Defibrillation

CHAPTER **9**

Learning outcomes

To understand:

- **The mechanism of defibrillation**
- **The factors affecting defibrillation success**
- **The importance of minimising interruptions to chest compressions during defibrillation**
- **How to deliver a shock safely using either a manual or automated external defibrillator (AED)**

Introduction

Following the onset of ventricular fibrillation or pulseless ventricular tachycardia (VF/VT), cardiac output ceases and cerebral hypoxic injury starts within 3 min. If complete neurological recovery is to be achieved, early successful defibrillation with a return of spontaneous circulation (ROSC) is essential. Defibrillation is a key link in the chain of survival and is one of the few interventions that has been shown to improve outcome from VF/VT cardiac arrest. The probability of successful defibrillation declines rapidly with time; therefore early defibrillation is one of the most important factors in determining survival from cardiac arrest. In the absence of bystander CPR, for every minute that passes between collapse and attempted defibrillation, mortality increases 10 - 12%. **The shorter the interval between the onset of VF/VT and delivery of the shock, the greater the chance of successful defibrillation and survival.** Although defibrillation is key to the management of patients in VF/VT, continuous, uninterrupted chest compressions are also required to optimise the chances of successful resuscitation. Clinical studies have demonstrated that even short interruptions in chest compressions (to deliver rescue breaths or perform rhythm analysis) reduce significantly the chances of successful defibrillation. Animal studies show that even if defibrillation is successful, these short interruptions are associated with post-resuscitation myocardial dysfunction and reduced survival. Analysis of CPR performance during out-of-hospital and in-hospital cardiac arrest has shown that significant interruptions are common and every effort should be made to minimise interruptions. The aim should be to ensure that chest compressions are performed continuously throughout the resuscitation attempt, pausing only to enable specific interventions.

Another factor that is critical in determining the success of defibrillation is the duration of the interval between stopping chest compressions and delivering the shock: the pre-shock pause. The duration of the pre-shock pause is related inversely to the chance of successful defibrillation; every 5-second increase in the pre-shock pause almost halves the chance of successful defibrillation (defined by the absence of VF 5 s after shock delivery). Consequently, defibrillation must always be performed quickly and efficiently in order to maximise the chances of successful resuscitation.

If there is any delay in obtaining a defibrillator, and while the defibrillator is applied, start chest compressions and ventilation immediately. When bystander CPR is given, the decrease in survival is more gradual and averages 3 - 4% per minute from collapse to defibrillation. Bystander CPR can double survival from witnessed cardiac arrest.

Mechanism of defibrillation

Defibrillation is the passage of an electrical current of sufficient magnitude across the myocardium to depolarise a critical mass of cardiac muscle simultaneously, enabling the natural pacemaker tissue to resume control. To achieve this, all defibrillators have three features in common: a power source capable of providing direct current, a capacitor that can be charged to a pre-determined energy level and two electrodes which are placed on the patient's chest, either side of the heart, across which the capacitor is discharged. Successful defibrillation is defined scientifically as the absence of VF/VT at 5 s after shock delivery, although the ultimate goal is ROSC.

Factors affecting defibrillation success

Defibrillation success depends on sufficient current being delivered to the myocardium. However, the delivered current is difficult to determine because it is influenced by transthoracic impedance (electrical resistance) and electrode position. Furthermore, much of the current is diverted along non-cardiac pathways in the thorax and, as a result, as little as 4% reaches the heart.

Transthoracic impedance

Current flow is inversely proportional to transthoracic impedance. Defibrillation technique must be optimised to minimise the transthoracic impedance in order to maximise delivery of current to the myocardium. In adults, impedance is normally in the range 70 - 80 ohm, but in the presence of poor technique may rise to 150 ohm, reducing the current delivered and thereby decreasing the chance of successful defibrillation. Transthoracic impedance is influenced by; electrode-to-skin contact, electrode size and phase of ventilation. Modern biphasic defibrillators can measure the transthoracic impedance and adjust the energy delivered to compensate and are therefore less susceptible to higher transthoracic impedance (impedance compensation).

The presence of a transdermal drug patch on the patient's chest may prevent good contact and may cause arcing and burns if self-adhesive pads are placed over them; if removing them and wiping the area dry before applying the electrodes is likely to delay defibrillation, place the pads in an alternative position that avoids the patch.

Shaving the chest

It may be difficult to obtain good electrode-to-skin contact in patients with very hairy chests. This increases impedance, reduces defibrillation efficacy and may cause burns to the patient's chest. If a patient has a very hairy chest, and if a razor is available immediately, use it to remove excessive hair from the area where the electrodes are placed. However, defibrillation should not be delayed if a razor is not to hand immediately. In very hairy patients, a bi-axillary electrode position may enable more rapid defibrillation.

Electrode size

The optimal electrode size is unknown. Current recommendations are that the sum of the electrode area should be a minimum of 150 cm^2. Self-adhesive pads 8 - 12 cm in diameter are widely used and function well. In practice the self-adhesive pads recommended by the manufacturer for the specific defibrillator should be used.

Ventilatory phase

Transthoracic impedance varies during ventilation and is minimal at end expiration. Therefore if possible, defibrillation should be attempted at this point. Positive end-expiratory pressure (PEEP) increases impedance and where possible should be minimised during defibrillation. During severe asthma, gas trapping within the lungs generates auto-PEEP that may result in the need for higher energy levels for defibrillation.

Electrode position

No human studies have evaluated the electrode position as a determinant of ROSC or survival from cardiac arrest due to a shockable rhythm. Transmyocardial current during defibrillation is likely to be maximal when the electrodes are placed so that the area of the heart that is fibrillating lies directly between them (i.e. ventricles in VF/VT, atria in atrial fibrillation (AF)). Therefore, the optimal electrode position may not be the same for ventricular and atrial arrhythmias.

When attempting to defibrillate a patient in VF/VT, the standard procedure is to place one electrode to the right of the upper sternum below the clavicle. The apical pad is placed in the mid-axillary line, approximately level with the V6 ECG electrode or female breast. This position should be clear of any breast tissue. It is important that this electrode is placed sufficiently laterally (Figure 9.1). Although the electrodes are marked positive and negative, each can be placed in either position. Other acceptable pad positions include:

- One electrode anteriorly, over the left precordium, and the other electrode on the back behind the heart, just inferior to the left scapula (antero-posterior).
- One electrode placed in the mid-axillary line, approximately level with the V6 ECG electrode or female breast and the other electrode on the back, over the right scapula (postero-lateral).
- Each electrode on the lateral chest walls, one on the right and the other on the left side (bi-axillary).

Figure 9.1 Standard electrode positions for defibrillation

CPR or defibrillation first?

In any unwitnessed cardiac arrest, those responding should provide high quality, uninterrupted CPR while a defibrillator is retrieved, attached and charged. Defibrillation must be performed as soon as possible, and a specific period of CPR (e.g. 2 - 3 min) before rhythm analysis and shock delivery is no longer recommended.

Shock sequence

Clinical studies have demonstrated improved defibrillation success and increased survival to hospital discharge when using a single-shock defibrillation protocol compared to a three-stacked-shock protocol for VF cardiac arrest.

With first-shock efficacy of biphasic waveforms generally exceeding 90%, failure to cardiovert VF successfully suggests the need for a period of CPR to perfuse the myocardium, rather than a further shock. Thus, immediately after giving a single shock, and without reassessing the rhythm or feeling for a pulse, resume CPR (30 compressions:2 ventilations) for 2 min before delivering another shock (if indicated - see below). Even if the defibrillation attempt is successful in restoring a perfusing rhythm, it is very rare for a pulse to be palpable immediately after defibrillation and the delay in trying to palpate a pulse will further compromise the myocardium if a perfusing rhythm has not been restored. If a perfusing rhythm has been restored, giving chest compressions does not increase the chance of VF recurring. In the presence of post-shock asystole, chest compressions may induce VF.

Witnessed, monitored VF/VT in the cardiac catheter laboratory or after cardiac surgery

If a patient has a **witnessed** and **monitored** cardiac arrest in the catheter laboratory or early after cardiac surgery:

- Confirm cardiac arrest and shout for help.
- If the initial rhythm is VF/VT, give up to three quick successive (stacked) shocks. Start chest compressions immediately after the third shock and continue CPR for 2 min. With respect to the ALS algorithm, these three quick, successive shocks are regarded as the first shock.

This three-shock strategy may also be considered for an initial, witnessed VF/VT cardiac arrest if the patient is already connected to a manual defibrillator - these circumstances are rare. There are no data supporting a three-shock strategy in any of these circumstances, but it is unlikely that chest compressions will improve the already very high chance of ROSC when defibrillation occurs early in the electrical phase, immediately after onset of VF.

Shock energy and waveforms

The optimal energy levels for defibrillation are unknown and the recommendations below are based on a consensus following a review of the current scientific literature. The aim is to achieve defibrillation and ROSC while minimising myocardial injury by using the lowest effective energy and reducing the number of repetitive shocks.

Although 'energy' levels are selected for defibrillation, it is the transmyocardial current flow that achieves defibrillation. Current correlates well with successful defibrillation and cardioversion. Transthoracic electrical current during defibrillation using biphasic waveforms is in the range of 15 - 20 A for approximately 10 ms.

Historically, defibrillators have delivered a monophasic pulse of current, i.e. one direction of flow between the pads/paddles. These devices are no longer manufactured, having been superseded by biphasic defibrillators, but it is likely that many will remain in clinical use for several years.

Biphasic defibrillators

Biphasic waveforms deliver current that flows in a positive direction for a specified duration before reversing to a negative direction for the remainder of the electrical discharge. There are two main types of biphasic waveform: the biphasic truncated exponential (BTE) (Figure 9.2) and rectilinear biphasic (RLB) (Figure 9.3). Most biphasic defibrillators compensate for the wide variations in transthoracic impedance by electronically adjusting the waveform magnitude and duration. Biphasic defibrillation requires less energy than monophasic defibrillation; thus biphasic defibrillators have smaller capacitors and need less battery power, and the waveform shape can be controlled by solid-state circuitry. Consequently they are smaller, lighter and easily portable.

Biphasic waveforms are more effective at terminating ventricular arrhythmias at lower energy levels and have a greater first-shock efficacy than monophasic waveforms, particularly for long duration VF/VT (85 - 98% compared with 54 - 91%). Hence the use of biphasic waveforms is recommended whenever possible. Biphasic waveforms are also superior for the elective cardioversion of atrial fibrillation, using less energy and thereby reducing the severity of cutaneous burns. Biphasic waveforms are currently the waveform of choice for this procedure.

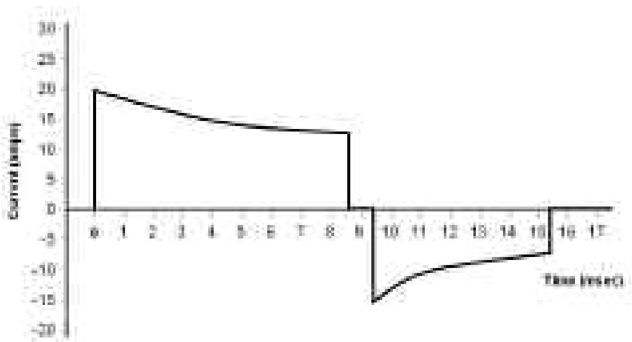

Figure 9.2 Biphasic truncated exponential waveform

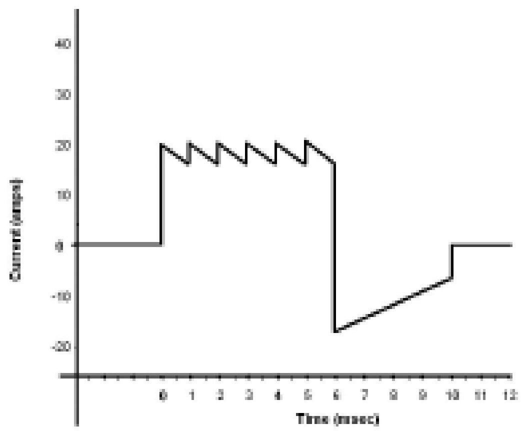

Figure 9.3 Rectilinear biphasic waveform

There is no evidence that either of the two most commonly used biphasic waveforms is more effective. Although the initial biphasic shock energy should be no lower than 120 J for a RLB waveform or 150 J for BTE waveforms, it is recommended that the initial biphasic shock should be at least 150 J for simplicity, irrespective of the biphasic waveform.

If the provider is unaware of the type of defibrillator (monophasic or biphasic) or its effective dose range, use the highest available energy for the first and subsequent shocks. If the first shock is unsuccessful, second and subsequent shocks can be delivered using either fixed or escalating energies of between 150 - 360 J, depending on the device in use. If a shockable rhythm recurs after successful defibrillation (with or without ROSC), give the next shock with the energy level that had previously been successful or higher.

Monophasic defibrillators

The monophasic waveform does not defibrillate as effectively as the biphasic waveform. Therefore, when using a monophasic defibrillator use 360 J for the first and all subsequent shocks.

Importance of uninterrupted chest compressions

The importance of early, uninterrupted chest compression is emphasised throughout this manual; they should be interrupted only for rhythm checking and shock delivery, and resumed as soon as a shock has been delivered. When two rescuers are present, the rescuer operating the defibrillator applies the electrodes whilst CPR is in progress. With manual defibrillation, it is possible to perform CPR during charging thereby reducing the pre-shock pause (interval from stopping compressions to shock delivery) to < 5 s. When using manual defibrillation, the entire process of pausing chest compressions, standing clear, delivering the shock and immediately resuming chest compressions should be achievable in < 5 s.

Safety

Attempted defibrillation should be undertaken without risk to members of the resuscitation team. This is achieved best by using self-adhesive pad electrodes as this eliminates the possibility of anyone touching any part of the electrode. Be wary of wet surroundings or clothing - wipe any water from the patient's chest before attempted defibrillation. No part of any person should make direct or indirect contact with the patient. Do not hold intravenous infusion equipment or the patient's trolley during shock delivery. The operator must ensure that everyone is clear of the patient before delivering a shock.

Gloves may provide limited protection from the electric current; therefore it is strongly recommended that all members of the resuscitation team wear gloves.

Safe use of oxygen during defibrillation

There are several reports of fires being caused in an oxygen-enriched atmosphere by sparking from poorly applied defibrillator paddles and most have resulted in significant burns to the patient. The use of self-adhesive pads is far less likely to cause sparks than manual paddles - no fires have been reported in association with the use of self-adhesive pads. The following are recommended as good practice:

- Take off any oxygen mask or nasal cannulae and place them at least 1 m away from the patient's chest.
- Leave the ventilation bag connected to the tracheal tube or supraglottic airway device, no increase in oxygen concentration occurs in the zone of defibrillation, even with an oxygen flow of 15 l min^{-1}. Alternatively, disconnect the ventilation bag from the tracheal tube or supraglottic airway device and remove it at least 1 m from the patient's chest during defibrillation.
- If the patient is connected to a ventilator, for example in the operating room or critical care unit, leave the ventilator tubing (breathing circuit) connected to the tracheal tube unless chest compressions prevent the ventilator from delivering adequate tidal volumes. In this case, the ventilator is usually substituted by a ventilation bag, which can be left connected or detached and removed to a distance of at least 1 m. If the ventilator tubing is disconnected, ensure that it is kept at least 1 m from the patient or, better still, switch the ventilator off; modern ventilators generate high oxygen flows when disconnected. During normal use, when connected to a tracheal tube, oxygen from a ventilator in the critical care unit will be vented from the main ventilator housing well away from the defibrillation zone. Patients in the critical care unit may be dependent on positive end expiratory pressure (PEEP) to maintain adequate oxygenation; during cardioversion, when the spontaneous circulation potentially enables blood to remain well oxygenated, it is particularly appropriate to leave the critically ill patient connected to the ventilator during shock delivery.

Automated external defibrillators

Automated external defibrillators are sophisticated, reliable, computerised devices that use voice and visual prompts to guide lay rescuers and healthcare professionals to attempt defibrillation safely in cardiac arrest victims (Figure 9.4). Advances in technology, particularly with respect to battery capacity, and software arrhythmia analysis have enabled the mass production of relatively cheap, reliable and easily operated portable defibrillators. Shock-advisory defibrillators have ECG-analysis capability but can usually be manually over-ridden by healthcare providers capable of rhythm recognition.

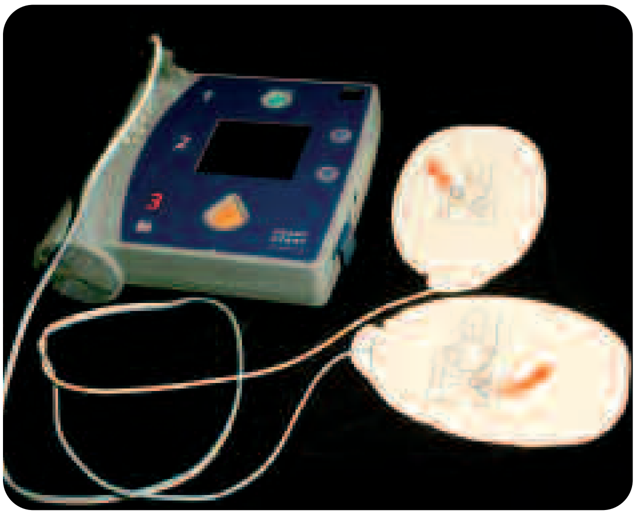

Figure 9.4 Automated external defibrillator (AED)

Automated rhythm analysis

Automated external defibrillators have microprocessors that analyse several features of the ECG, including frequency and amplitude. Some AEDs are programmed to detect spontaneous movement by the patient or others. Developing technology should soon enable AEDs to provide information about frequency and depth of chest compressions during CPR that may improve resuscitation performance by all rescuers.

Automated external defibrillators have been tested extensively against libraries of recorded cardiac rhythms and in many trials in adults and children. They are extremely accurate in rhythm analysis. Although AEDs are not designed to deliver synchronised shocks, all AEDs will recommend shocks for VT if the rate and R-wave morphology exceed preset values.

In-hospital use of AEDs

Delayed defibrillation may occur when patients sustain cardiac arrest in unmonitored hospital beds and in outpatient departments. In these areas several minutes may elapse before resuscitation teams arrive with a defibrillator and deliver shocks. Two non-randomised studies of adults with in-hospital cardiac arrest from shockable rhythms showed higher survival-to-hospital discharge rates when defibrillation was provided through an AED program than with manual defibrillation alone. Despite limited evidence, AEDs should be considered for the hospital setting as a way to facilitate defibrillation as soon as possible (within 3 min of collapse at the most) especially in areas where staff have no rhythm recognition skills or where they use defibrillators infrequently. An effective system for training and retraining should be in place. Adequate numbers of staff should be trained to enable achievement of the goal of providing the first shock within 3 min of collapse anywhere in the hospital.

Training in the use of AEDs can be achieved much more rapidly and easily than for manual defibrillators. Automated equipment has made attempted defibrillation available to a much wider range of medical, nursing, paramedical, and lay workers (e.g. police and first-aiders - ‘first-responder defibrillation’). Healthcare providers with a duty to perform CPR should be trained, equipped, and authorised to perform defibrillation. First-responder attempted defibrillation is vital, as the delay to delivery of the first shock is the main determinant of survival in cardiac arrest.

Public access defibrillation (PAD) programmes

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 cardiac arrest. These programmes require an organised and practised response with rescuers trained and equipped to recognise emergencies, activate the EMS system, provide CPR, and use the AED. Lay rescuer AED programmes with very rapid response times in airports, on aircraft, or in casinos, and uncontrolled studies using police officers as first responders have achieved reported survival rates as high as 49 - 74%.

Recommended elements for PAD programmes include:

- a planned and practised response;
- training of anticipated rescuers in CPR and use of the AED;
- link with the local EMS system;
- programme of continuous audit (quality improvement).

Public access defibrillation programmes are most likely to improve survival from cardiac arrest if they are established in locations where witnessed cardiac arrest is likely to occur. Suitable sites might include airports, casinos and sports facilities. Approximately 80% of out-of-hospital cardiac arrests occur in private or residential settings; this fact inevitably limits the overall impact that PAD programmes can have on survival rates.

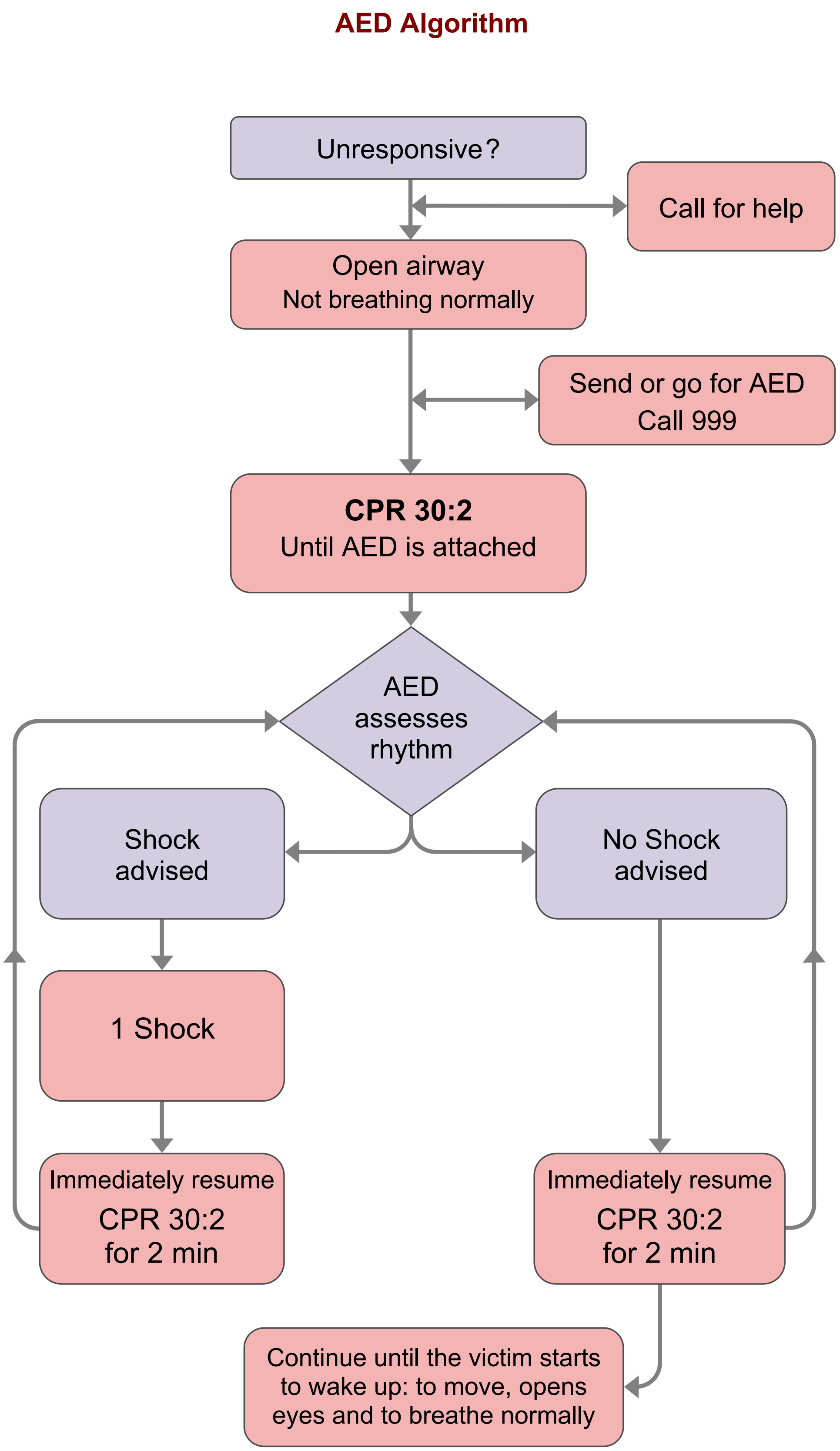

Figure 9.5 AED Algorithm

Sequence for use of an AED or shock-advisory defibrillator

1 Make sure the victim, any bystanders, and you are safe

2 If the victim is unresponsive and not breathing normally:

- Send someone for the AED and call for an ambulance or resuscitation team. If you are on your own, do this yourself.

3 Start CPR according to the guidelines (Chapter 5).

4 As soon as the AED arrives:

- Switch on the AED and attach the electrode pads. If more than one rescuer is present, continue CPR while this is done.
- Follow the voice/visual directions.
- Ensure that nobody touches the victim whilst the AED is analysing the rhythm.

5A If a shock **IS** indicated:

- Ensure that nobody touches the victim (Figure 9.6a).
- Push the shock button (Figure 9.6b) as directed.
- Continue as directed by the voice/visual prompts.

5B If **NO** shock is indicated:

- Immediately resume CPR using a ratio of 30 compressions to 2 rescue breaths (Figure 9.6c).
- Continue as directed by the voice/visual prompts.

6 Continue to follow the AED prompts until:

- Qualified help (e.g. ambulance or resuscitation team) arrives and takes over.
- The victim starts to breathe normally, or
- You become exhausted.

Notes

- The carrying case with the AED must contain some strong scissors for cutting through clothing and a disposable razor for shaving excessive chest hair in order to obtain good electrode contact.
- If ALS providers are using the AED, they should implement other ALS interventions (advanced airway, ventilation, IV access, drug delivery, etc.) according to local protocols.

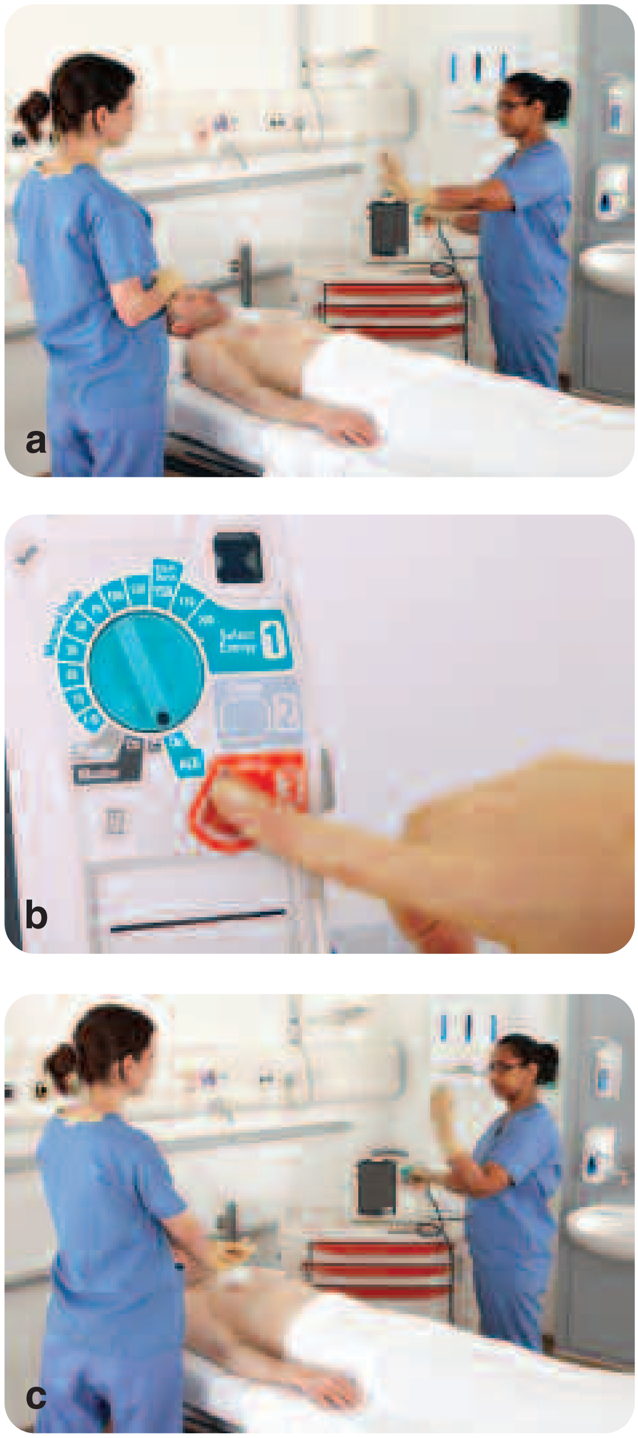

Figure 9.6a-c Operation of a shock-advisory defibrillator and efficient CPR

Manual defibrillation

Manual defibrillators have several advantages over AEDs. They enable the operator to diagnose the rhythm and deliver a shock rapidly without having to wait for rhythm analysis. This minimises the interruption in chest compressions. Manual defibrillators often have additional functions, such as the ability to deliver synchronised shocks, and external pacing facilities. The main disadvantage of these devices is that the operator has to be skilled in ECG rhythm recognition; therefore, in comparison with AEDs, extra training is required.

Sequence for use of a manual defibrillator

This sequence is an integral part of the advanced life support treatment algorithm in Chapter 6.

1. Confirm cardiac arrest - check for signs of life or if trained to do so, breathing and pulse simultaneously.

2. Call resuscitation team.

3. Perform uninterrupted chest compressions while applying self-adhesive defibrillation/monitoring pads (Figure 9.7) - one below the right clavicle and the other in the V6 position in the midaxillary line.

4. Plan actions before pausing CPR for rhythm analysis and communicate these to the team.

5. Stop chest compressions; confirm VF from the ECG.

6. Resume chest compressions immediately; simultaneously, the designated person selects the appropriate energy on the defibrillator (150 - 200 J biphasic for the first shock and 150 - 360 J biphasic for subsequent shocks) and presses the charge button (Figure 9.8).

7. While the defibrillator is charging, warn all rescuers other than the individual performing the chest compressions to “stand clear” and remove any oxygen delivery device as appropriate. Ensure that the rescuer giving the compressions is the only person touching the patient.

8. Once the defibrillator is charged, tell the rescuer doing the chest compressions to ”stand clear”; when clear, give the shock.

9. Without reassessing the rhythm or feeling for a pulse, restart CPR using a ratio of 30:2, starting with chest compressions.

10. Continue CPR for 2 min; the team leader prepares the team for the next pause in CPR.

11. Pause briefly to check the monitor.

12. If VF/VT, repeat steps 6 - 11 above and deliver a second shock.

13. If VF/VT persists repeat steps 6 - 8 above and deliver a third shock. Resume chest compressions immediately and then give adrenaline 1 mg IV and amiodarone 300 mg IV while performing a further 2 min CPR.

14. Repeat this 2 min CPR - rhythm/pulse check - defibrillation sequence if VF/VT persists.

15. Give further adrenaline 1 mg IV after alternate shocks (i.e. approximately every 3 - 5 min).

16. If organised electrical activity is seen during the pause to check the monitor, feel for a pulse:

    a. If a pulse is present, start post-resuscitation care.
    b. If no pulse is present, continue CPR and switch to the non-shockable algorithm.

17. If asystole is seen, continue CPR and switch to the non-shockable algorithm.

Figure 9.7 Applying defibrillator pads

Figure 9.8 Charging during chest compressions

Prehospital defibrillation

Although previous guidelines have recommended that a period of CPR before defibrillation may be beneficial after prolonged collapse, recent studies have failed to confirm the value of this. Furthermore, the duration of collapse before the arrival of the EMS is often difficult to assess accurately. However, there is evidence that performing chest compressions while retrieving, applying and charging the defibrillator improves the probability of survival. For these reasons, when attending any cardiac arrest not witnessed by EMS personnel, one member of the EMS team should provide good-quality CPR until the other is ready to deliver a shock. Do not give a specified period of CPR before rhythm analysis and shock delivery (see Chapter 14).

Laypeople and first responders using AEDs should attach the device as soon as possible and follow the prompts.

Defibrillation with an AED in children

A standard AED using the energy settings already described is suitable for defibrillation of children above the age of 8 years. For defibrillation of children between 1 and 8 years, special paediatric electrodes with integral energy attenuators are recommended; these reduce the delivered energy to that recommended for manual defibrillation. If these electrodes are not available, use standard adult electrodes, ensuring that they do not overlap, and adult AED settings. For children below 1 year of age, based on some case reports documenting successful use in this group, it is acceptable to use an AED if no other option is available.

Synchronised cardioversion

If electrical cardioversion is used to convert atrial or ventricular tachyarrhythmias, the shock must be synchronised to occur with the R wave (not the T wave) of the electrocardiogram. By avoiding the relative refractory period, the risk of inducing VF is minimised. Most manual defibrillators incorporate a switch that enables the shock to be triggered by the R wave on the electrocardiogram. Electrodes are applied to the chest wall and cardioversion is achieved in the same way as attempted defibrillation but the operator must anticipate the slight delay between pressing the buttons and the discharge of the shock when the next R wave occurs. Do not move the defibrillator electrodes during this interval; otherwise the QRS complex will not be detected.

Synchronisation can be difficult in VT because of the wide-complex and variable forms of ventricular arrhythmia. If synchronisation fails, give unsynchronised shocks to the unstable patient in VT to avoid prolonged delay in restoring sinus rhythm. Ventricular fibrillation or pulseless VT requires unsynchronised shocks. Conscious patients must be anaesthetised or sedated before attempting synchronised cardioversion.

With some defibrillators, the synchronised mode has to be reset if a second shock is required. Other machines remain in the synchronised mode; be careful not to leave the synchronisation switch in the 'on' position following use as this will inhibit discharge of the defibrillator when it is next used for treating VF/VT.

Energy doses for cardioversion are discussed in Chapter 11.

Cardiac pacemakers and implantable cardioverter-defibrillators

If the patient has a cardiac pacemaker or implantable cardioverter-defibrillator (ICD), be careful when placing the electrodes. Although modern pacemakers are fitted with protection circuits, the current may travel along the pacemaker wire or ICD lead causing burns where the electrode tip makes contact with the myocardium. This may increase resistance at the contact point and gradually increase the threshold for pacing. Place the defibrillator electrodes at least 8 cm from the pacemaker unit to minimise the risk. Alternatively place the pads in the antero-posterior or postero-lateral position as described above. If resuscitation is successful following defibrillation, check the pacemaker threshold regularly over the next two months. Recent case reports have documented rescuers receiving shocks from ICDs when in contact with the patient during CPR. It is particularly important to wear gloves and avoid skin-to-skin contact with the patient while performing CPR as there is no warning before the ICD discharges.

Internal defibrillation

Internal defibrillation using paddles applied directly across the ventricles requires considerably less energy than that used for external defibrillation. Biphasic shocks are substantially more effective than monophasic shocks for direct defibrillation. For biphasic shocks, use 10 - 20 J, delivered directly to the myocardium through internal paddles. Monophasic shocks require approximately double these energy levels. Do not exceed 50 J when using internal defibrillation - failure to defibrillate at these energy levels requires myocardial optimisation before defibrillation is attempted again.

Key learning points

- For the patient in VF, early defibrillation is the only effective means of restoring a spontaneous circulation.
- When using a defibrillator, minimise interruptions in chest compressions.

Further reading

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