPR in many cases. Chest-compression-only CPR is not as effective as conventional CPR for cardiac arrests of non-cardiac origin (e.g., drowning or suffocation) in adults and children.[106,107]

Chest compression combined with rescue breaths is, therefore, the method of choice for CPR delivered by both trained lay rescuers and professionals. Laypeople should be encouraged to perform compression-only CPR if they are unable or unwilling to provide rescue breaths, or when instructed during an emergency call to an ambulance dispatcher centre.[26,27]

CPR in confined spaces

Over-the-head CPR for single rescuers and straddle-CPR for two rescuers may be considered for resuscitation in confined spaces.[108,109]

Risks to the victim during CPR

Many rescuers, concerned that delivering chest compressions to a victim who is not in cardiac arrest will cause serious complications, do not initiate CPR. In a study of dispatch-assisted bystander CPR, however, where non-arrest victims received chest compressions, 12% experienced discomfort but only 2% suffered a fracture: no victims suffered visceral organ injury.[110] Bystander CPR extremely rarely leads to serious harm in victims who are eventually found not to be in cardiac arrest. Rescuers should not, therefore, be reluctant to initiate CPR because of concern of causing harm.

Risks to the rescuer during training and during real-life CPR

Physical effects

Observational studies of training or actual CPR performance have described rare occurrences of muscle strain, back symptoms, shortness of breath, hyperventilation, and case reports of pneumothorax, chest pain, myocardial infarction and nerve injury.[111,112] The incidence of these events is very low, and CPR training and actual performance is safe in most circumstances.[113] Individuals undertaking CPR training should be advised of the nature and extent of the physical activity required during the training programme. Learners and rescuers who develop significant symptoms (e.g. chest pain or severe shortness of breath) during CPR training should be advised to stop.

Rescuer fatigue

Several manikin studies have found that chest compression depth can decrease as little as 2 min after starting chest compressions. An in-hospital patient study showed that, even while using real-time feedback, the mean depth of compression deteriorated between 1.5 and 3 min after starting CPR.[114] It is therefore recommended that rescuers change about every 2 min to prevent a decrease in compression quality due to rescuer fatigue. Changing rescuers should not interrupt chest compressions.

Risks during defibrillation

A large randomised trial of public access defibrillation showed that AEDs can be used safely by laypeople and first responders.[115] A systematic review identified eight papers that reported a total of 29 adverse events associated with defibrillation.[116] The causes included accidental or intentional defibrillator misuse, device malfunction and accidental discharge during training or maintenance procedures. Four single-case reports described shocks to rescuers from discharging implantable cardioverter defibrillators (ICDs), in one case resulting in a peripheral nerve injury. There are no reports of harm to rescuers from attempting defibrillation in wet environments.

Injury to the rescuer from defibrillation is extremely rare. Nevertheless, rescuers should not continue manual chest compressions during shock delivery. Victims should not be touched during ICD discharge. Direct contact between the rescuer and the victim should be avoided when defibrillation is carried out in wet environments.

Psychological effects

One large, prospective trial of public access defibrillation reported a few adverse psychological effects associated with CPR or AED use that required intervention.[113] Two large, retrospective, questionnaire-based reports relating to performance of CPR by a bystander reported that nearly all respondents regarded their intervention as a positive experience.[117,118] The rare occurrences of adverse psychological effects in rescuers after CPR should be recognised and managed appropriately.

Disease transmission

There are only very few cases reported where performing CPR has been linked to disease transmission, implicating Salmonella infantis, Staphylococcus aureus, severe acute respiratory syndrome (SARS), meningococcal meningitis, Helicobacter pylori, Herpes simplex virus, cutaneous tuberculosis, stomatitis, tracheitis, Shigella and Streptococcus pyogenes. One report described herpes simplex virus infection as a result of training in CPR. One systematic review found that in the absence of high-risk activities, such as intravenous cannulation, there were no reports of transmission of hepatitis B, hepatitis C, human immunodeficiency virus (HIV) or cytomegalovirus during either training or actual CPR.[119]

The risk of disease transmission during training and actual CPR performance is extremely low. Wearing gloves during CPR is reasonable, but CPR should not be delayed or withheld if gloves are not available. Rescuers should take appropriate safety precautions if a victim is known to have a serious infection (e.g. HIV, tuberculosis, hepatitis B virus or SARS).

Barrier devices

No human studies have addressed the safety, effectiveness or feasibility of using barrier devices (such as a face shield or face mask) to prevent victim contact during rescuer breathing. Two studies showed that barrier devices decreased transmission of bacteria in controlled laboratory settings.[120,121] Because the risk of disease transmission is very low, initiating rescue breathing without a barrier device is reasonable. If the victim is known to have a serious infection (e.g. HIV, tuberculosis, hepatitis B virus, or SARS) a barrier device is recommended.

Recovery position

There are several variations of the recovery position, each with its own advantages. No single position is perfect for all victims.[122,123] The position should be stable, near to a true lateral position with the head dependent, and with no pressure on the

Fig. 2.13. Place the arm nearest to you out at right angles to his body, elbow bent with the hand palm uppermost.

Fig. 2.14. Bring the far arm across the chest, and hold the back of the hand against the victim's cheek nearest to you.

chest to impair breathing.[124]The ERC recommends the following sequence of actions to place a victim in the recovery position:

- Kneel beside the victim and make sure that both legs are straight.
- Place the arm nearest to you out at right angles to the body, elbow bent with the hand palm uppermost (Fig. 2.13).
- Bring the far arm across the chest, and hold the back of the hand against the victim's cheek nearest to you (Fig. 2.14).
- With your other hand, grasp the far leg just above the knee and pull it up, keeping the foot on the ground (Fig. 2.15).
- Keeping the hand pressed against the cheek, pull on the far leg to roll the victim towards you onto his side.
- Adjust the upper leg so that both hip and knee are bent at right angles.
- Tilt the head back to make sure the airway remains open.
- Adjust the hand under the cheek, if necessary, to keep the head tilted and facing downwards to allow liquid material to drain from the mouth (Fig. 2.16).
- Check breathing regularly.

If the victim has to be kept in the recovery position for more than 30 min, turn him to the opposite side to relieve the pressure on the lower arm.

Fig. 2.15. With your other hand, grasp the far leg just above the knee and pull it up, keeping the foot on the ground.

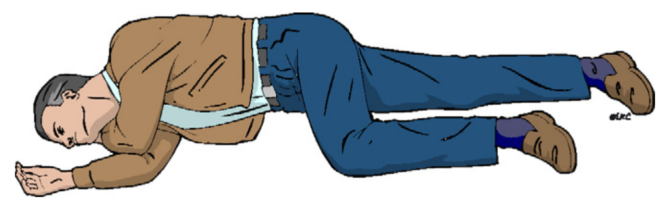

Fig. 2.16. The recovery position completed. Keep the head tilted to keep the airway open. Keep the face downward to allow fluids to go out.

Foreign-body airway obstruction (choking)

Foreign-body airway obstruction (FBAO) is an uncommon but potentially treatable cause of accidental death.[125] As most choking events are associated with eating, they are commonly witnessed. Thus, there is often the opportunity for early intervention while the victim is still responsive.

Recognition

Because recognition of airway obstruction is the key to successful outcome, it is important not to confuse this emergency with fainting, myocardial infarction, seizure or other conditions that may cause sudden respiratory distress, cyanosis or loss of consciousness. Foreign bodies may cause either mild or severe airway obstruction. The signs and symptoms enabling differentiation between mild and severe airway obstruction are summarised in Table 2.1. It is important to ask the conscious victim "Are you choking?"

Table 2.1
Differentiation between mild and severe foreign body airway obstruction (FBAO).[a]

Sign	Mild obstruction	Severe obstruction
"Are you choking?"	"Yes"	Unable to speak, may nod
Other signs	Can speak, cough, breathe	Cannot breathe/wheezy breathing/silent attempts to cough/unconsciousness

[a] General signs of FBAO: attack occurs while eating; victim may clutch his neck.

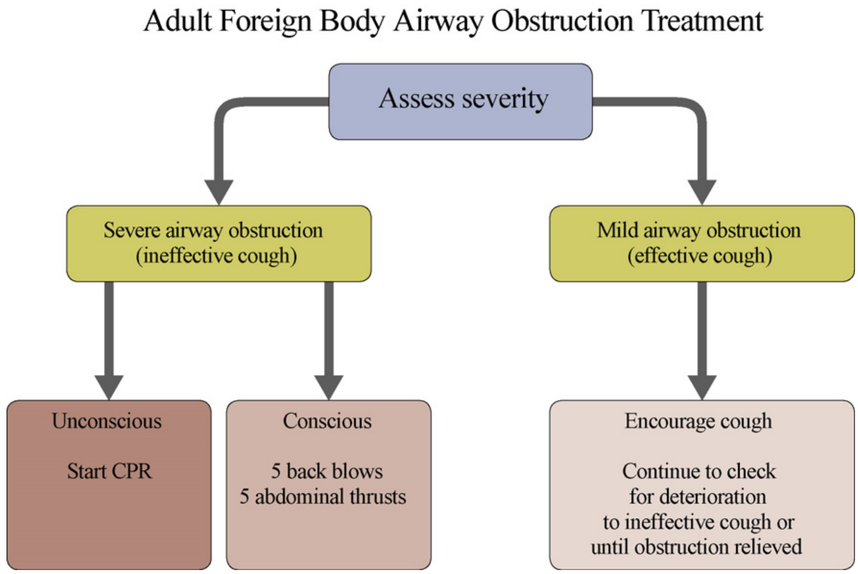

Fig. 2.17. Adult foreign body airway obstruction treatment algorithm.

Adult foreign-body airway obstruction (choking) sequence (this sequence is also suitable for use in children over the age of 1 year) (Fig. 2.17)

1. If the victim shows signs of mild airway obstruction:
   - Encourage continued coughing but do nothing else.
2. If the victim shows signs of severe airway obstruction and is conscious:
   - Apply five back blows as follows:
     - stand to the side and slightly behind the victim;
     - support the chest with one hand and lean the victim well forwards so that when the obstructing object is dislodged it comes out of the mouth rather than goes further down the airway;
     - give five sharp blows between the shoulder blades with the heel of your other hand.
   - If five back blows fail to relieve the airway obstruction, give five abdominal thrusts as follows:
     - stand behind the victim and put both arms round the upper part of the abdomen;
     - lean the victim forwards;
     - clench your fist and place it between the umbilicus (navel) and the ribcage;
     - grasp this hand with your other hand and pull sharply inwards and upwards;
     - repeat five times.
   - If the obstruction is still not relieved, continue alternating five back blows with five abdominal thrusts.
3. If the victim at any time becomes unconscious:
   - support the victim carefully to the ground;
   - immediately activate the ambulance service;
   - begin CPR with chest compressions.

Foreign-body airway obstruction causing mild airway obstruction

Coughing generates high and sustained airway pressures and may expel the foreign body. Aggressive treatment, with back blows, abdominal thrusts and chest compression, may cause potentially serious complications and could worsen the airway obstruction. It should be reserved for victims who have signs of severe airway obstruction. Victims with mild airway obstruction should remain under continuous observation until they improve, as severe airway obstruction may subsequently develop.

Foreign-body airway obstruction with severe airway obstruction

The clinical data on choking are largely retrospective and anecdotal. For conscious adults and children over 1 year with a complete FBAO, case reports demonstrate the effectiveness of back blows or "slaps", abdominal thrusts and chest thrusts.[126] Approximately 50% of episodes of airway obstruction are not relieved by a single technique.[127] The likelihood of success is increased when combinations of back blows or slaps, and abdominal and chest thrusts are used.[126]

A randomised trial in cadavers[128] and two prospective studies in anaesthetised volunteers[129,130] showed that higher airway pressures can be generated using chest thrusts compared with abdominal thrusts. Since chest thrusts are virtually identical to chest compressions, rescuers should be taught to start CPR if a victim of known or suspected FBAO becomes unconscious. The purpose of the chest compressions is primarily to attempt to remove the airway obstruction in the unconscious and supine victim, and only secondarily to promote circulation. Therefore, chest compressions are required even when a professional rescuer still feels a pulse. If the obstruction is not relieved, progressive bradycardia and asystole will occur. During CPR for choking, each time the airway is opened the victim's mouth should be quickly checked for any foreign body that has been partly expelled. During CPR in other cases, therefore, a routine check of the mouth for foreign bodies is not necessary.

The finger sweep

No studies have evaluated the routine use of a finger sweep to clear the airway in the absence of visible airway obstruction,[131–133] and four case reports have documented harm to the victim[131,134] or rescuer[126] during this manoeuvre. Blind finger sweeps should, therefore, be avoided, and solid material in the airway removed manually only if it can be seen.

Aftercare and referral for medical review

Following successful treatment for FBAO, foreign material may nevertheless remain in the upper or lower respiratory tract and cause complications later. Victims with a persistent cough, difficulty swallowing or the sensation of an object being still stuck in the throat should, therefore, be referred for a medical opinion. Abdominal thrusts and chest compressions can potentially cause serious internal injuries, and all victims successfully treated with these measures should be examined afterwards for injury.

Resuscitation of children (see also Section 6)[134a] and victims of drowning (see also Section 8c)[134b]

For victims of primary cardiac arrest who receive chest-compression-only CPR, oxygen stores become depleted about 2–4 min after initiation of CPR.[92,104] The combination of chest compressions with ventilation then becomes critically important. After collapse from asphyxial arrest, a combination of chest compressions with ventilations is important immediately after the start of resuscitation. Previous guidelines have tried to address this difference in pathophysiology, and have recommended that victims of identifiable asphyxia (drowning, intoxication) and children should receive 1 min of CPR before the lone rescuer leaves the victim to get help. The majority of cases of SCA out of hospital, however, occur in adults, and although the rate of VF as the first recorded rhythm has declined over recent years, the cause of adult cardiac arrest remains VF in most cases (59%) when documented in the earliest phase by an AED.[13] In children, VF is much less common as the primary cardiac arrest rhythm (approximately 7%).[135] These additional recommendations, therefore, added to the complexity of the guidelines while affecting only a minority of victims.

It is important to be aware that many children do not receive resuscitation because potential rescuers fear causing harm if they are not specifically trained in resuscitation for children. This fear is unfounded; it is far better to use the adult BLS sequence for resuscitation of a child than to do nothing. For ease of teaching and retention laypeople should be taught that the adult sequence may also be used for children who are not responsive and not breathing or not breathing normally.

The following minor modifications to the adult sequence will make it even more suitable for use in children.

- Give 5 initial rescue breaths before starting chest compressions (adult sequence of actions, 5b).

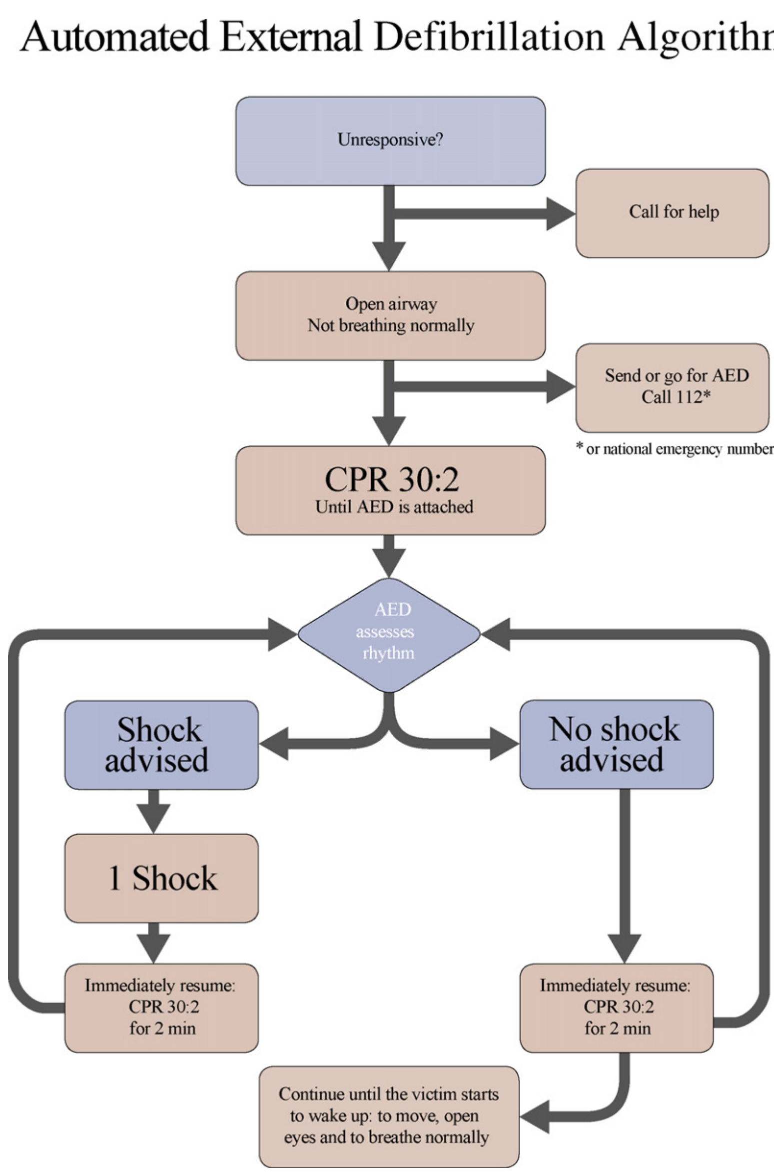

Fig. 2.18. Algorithm for use of an automated external defibrillator. © 2010 ERC.

- A lone rescuer should perform CPR for approximately 1 min before going for help.
- Compress the chest by at least one third of its depth; use 2 fingers for an infant under 1 year; use 1 or 2 hands for a child over 1 year as needed to achieve an adequate depth of compression.

The same modifications of 5 initial breaths and 1 min of CPR by the lone rescuer before getting help, may improve outcome for victims of drowning. This modification should be taught only to those who have a specific duty of care to potential drowning victims (e.g. lifeguards). Drowning is easily identified. It can be difficult, on the other hand, for a layperson to determine whether cardiorespiratory arrest is a direct result of trauma or intoxication. These victims should, therefore, be managed according to the standard BLS protocols.

Use of an automated external defibrillator

Section 3 discusses the guidelines for defibrillation using both automated external defibrillators (AEDs) and manual defibrillators. AEDs are safe and effective when used by laypeople, and make it possible to defibrillate many minutes before professional help arrives. Rescuers should continue CPR with minimal interruption of chest compressions while applying an AED and during its use. Rescuers should concentrate on following the voice prompts immediately they are received, in particular, resuming CPR as soon as instructed.

Standard AEDs are suitable for use in children older than 8 years. For children between 1 and 8 years paediatric pads should be used, together with an attenuator or a paediatric mode if available; if these are not available, the AED should be used as it is. Use of AEDs is not recommended for children <1 year. There are, however, a few case reports describing the use of AEDs in children aged <1 year.[136,137] The incidence of shockable rhythms in infants is very low except when there is cardiac disease[135,138,139]; in these rare cases, if an AED is the only defibrillator available its use should be considered (preferably with dose attenuator).

Sequence for use of an AED

See Fig. 2.18

1. Make sure you, the victim, and any bystanders are safe.
2. Follow the Adult BLS sequence (steps 1–5).
   - if the victim is unresponsive and not breathing normally, send someone for help and to find and bring an AED if available;
   - if you are on your own, use your mobile telephone to alert the ambulance service—leave the victim only when there is no other option.
3. Start CPR according to the adult BLS sequence. If you are on your own and the AED is in your immediate vicinity, start by applying the AED.
4. As soon as the AED arrives
   - switch on the AED and attach the electrode pads on the victim's bare chest (Fig. 2.19);
   - if more than one rescuer is present, CPR should be continued while electrode pads are being attached to the chest;
   - follow the spoken/visual directions immediately;
   - ensure that nobody is touching the victim while the AED is analysing the rhythm (Fig. 2.20).

5a. If a shock is indicated
   - ensure that nobody is touching the victim (Fig. 2.21);
   - push shock button as directed (fully automatic AEDs will deliver the shock automatically);
   - immediately restart CPR 30:2 (Fig. 2.22);
   - continue as directed by the voice/visual prompts.

Fig. 2.19. Attaching the electrode pads. Place the first electrode pad in the mid-axillary line just below the armpit. Place the second electrode just below the right collarbone (clavicle). © 2010 ERC.

5b. If no shock is indicated
   - immediately resume CPR, using a ratio of 30 compressions to 2 rescue breaths;
   - continue as directed by the voice/visual prompts.

6. Continue to follow the AED prompts until
   - professional help arrives and takes over;
   - the victim starts to wake up: moves, open eyes and breathes normally;
   - you become exhausted.

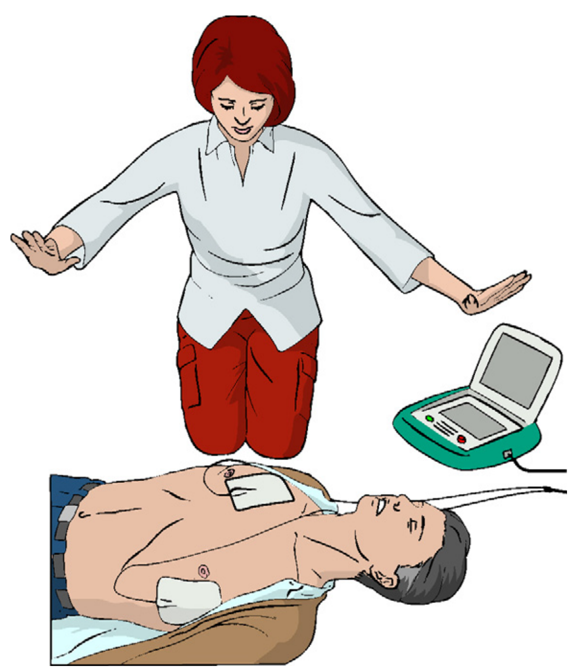

Fig. 2.20. While the AED analyses the heart rhythm, nobody should touch the victim. © 2010 ERC.

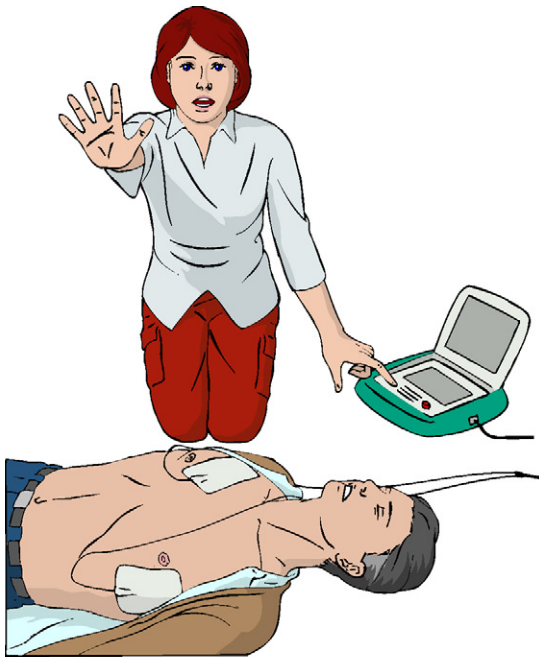

Fig. 2.21. When the shock button is pressed, make sure that nobody touches the victim. © 2010 ERC.

Fig. 2.22. After the shock the AED will prompt you to start CPR. Do not wait—start CPR immediately and alternate 30 chest compressions with 2 rescue breaths. © 2010 ERC.

CPR before defibrillation

The importance of immediate defibrillation, as soon as an AED becomes available, has always been emphasised in guidelines and during teaching, and is considered to have a major impact on survival from ventricular fibrillation. This concept has been challenged, because evidence has suggested that a period of chest compression before defibrillation may improve survival when the time between calling for the ambulance and its arrival exceeds 5 min.[140,141] Two recent clinical studies[142,143] and a recent animal study[144] did not confirm this survival benefit. For this reason, a pre-specified period of CPR, as a routine before rhythm analysis and shock delivery, is not recommended. High-quality CPR, however, must continue while the defibrillation pads are being applied and the defibrillator is being prepared. The importance of early delivery of minimally interrupted chest compression is emphasised. Given the lack of convincing data either supporting or refuting this strategy, it is reasonable for emergency medical services that have already implemented a specified period of chest compression before defibrillation to continue this practice.

Voice prompts

In several places, the sequence of actions states "follow the voice/visual prompts". Voice prompts are usually programmable, and it is recommended that they be set in accordance with the sequence of shocks and timings for CPR given in Section 2. These should include at least:

1. a single shock only, when a shockable rhythm is detected;
2. no rhythm check, or check for breathing or a pulse, after the shock;
3. a voice prompt for immediate resumption of CPR after the shock (giving chest compressions in the presence of a spontaneous circulation is not harmful);
4. a period of 2 min of CPR before a next prompt to re-analyse the rhythm.

The shock sequence and energy levels are discussed in Section 3.[2]

Fully automatic AEDs

Having detected a shockable rhythm, a fully automatic AED will deliver a shock without further input from the rescuer. One manikin study has shown that untrained nursing students commit fewer safety errors using a fully automatic AED rather than a (semi-) automated AED.[145] There are no human data to determine whether these findings can be applied to clinical use.

Public access defibrillation programmes

AED programmes should be actively considered for implementation in non-hospital settings. This refers to public places like airports,[32] sport facilities, offices, in casinos[35] and on aircraft,[33] where cardiac arrests are usually witnessed and trained rescuers are quickly on scene. Lay rescuer AED programmes with very rapid response times, and uncontrolled studies using police officers as first responders,[146,147] have achieved reported survival rates as high as 49–74%. These programmes will be successful only if enough trained rescuers and AEDs are available.

The full potential of AEDs has not yet been achieved, because they are mostly used in public settings, yet 60–80% of cardiac arrests occur at home. Public access defibrillation (PAD) and first responder AED programmes may increase the number of victims who receive bystander CPR and early defibrillation, thus improving survival from out-of-hospital SCA.[148] Recent data from nationwide studies in Japan and the USA[13,43] showed that when an AED was available, victims were defibrillated much sooner and with a better chance of survival. However, an AED delivered a shock in only 3.7% and 5% of all VF cardiac arrests, respectively. There was a clear inverse relationship in the Japanese study between the number of AEDs available per square km and the interval between collapse and the first shock, and a positive relationship with survival. In both studies, AED shocks still occurred predominantly in a public rather than a residential setting. Dispatched first responders like police and fire fighters will, in general, have longer response times, but have the potential to reach the whole population.

When implementing an AED programme, community and programme leaders should consider factors such as the strategic location of AEDs, development of a team with responsibility for monitoring and maintaining the devices, training and retraining programmes for the individuals who are likely to use the AED, and identification of a group of volunteer individuals who are committed to using the AED for victims of cardiac arrest.[149]

The logistic problem for first responder programmes is that the rescuer needs to arrive, not just earlier than the traditional ambulance, but within 5–6 min of the initial call, to enable attempted defibrillation in the electrical or circulatory phase of cardiac arrest.[44] With longer delays, the survival benefits decrease:[36,47] a few minutes' gain in time will have little impact when a first responder arrives more than 10 min after the call,[14,150] or when a first responder does not improve on an already short ambulance response time.[151] However, small reductions in response intervals achieved by first-responder programmes that impact on many residential victims may be more cost-effective than the larger reductions in response interval achieved by PAD programmes that have an impact on fewer cardiac arrest victims.[152,153]

Programmes that make AEDs publicly available in residential areas have not yet been evaluated. The acquisition of an AED for individual use at home, even for those considered at high risk of sudden cardiac arrest, has proved not to be effective.[154]

Universal AED signage

When a collapse occurs, and an AED must be found rapidly, simple and clear signage indicating the location of, and the fastest way to an AED is important. ILCOR has designed an AED sign that may be recognised worldwide and is recommended for indicating the location of an AED (Fig. 2.23). More detailed information on design and application of this AED sign can be found at: https://www.erc.edu/index.php/newsItem/en/nid=204/

Fig. 2.23. Universal ILCOR signage to indicate presence of an AED. This sign can be combined with arrows to indicate the direction of the nearest AED.

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