Airway management and ventilation

Chapter 7

Contents

Learning outcomes

To enable you to:

- Recognise the causes of airway obstruction
- Manage the airway effectively during resuscitation
- Understand the role of simple techniques and devices for maintaining the airway and ventilating the lungs
- Understand the role of supraglottic airways during CPR
- Consider the role of tracheal intubation during CPR
- Understand the role of needle and surgical cricothyroidotomy

Introduction

Patients requiring resuscitation often have an obstructed airway, usually caused by loss of consciousness, but occasionally it may be the primary cause of cardiorespiratory arrest. Prompt assessment, with control of airway patency and provision of ventilation if required are essential. This will help to prevent secondary hypoxic damage to the brain and other vital organs. Without adequate oxygenation it may be impossible to restore an organised, perfusing cardiac rhythm. These principles may not apply to the witnessed primary cardiac arrest in the vicinity of a defibrillator; in this case, the priority is immediate defibrillation followed by attention to the airway.

Causes of airway obstruction

Obstruction of the airway may be partial or complete. It may occur at any level from the nose and mouth down to the level of the carina and bronchi. In the unconscious patient, the commonest site of airway obstruction is the pharynx – more often at the soft palate and epiglottis rather than the tongue. Obstruction may also be caused by vomit or blood, following regurgitation of gastric contents or trauma, or by foreign bodies. Laryngeal obstruction may be caused by oedema from burns, inflammation or anaphylaxis. Upper airway stimulation or inhalation of foreign material may cause laryngeal spasm. Obstruction of the airway below the larynx is less common, but may be caused by excessive bronchial secretions, mucosal oedema, bronchospasm, pulmonary oedema, or aspiration of gastric contents. Extrinsic compression of the airway may also occur above or below the larynx (e.g. trauma, haematoma or tumour).

Recognition of airway obstruction

Airway obstruction can be subtle and is often missed by healthcare professionals. Recognition is best achieved by the look, listen and feel approach.

- LOOK for chest and abdominal movements.
- LISTEN and FEEL for airflow at the mouth and nose.

In partial airway obstruction, air entry is diminished and usually noisy.

- Inspiratory stridor - caused by obstruction at the laryngeal level or above.
- Expiratory wheeze - suggests obstruction of the lower airways, which tend to collapse and obstruct during expiration.
- Gurgling - suggests the presence of liquid or semisolid foreign material in the upper airways.
- Snoring - arises when the pharynx is partially occluded by the tongue or palate.

Complete airway obstruction in a patient who is making respiratory efforts causes paradoxical chest and abdominal movement, described as 'see-saw breathing'. As the patient attempts to breathe in, the chest is drawn in and the abdomen expands; the opposite occurs in expiration. This is in contrast to the normal breathing pattern of synchronous movement of the abdomen upwards and outwards (pushed down by the diaphragm) with lifting of the chest wall. During airway obstruction, accessory muscles of respiration are used - the neck and the shoulder muscles contract to assist movement of the thoracic cage. There may also be intercostal and subcostal recession and a tracheal tug. Full examination of the neck, chest and abdomen should enable differentiation of the movements associated with complete airway obstruction from those of normal breathing. Listen for airflow: normal breathing should be quiet, completely obstructed breathing will be silent, and noisy breathing indicates partial airway obstruction.

During apnoea, when spontaneous breathing movements are absent, complete airway obstruction is recognised by failure to inflate the lungs during attempted positive pressure ventilation. Unless airway obstruction can be relieved to enable adequate lung ventilation within a few minutes the resulting hypoxia will cause injury to the brain and other vital organs, and cardiac arrest if this has not already occurred. Whenever possible, give high-concentration oxygen during the attempt to relieve airway obstruction. Arterial blood oxygen saturation (SaO_2) measurements (normally using pulse oximetry (SpO_2)) will guide further use of oxygen as airway patency improves. If airway patency remains poor and SpO_2 remains low, continue to give high inspired oxygen concentration. As airway patency improves, blood oxygen saturation levels will be restored more rapidly if the inspired oxygen concentration is initially high. Inspired oxygen concentrations can then be adjusted to maintain SpO_2 at 94%–98%.

Patients with tracheostomies or permanent tracheal stomas

A patient with a tracheostomy tube or a permanent tracheal stoma (usually following a laryngectomy) may develop airway obstruction from blockage of the tracheostomy tube or stoma — airway obstruction cannot occur at the level of the pharynx in these patients. Remove any obvious foreign material from the stoma or tracheostomy tube. If necessary, remove the tracheostomy tube and exchange it if possible or, if present, exchange the tracheostomy tube liner alone. If a blocked tracheostomy tube is removed it may be possible to ventilate the patient's lungs by sealing the stoma and using a bag-mask applied to the face, or by intubating the trachea orally with a standard tracheal tube. This might not be possible if the tracheostomy was created because of significant upper airway obstruction (e.g. tumour).

In a patient with a permanent tracheal stoma, give oxygen and, if required, assist ventilation via the stoma, and not the mouth. The National Tracheostomy and Safety Project in collaboration with the Resuscitation Council (UK) has produced emergency guidelines and resources that are available at www.tracheostomy.org.uk

Choking

Recognition

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 7.1.

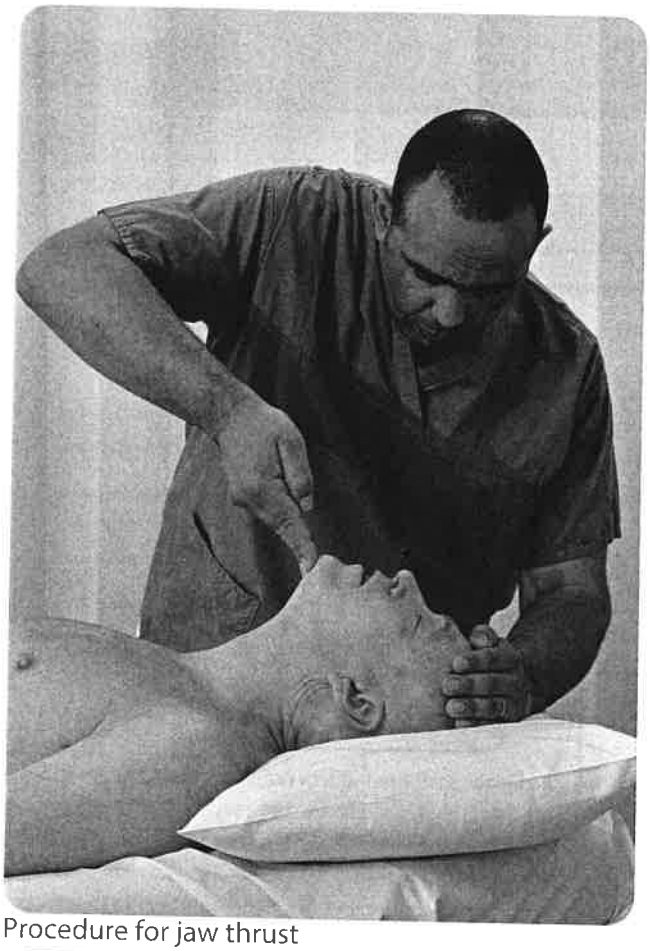
General signs of choking	
• Attack occurs while eating • Patient may clutch his neck	
Signs of severe airway obstruction	**Signs of mild airway obstruction**
Response to question 'Are you choking?' • Patient unable to speak • Patient may respond by nodding	Response to question 'Are you choking?' • Patient speaks and answers yes
Other signs • Patient unable to breathe • Breathing sounds wheezy • Attempts at coughing are silent • Patient may be unconscious	Other signs • Patient is able to speak, cough, and breathe

Table 7.1 Signs of choking

Sequence for the treatment of adult choking

1. If the patient shows signs of mild airway obstruction and has an effective cough (figure 7.1)

- Encourage him to continue coughing, and observe him.
- Continue to check him until recovery of deterioration.



Procedure for jaw thrust

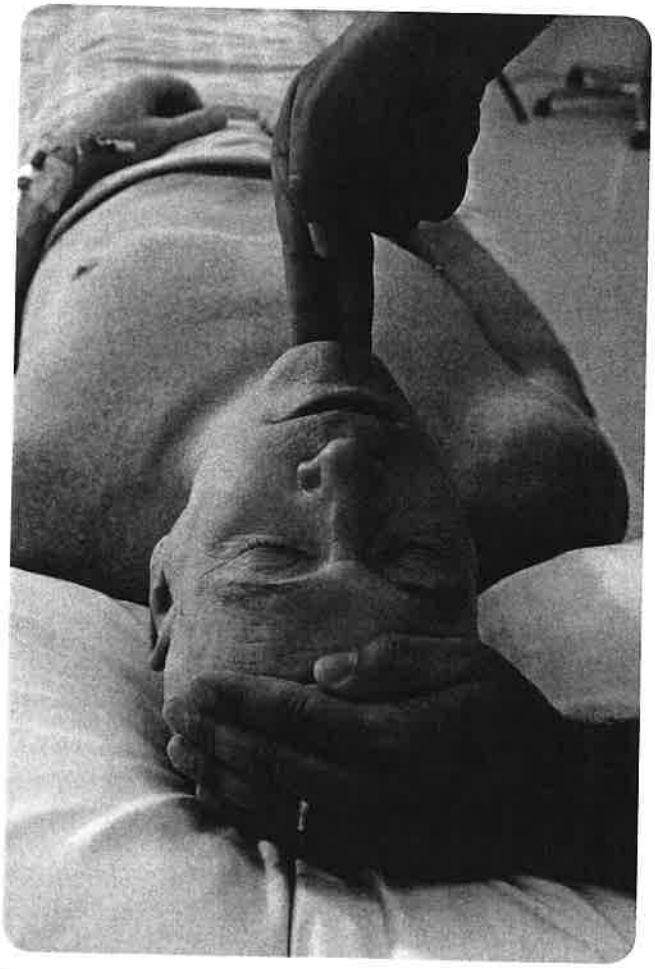


Figure 7.2 Head tilt and chin lift

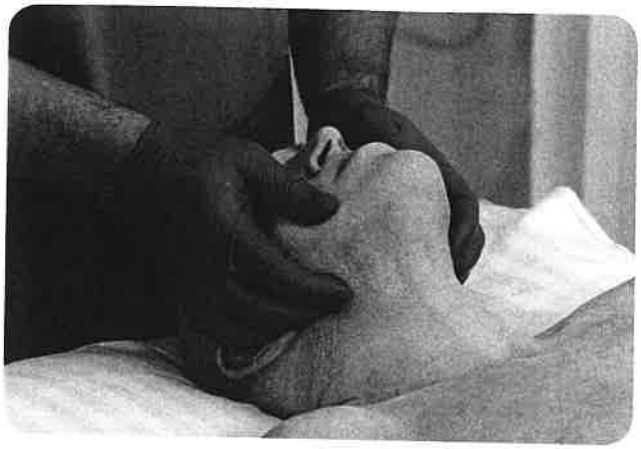


Figure 7.3 Jaw thrust

- Identify the angle of the mandible.
- With the index and other fingers placed behind the angle of the mandible, apply steady upwards and forward pressure to lift the mandible, (where possible some counter pressure may be needed).
- Using the thumbs, slightly open the mouth by downward displacement of the chin.

These simple positional methods are successful in most cases where airway obstruction is caused by loss of muscle tone in the pharynx. After each manoeuvre, check for success using the look, listen and feel sequence. If a clear airway cannot be achieved, look for other causes of airway obstruction. Carefully remove any visible foreign body with forceps or suction. Remove broken or displaced dentures but leave well-fitting dentures in place as they help to maintain the contours of the mouth, facilitating a good seal for ventilation by mouth-to-mask or bag-mask techniques.

Airway manoeuvres in a patient with suspected cervical spine injury

If spinal injury is suspected (e.g. if the victim has fallen, been struck on the head or neck, or has been rescued after diving into shallow water) maintain the head, neck, chest, and lumbar region in the neutral position during resuscitation. Excessive head tilt could aggravate the injury and damage the cervical spinal cord; however, this complication remains theoretical and the relative risk is unknown. When there is a risk of cervical spine injury, establish a clear upper airway by using jaw thrust or chin lift in combination with manual in-line stabilisation (MILS) of the head and neck by an assistant. If life-threatening airway obstruction persists despite effective application of jaw thrust or chin lift, add head tilt a small amount at a time until the airway is open; establishing a patent airway takes priority over concerns about a potential cervical spine injury.

Adjuncts to basic airway techniques

Simple airway adjuncts are often helpful, and sometimes essential to maintain an open airway, particularly when resuscitation is prolonged. The position of the head and neck must be maintained to keep the airway aligned.

Oropharyngeal and nasopharyngeal airways are designed to overcome soft palate obstruction and backward tongue displacement in an unconscious patient, but head tilt and jaw thrust may also be required.

Oropharyngeal airway

The oropharyngeal (or Guedel) airway is a curved plastic tube, flanged and reinforced at the oral end with a flattened shape to ensure that it fits neatly between the tongue and hard palate (Figure 7.4). It is available in sizes suitable for small and large adults. An estimate of the size required may be obtained by selecting an airway with a length corresponding to the vertical distance between the patient's incisors and the angle of the jaw (Figure 7.5). The most common sizes are 2, 3 and 4 for small, medium and large adults respectively. An oropharyngeal airway that is slightly too big will be more beneficial than one that is slightly too small, however correct sizing is optimal.

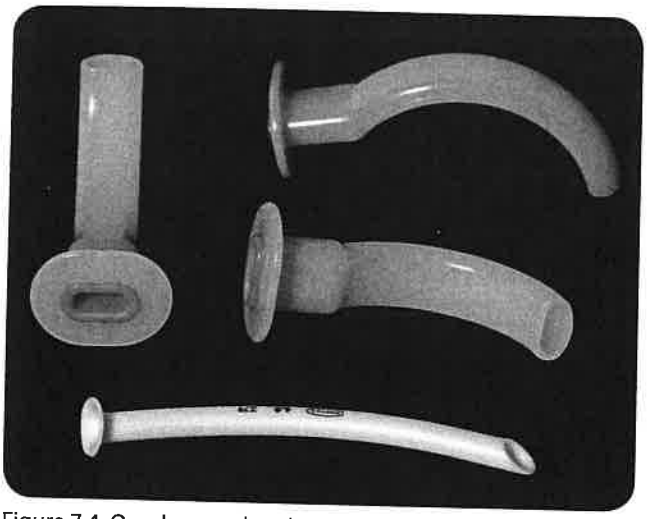


Figure 7.4 Oropharyneal and nasopharyngeal airways

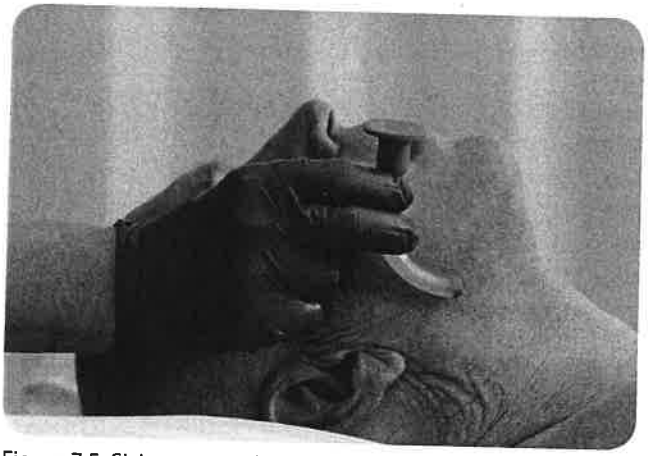


Figure 7.5 Sizing an oropharyngeal airway

During insertion of an oropharyngeal airway, the tongue can occasionally be pushed backwards, exacerbating obstruction instead of relieving it. The oropharyngeal airway may lodge in the vallecula, or the epiglottis may obstruct the lumen. Ensuring a correct insertion technique should avoid this problem. Attempt insertion only in unconscious patients: vomiting or laryngospasm may occur if glossopharyngeal or laryngeal reflexes are present.

Technique for insertion of an oropharyngeal airway

- Open the patient's mouth and ensure that there is no foreign material that may be pushed into the larynx (if there is any, then use suction to remove it).
- Insert the airway into the oral cavity in the 'upside-down' position as far as the junction between the hard and soft palate and then rotate it through 180° (Figure 7.6). Advance the airway until it lies within the pharynx. This rotation technique minimises the chance of pushing the tongue backwards and downwards. Remove the airway if the patient gags or strains. Correct placement is indicated by an improvement in airway patency and by the seating of the flattened reinforced section between the patient's teeth or gums (if edentulous). A jaw thrust may further aid final placement of the airway as it is finally pushed into the correct position.

After insertion, maintain head-tilt/chin-lift or jaw thrust, and

Figure 7.6 Oral airway insertion

check the patency of the airway and ventilation using the look, listen and feel technique. Where there is suspicion of an injury to the cervical spine, maintain alignment and immobilisation of the head and neck. Suction is usually possible through an oropharyngeal airway using a fine- bore flexible suction catheter.

Nasopharyngeal airway

This is made from soft malleable plastic, bevelled at one end and with a flange at the other (Figure 7.4). In patients who are not deeply unconscious, it is better tolerated than an oropharyngeal airway. It may be life-saving in patients with clenched jaws, trismus or maxillofacial injuries.

Inadvertent insertion of a nasopharyngeal airway through a fracture of the skull base and into the cranial vault is possible, but extremely rare. In the presence of a known or suspected basal skull fracture an oral airway is preferred, but if this is not possible, and the airway is obstructed, gentle insertion of a nasopharyngeal airway may be life-saving (i.e. the benefits may far outweigh the risks).

The tubes are sized in millimeters according to their internal diameter, and the length increases with diameter.

The external diameter may vary depending on manufacturer and material. The traditional methods of sizing a nasopharyngeal airway (measurement against the patient's little finger or anterior nares) do not correlate with the airway anatomy and are unreliable. There is research evidence demonstrating a relationship between NPA length to subject height.

Sizes 6–7 mm are suitable for most adults. When inserted the nostrils should not be blanched.

To insert a nasopharyngeal airway:

1. Choose the correct size (commonly 6–7 mm in an adult).
2. Lubricate with a water-based lubricant on outside of tube.
3. If a safety pin is to be used to prevent the airway from advancing too far insert this into the tube before inserting the airway.
4. Check the right nostril for patency. If obstructed use the left.
5. Hold the upper third of the airway - if it meets an obstruction it will hopefully bend before causing trauma.
6. Insert the airway into the nostril, bevelled end first.
7. Pass the airway vertically along the floor of the nose, using a slight twisting back and forth action, into the posterior pharynx.
8. If there is resistance remove the airway and try the left nostril.
9. Once inserted the flange should be at the level of the nostril.
10. Check patency with look listen feel approach.

Insertion can cause damage to the mucosal lining of the nasal airway, resulting in bleeding in up to 30% of cases. If the tube is too long it may stimulate the laryngeal or glossopharyngeal reflexes to produce laryngospasm or vomiting.

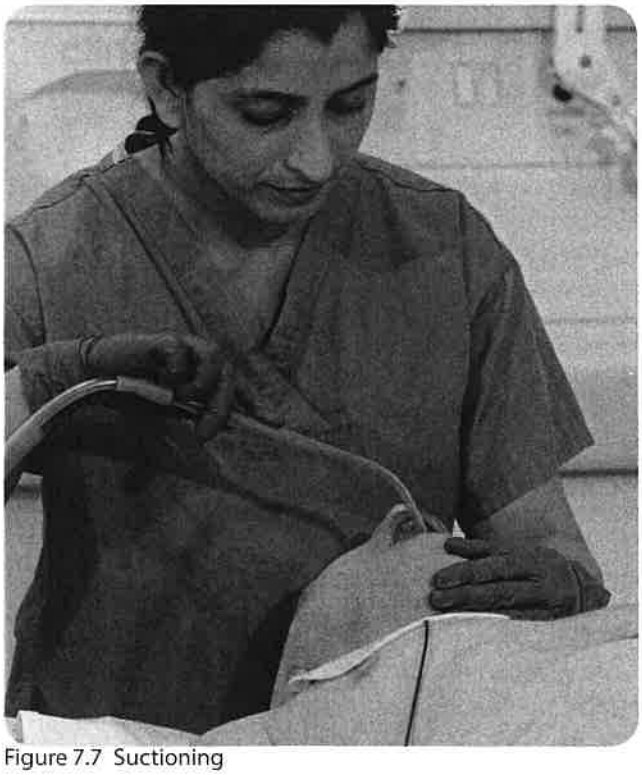


Figure 7.7 Suctioning

Oxygen

In the absence of data indicating the optimal SaO_2 during CPR, ventilate the lungs with 100% until return of spontaneous circulation (ROSC) is achieved. After ROSC is achieved and in any acutely ill, or unconscious patient, give high-flow oxygen until the SaO_2 can be measured reliably. There are some registry data indicating an association between hyperoxaemia after ROSC and worse outcome. A standard oxygen mask will deliver up to 50%, providing the flow of oxygen is high enough. Initially, give the highest possible oxygen concentration - a mask with reservoir bag (non-rebreathing mask) can deliver an inspired oxygen concentration of 85% at flows of 10 L min^{-1}. Monitor the SpO_2 or arterial blood gases to enable titration of the inspired oxygen concentration. When blood oxygen saturation can be measured reliably, try to maintain the SpO_2 at 94%–98%; or 88%–92% if the patient has chronic obstructive pulmonary disease (COPD).

Suction

Use a wide-bore rigid sucker (Yankauer) to remove liquid (blood, saliva, gastric contents) from the upper airway (Figure 7.7). Use the sucker cautiously if the patient has an intact gag reflex – it can provoke vomiting. Fine-bore flexible suction catheters may be required in patients with limited mouth opening. These suction catheters can also be passed through oropharyngeal or nasopharyngeal airways.

Ventilation

Artificial ventilation is started as soon as possible in any patient in whom spontaneous ventilation is inadequate or absent. Expired air ventilation (rescue breathing) is effective but the rescuer's expired oxygen concentration is only 16–17%; so it must be replaced as soon as possible by ventilation with oxygen-enriched air. Although mouth-to-mouth ventilation has the benefit of not requiring any equipment, the technique is aesthetically unpleasant, particularly when vomit or blood is present, and the rescuer may be reluctant to place themselves in intimate contact with the victim who may be unknown to them.

There are only isolated reports of individuals acquiring infections after providing rescue breathing (e.g. tuberculosis and severe acute respiratory distress syndrome (SARS)). Transmission of HIV during provision of rescue breathing has never been reported. Simple adjuncts are available to enable direct person-to-person contact to be avoided; some of these devices may reduce the risk of cross infection between patient and rescuer.

The pocket resuscitation mask is used widely. It is similar to an anaesthetic face mask and enables mouth-to-mask ventilation. It has a unidirectional valve, which directs the patient's expired air away from the rescuer. The mask is transparent so that vomit or blood from the patient can be seen. Some masks have a port for the addition of oxygen. When using masks without an oxygen port, supplemental oxygen can be given by placing oxygen tubing underneath one side and ensuring an adequate seal. Use a two-hand technique to maximise the seal with the patient's face (Figure 7.8).

High airway pressures can be generated if the tidal volumes or inspiratory flows are too great, predisposing to gastric inflation and subsequent risk of regurgitation and pulmonary aspiration. As gastric inflation occurs, lung compliance is further reduced making ventilation more difficult.

The possibility of gastric inflation is increased by:

- malalignment of the head and neck, and an obstructed airway
- an incompetent oesophageal sphincter (present in all patients with cardiac arrest)
- a high inflation pressure.

Tidal volumes in the region of 6–7 mL kg^{-1} will provide adequate oxygenation and ventilation, and will reduce the risk of gastric inflation. If inspiratory flow is too slow, inspiratory time will be prolonged and the time available to give chest compressions is reduced. Deliver each breath over approximately 1 s and give a volume that corresponds to normal visible chest movement; this represents a compromise between giving an adequate volume, minimising the risk of gastric inflation, and allowing adequate time for chest compressions. Avoid hyperventilation as this will increase intrathoracic pressure and reduce coronary perfusion. During CPR with an unprotected airway, give 2 ventilations after each sequence of 30 chest compressions.

Technique for mouth-to-mask ventilation

- Place the patient supine with the head in a 'sniffing' position (i.e. neck slightly flexed on a pillow with the head extended (tilted backwards) on the neck).
- Apply the mask to the patient's face using the thumbs of both hands.

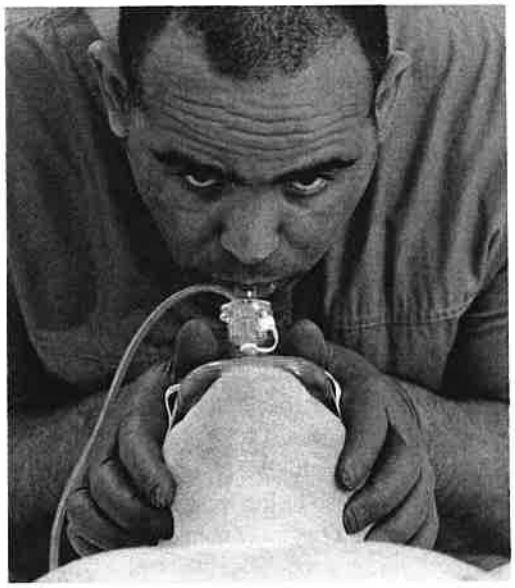


Figure 7.8 Mouth-to-mask ventilation

- Lift the jaw into the mask with the remaining fingers by exerting pressure behind the angles of the jaw (i.e. jaw thrust). At the same time, press the mask onto the face with the thumbs to make a tight seal (Figure 7.8).
- Blow gently through the inspiratory valve and watch the chest rise normally.
- Stop inflation and observe the chest falling.
- Any leaks between the face and mask can be reduced by adjusting the contact pressure, altering the position of the fingers and thumbs, or increasing jaw thrust.
- If oxygen is available, add it via the port at a flow of 10 L min^{-1}.

Self-inflating bag

The self-inflating bag can be connected to a face mask, tracheal tube, or supraglottic airway (SGA). As the bag is squeezed, the contents are delivered to the patient's lungs. On release, the expired gas is diverted to the atmosphere via a one-way valve; the bag then refills automatically via an inlet at the opposite end. When used without supplemental oxygen, the self-inflating bag ventilates the patient's lungs with ambient air (oxygen concentration 21%) only. This is increased to around 45% by attaching high-flow oxygen directly to the bag adjacent to the air intake. An inspired oxygen concentration of approximately 85% is achieved if a reservoir system is attached and the oxygen flow is maximally increased. As the bag re-expands it fills with oxygen from both the reservoir and the continuous flow from the attached oxygen tubing.

Although the bag-mask apparatus enables ventilation with high concentrations of oxygen, its use by a single person requires considerable skill. When used with a face mask, it is often difficult to achieve a gas-tight seal between the mask and the patient's face, and maintain a patent airway with one hand while squeezing the bag with the other. Any significant leak will cause hypoventilation and if the airway is not patent, gas may also be forced into the stomach. This will reduce ventilation further and greatly increase the risk of regurgitation and aspiration. There is a natural tendency to try to compensate for a leak by excessive compression of the bag, which causes high peak airway pressures and forces more gas into the stomach. Some self-inflating bags have flow restrictors that limit peak airway pressure with the aim of reducing gastric inflation.

Do not use cricoid pressure routinely in cardiac arrest. Cricoid pressure can reduce the risk of gastric inflation but requires the presence of a trained assistant. Poorly applied cricoid pressure may make it more difficult to ventilate the patient's lungs.

The two-person technique for bag-mask ventilation is preferable (Figure 7.9a). One person holds the face mask in place using a jaw thrust with both hands and the assistant squeezes the bag. In this way, a better seal can be achieved and the patient's lungs can be ventilated more effectively and safely.

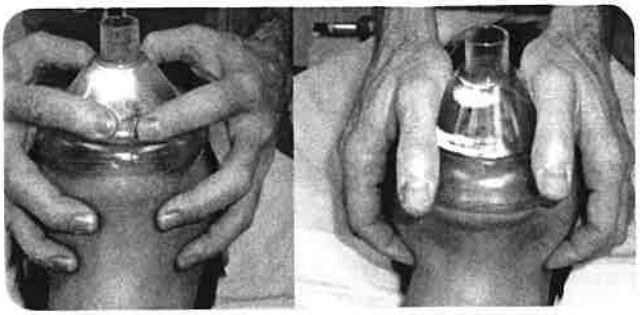


Figure 7.9. Holding the mask in place using the CE (left) and thenar eminence method (right)

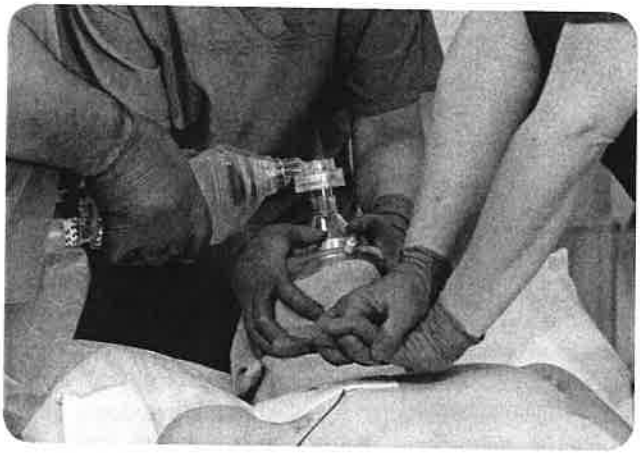


Figure 7.9a The two-person technique for bag-mask ventilation

Holding the mask onto the face to achieve a good seal is commonly by either the C-E or thenar eminence grip method. This C-E grip involves the thumb and index finger holding the mask and the inferior and superior mask borders, respectively (the C). The other three fingers hold the mandible while pulling the face into the mask (the E). In the thenar eminence method, the mask holder applies pressure to the mask by placing both thenar eminences parallel to the long axis of the mask. The other four fingers are placed under the mandible to apply jaw lift, (figure 7.9). Either mask holding technique can be used, depending on the level of experience and comfort of the provider to achieve a good seal and permit ventilation.

Automatic resuscitators

Various small portable automatic ventilators may be used during resuscitation; they are more likely to be used pre-hospital rather than in-hospital. Most automatic resuscitators provide a constant flow of gas to the patient during inspiration; the volume delivered is dependent on the inspiratory time (a longer time provides a greater tidal volume). Because pressure in the airway rises during inspiration, these devices are often pressure-limited to protect the lungs against barotrauma.

Automatic resuscitators have some advantages over alternative methods of ventilation:

- In unintubated patients, the rescuer has both hands free for mask and airway alignment.
- In intubated patients they free the rescuer for other tasks.
- Once set, they provide a constant tidal volume, respiratory rate and minute ventilation; thus, they may help to avoid excessive ventilation.

Some professional first responders (e.g. police, fire, and sports rescue personnel) may use simple automatic resuscitators provided that they have been trained adequately.

Passive oxygen delivery

In the presence of a patent airway, chest compressions alone may result in some ventilation of the lungs. Oxygen can be delivered passively, either via an adapted tracheal tube or with the combination of an oropharyngeal airway and standard oxygen mask with non-rebreather reservoir. There is insufficient evidence to support or refute the use of passive oxygen delivery during CPR to improve outcome when compared with oxygen delivery by positive pressure ventilation and until further data are available, passive oxygen delivery without ventilation is not currently recommended for routine use during CPR.

Supragottic airways

Effective bag-mask ventilation requires a reasonable level of skill and experience: the inexperienced are likely to achieve ineffective tidal volumes and cause gastric inflation with risk of regurgitation and pulmonary aspiration. In comparison with bag-mask ventilation, use of SGAs may enable more effective ventilation and reduce the risk of gastric inflation. Furthermore, SGAs are easier to insert than a tracheal tube and, unlike tracheal intubation, they can generally be positioned without interrupting chest compressions.

Without adequate training and experience, the incidence of complications associated with attempted tracheal intubation is unacceptably high. Unrecognised oesophageal intubation is disastrous and prolonged attempts at tracheal intubation are harmful: the pause in chest compressions during this time will severely compromise coronary and cerebral perfusion. Alternative airway devices should be used if attempted tracheal intubation by those highly skilled to perform the technique has failed or by all other personnel not skilled in regular intubation of the trachea.

There are no data supporting the routine use of any specific approach to airway management during cardiac arrest. The best technique is dependent on the precise circumstances of the cardiac arrest and the competence of the rescuer.

Laryngeal mask airway

The laryngeal mask airway (LMA) consists of a wide-bore tube with an elliptical inflated cuff designed to seal around the laryngeal opening (Figure 7.10). It was introduced into anaesthetic practice in the middle of the 1980s and is a reliable and safe device, which can be introduced easily, with a high success rate after a short period of training. Ventilation using the LMA is more efficient and easier than with a bag-mask apparatus; provided high inflation pressures (> 20 cmH_2O) are avoided, gastric inflation is minimised. When an LMA can be inserted without delay it is preferable to avoid bag-mask ventilation altogether: the risk of gastric inflation and regurgitation is reduced. Though not guaranteeing protection of the airway from gastric contents, pulmonary aspiration during use of the LMA is uncommon. The LMA does protect against sources of aspiration from above the larynx. Use of the LMA by nursing, paramedical and medical staff during resuscitation has been studied and reported to be effective. Like tracheal intubation, it requires the patient to be deeply unconscious. The LMA is particularly valuable if attempted intubation by skilled personnel has failed and bag-mask ventilation is impossible (the cannot ventilate, cannot intubate scenario). The original LMA (classic LMA (cLMA)), which is

reusable, has been studied during CPR, but none of these studies has compared it directly with the tracheal tube. Although the cLMA remains in common use in elective anaesthetic practice, it has been superseded by several second generation SGAs that have more favourable characteristics, particularly when used for emergency airway management. Most of these SGAs are single-use devices and achieve higher oropharyngeal seal pressures than the cLMA, and some incorporate gastric drain tubes.

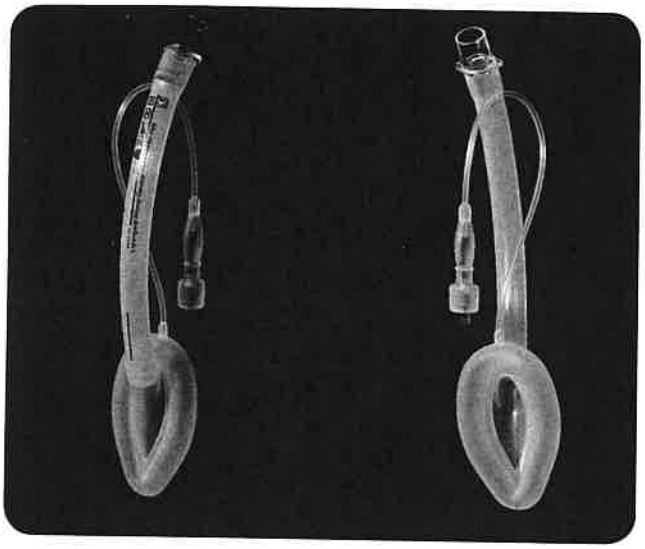


Figure 7.10 Laryngeal mask airway

Technique for insertion of a laryngeal mask airway

- Try to maintain chest compressions throughout the insertion attempt; if it is necessary to stop chest compressions during the insertion attempt, limit this pause in chest compressions to a maximum of 5 seconds.
- Select a LMA of an appropriate size for the patient and deflate the cuff fully. A size 5 will be correct for most men and a size 4 for most women. Lubricate the outer face of the cuff area (the part that will not be in contact with the larynx) with water-soluble gel.
- Flex the patient's neck slightly and extend the head (try to maintain neutral alignment of the head and neck if there is suspicion of cervical spine injury).
- Holding the LMA like a pen, insert it into the mouth (Figure 7.11). Advance the tip behind the upper incisors with the upper surface applied to the palate until it reaches the posterior pharyngeal wall. Press the mask backwards and downwards around the corner of the pharynx until a resistance is felt as it locates in the back of the pharynx. If possible, get an assistant to apply a jaw thrust after the LMA has been inserted into the mouth - this increases the space in the posterior pharynx and makes successful placement easier. A slight 45 degree twist will often aid placement if initial attempts at insertion beyond the pharynx are proving difficult.
- Connect the inflating syringe and inflate the cuff with air (up to 40 mL for a size 5 LMA and up to 30 mL for a size 4 LMA). If insertion is satisfactory, the tube will lift 1–2 cm out of the mouth as the cuff finds its correct position and the larynx is pushed forward.
- If the LMA has not been inserted successfully after 30 s, oxygenate the patient using a pocket mask or bag-mask before reattempting LMA insertion.

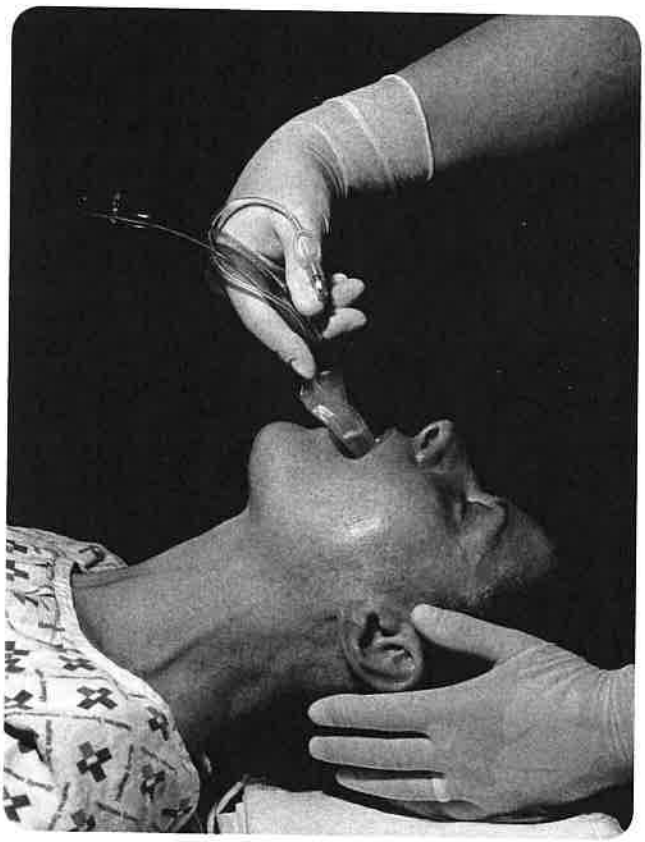


Figure 7.11 Insertion of a laryngeal mask airway

- Confirm a clear airway by listening over the chest during inflation and observing bilateral chest movement. A large, audible leak suggests malposition of the LMA, but a small leak is acceptable provided chest rise is adequate.

Limitations of the LMA

- In the presence of high airway resistance or poor lung compliance (pulmonary oedema, bronchospasm, chronic obstructive pulmonary disease) there is a risk of a significant leak around the cuff causing hypoventilation. Most of the gas leaking around the cuff normally escapes through the patient's mouth but some gastric inflation may occur.
- Uninterrupted chest compressions are likely to cause at least some gas leak from the LMA cuff when ventilation is attempted. Attempt continuous compressions initially but abandon this if persistent leaks and hypoventilation occur.
- There is a theoretical risk of aspiration of stomach contents because the LMA does not sit within the larynx like a tracheal tube; however, this complication is rarely documented in clinical practice.

- If the patient is not deeply unconscious, insertion of the LMA may cause coughing, straining or laryngeal spasm. This will not occur in patients in cardiorespiratory arrest.
- If an adequate airway is not achieved, withdraw the LMA, deflate the cuff and attempt reinsertion ensuring a good alignment of the head and neck.
- Uncommonly, airway obstruction may be caused by the epiglottis folding down to cover the laryngeal inlet. Withdraw the LMA, deflate the cuff and attempt reinsertion, (without interruption to compressions).

To become proficient in the insertion of an LMA requires practice on patients and this should be achieved under the supervision of an appropriately experienced person (e.g. anaesthetist) in a controlled environment.

i-gel airway

The i-gel incorporates a cuff made of thermoplastic elastomer gel and does not require inflation; the stem of the i-gel incorporates a bite block and a narrow oesophageal drain tube (Figure 7.12). It is easy to insert, requiring only minimal training, and a laryngeal seal pressure of 20–24 cmH_2O can be achieved. Insertion of the i-gel is faster than most other airway devices. The ease of insertion of the i-gel and its favourable leak pressure make it very attractive as a resuscitation airway device for those inexperienced in tracheal intubation. The i-gel is in widespread use in the Australia both in-hospital and out-of-hospital.

Technique for insertion of an i-gel

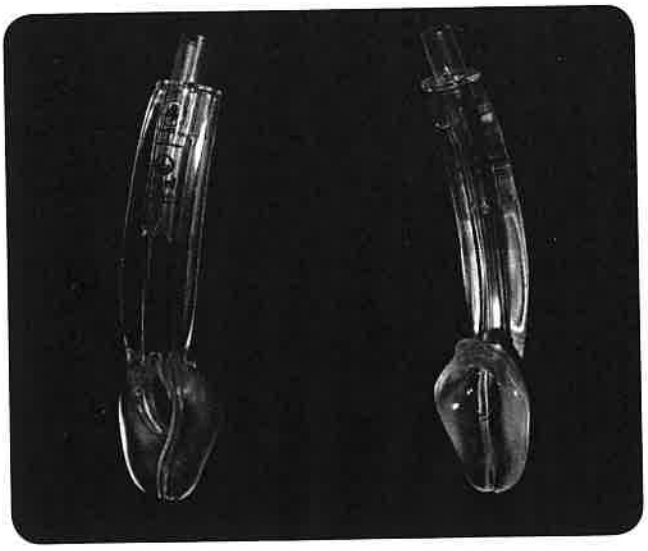


Figure 7.12 i-gel

- Try to maintain chest compressions throughout the insertion attempt; if it is necessary to stop chest compressions during the insertion attempt, limit this pause in chest compressions to a maximum of 5 s.
- Select an appropriately sized i-gel: a size 4 will function well in most adults although small females may require a size 3 and tall men a size 5.
- Lubricate the back, sides and front of the i-gel cuff with a thin layer of lubricant.
- Grasp the lubricated i-gel firmly along the integral bite block. Position the device so that the i-gel cuff outlet is facing towards the chin of the patient.
- Ensure the patient is in the 'sniffing the morning air' position with head extended and neck flexed. Gently press the chin down before inserting the i-gel.
- Introduce the leading soft tip into the mouth of the patient in a direction towards the hard palate (Figure 7.13).

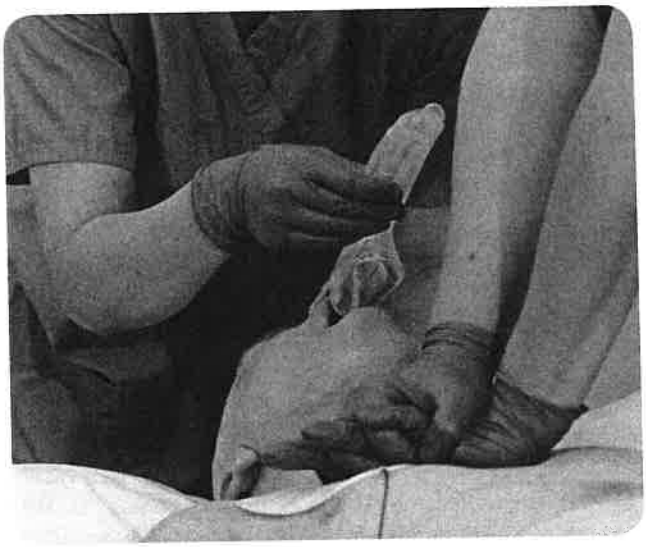


Figure 7.13 Insertion of an i-gel

- Do not apply excessive force to the device during insertion. It is not normally necessary to insert fingers or thumbs into the patient's mouth during the process of inserting the device. If there is early resistance during insertion, get an assistant to apply a jaw thrust or rotate the device.
- Glide the device downwards and backwards along the hard palate with a continuous but gentle push until a definitive resistance is felt.
- At this point the tip of the airway should be located at the upper oesophageal opening and the cuff should be located against the larynx. The incisors should be resting on the integral bite-block.
- A horizontal line at the middle of the integral bite-block represents the approximate position of the teeth when the i-gel is positioned correctly. However, this line is only a guide – there is considerable variation in its location relative to the incisors. In short patients, this line may be at least 1 cm higher than the teeth, even when correctly positioned. In tall patients, the line may not be visible above the teeth.

There are also next generation i-gels available with additional features such as the i-gel O_2. This incorporates a supplementary oxygen port, so it can also be used for the delivery of passive oxygenation.

The ProSeal LMA

The ProSeal LMA (PLMA) is a modified version of the original LMA. It has an additional posterior cuff and a gastric drain tube. It has several attributes that, in theory, make it more suitable than the original LMA for use during CPR: improved seal with the larynx enabling ventilation at higher airway pressures (commonly up to 35–40 cmH_2O), the inclusion of a gastric drain tube enabling venting of liquid regurgitated gastric contents from the upper oesophagus and passage of a gastric tube to drain liquid gastric contents, and the inclusion of a bite block. The higher seal pressures achieved with the PLMA may enable ventilation volume to be maintained during uninterrupted chest compressions.

Potential weaknesses of the PLMA as an airway device for CPR are that it is slightly more difficult to insert than the original LMA, it is relatively expensive and it requires re-sterilisation between uses. Careful technique is required when inserting the PLMA to avoid malposition and failure of the device in adults. A disposable form of the PLMA – the LMA Supreme is more appropriate than the reusable version for use during CPR. It has a more rigid shape and lacks a posterior inflatable cuff.

Tracheal intubation

There is insufficient evidence to support or refute the use of any specific technique to maintain an airway and provide ventilation in adults with cardiorespiratory arrest. In practice, airway management is most commonly undertaken using a stepwise approach, starting with basic techniques and moving to more advanced techniques, depending on available skills, until effective ventilation and satisfactory airway protection is achieved. Tracheal intubation should be attempted only when trained personnel are available to carry out the procedure with a high level of skill and competence. The perceived advantages of tracheal intubation over bag-mask ventilation include maintenance of a patent airway which is protected from aspiration of gastric contents or blood from the oropharynx, the ability to provide an adequate tidal volume reliably even when chest compressions are uninterrupted, the potential to free the rescuers hands for other tasks, and the ability to suck-out airway secretions. Use of a bag-mask is more likely to cause gastric distension, which, theoretically, is more likely to cause regurgitation and the risk of aspiration. This theoretical risk has yet to be proven in randomised clinical trials.

The perceived disadvantages of tracheal intubation over bag-mask ventilation include the risk of an unrecognised misplaced tracheal tube (which is as high as 17% in some older studies of out-of-hospital cardiac arrest), a prolonged time without chest compressions while tracheal intubation is attempted (tracheal intubation attempts accounted for almost 25% of all CPR interruptions in one pre-hospital study) and a comparatively high failure rate. Tracheal intubation success rates depend on the intubation experience attained by the rescuer. Healthcare personnel who undertake pre-hospital intubation should do so only within a structured, monitored program, which should include comprehensive competency-based training and regular opportunities to refresh skills.

Rescuers must therefore weigh the risks and benefits of tracheal intubation against the need to provide effective chest compressions. The intubation attempt will require some interruption of chest compressions but, once an advanced airway is in place, ventilation will not require further interruption of chest compressions. Personnel skilled in advanced airway management should undertake laryngoscopy without stopping chest compressions; a brief pause in chest compressions will be required only as the tube passes through the vocal cords. Alternatively, to avoid any interruptions in chest compressions, the intubation attempt may be deferred until ROSC. The intubation attempt should interrupt chest compressions for less than 5 s; if intubation is not achievable within these constraints, recommence bag-mask ventilation. After tracheal intubation, tube placement must be confirmed and the tube secured adequately. If there is any doubt about the correct position of the tube, remove it and re-oxygenate the patient before making another attempt.

In some cases, laryngoscopy and attempted intubation may prove impossible or cause life-threatening deterioration in the patient's condition. Such circumstances include acute epiglottitis, pharyngeal pathology, head injury (where coughing or straining may cause further increase in intra-cranial pressure), or in patients with cervical spine injury. In these circumstances, specialist skills such as the use of anaesthetic drugs, videolaryngoscopy or flexible fibreoptic laryngoscopy may be required. Such techniques require a high level of skill and training.

Essential equipment for tracheal intubation

Such techniques require a high level of skill and training.

- Laryngoscope - generally a curved Macintosh blade. Several sizes are available, but a size 4 will be adequate for most patients. Check the light source and battery regularly and just before use, and ensure that spares are immediately available. New videolaryngoscopes may be available in some settings (see below).
- Cuffed tracheal tubes - a selection should be available appropriate to the size of the patient. A 7.5 mm or 8.0 mm internal diameter tube is suitable for an adult male and a 7.0 mm internal diameter tube for a female.
- Sizes 6, 7 and 8 mm will generally cover the immediate needs of all adults. Availability of smaller tracheal tubes will be helpful for patients with conditions causing narrowing of the upper airway.
- Syringe for cuff inflation.
- Equipment for confirming correct placement of the tracheal tube.

- Extras:
  - water-soluble lubricating jelly
  - Magill's forceps
  - introducers: either an intubating bougie or a semi-rigid stylet
  - tape or bandage to secure tube in position
  - suction apparatus with a wide-bore rigid suction end (e.g. Yankauer) and a range of smaller flexible catheters
  - shading for high levels of ambient light (sunlight, theatre)

Post-intubation procedures

- After successful intubation, connect the tracheal tube (via a catheter mount if necessary) to a ventilating device (e.g. self-inflating bag), and ventilate with the highest oxygen concentration available.
- Inflate the cuff of the tracheal tube just sufficiently to stop an air leak during inspiration.
- Confirm correct placement of the tracheal tube using clinical assessment AND waveform capnography. Unrecognised oesophageal intubation is the most serious complication of attempted tracheal intubation. Routine use of waveform capnography to confirm correct placement of the tracheal tube will reduce this risk.
- Continue ventilation with a high-concentration of oxygen until ROSC and oxygen saturations are recordable.
- Secure the tube with a bandage or tie. Adhesive tape is not reliable if the face is moist.
- An oropharyngeal airway may be inserted alongside the tracheal tube to maintain the position of the tube, and prevent damage from biting when consciousness returns.

Clinical assessment

Primary assessment includes observation of chest expansion bilaterally, auscultation over the lung fields bilaterally in the axillae (breath sounds should be equal and adequate) and over the epigastrium (breath sounds should not be heard). Clinical signs of correct tube placement (condensation in the tube, chest rise, breath sounds on auscultation of lungs, and inability to hear gas entering the stomach) are not completely reliable. The reported sensitivity (proportion of tracheal intubation's correctly identified) and specificity (proportion of oesophageal intubation's correctly identified) of clinical assessment varies.

Secondary confirmation of tracheal tube placement by waveform capnography will reduce the risk of unrecognised oesophageal intubation; however, this will not differentiate between a tube placed in a main bronchus and one placed correctly in the trachea.

Carbon dioxide detectors

Carbon dioxide (CO_2) detector devices measure the concentration of exhaled carbon dioxide from the lungs. The persistence of exhaled CO_2 after six ventilations indicates placement of the tracheal tube in the trachea or a main bronchus. Confirmation of correct placement above the carina will require auscultation of the chest bilaterally in the mid-axillary lines. Broadly, there are three types of CO_2 detector device:

1. End-tidal CO_2 detectors that include a waveform graphical display (capnograph) are the most reliable for verification of tracheal tube position during cardiac arrest. Studies of waveform capnography to verify tracheal tube position in victims of cardiac arrest demonstrate 100% sensitivity and 100% specificity in identifying correct tracheal tube placement.

2. Numerical/Non-waveform electronic digital end-tidal CO_2 devices generally measure end-tidal CO_2 using an infrared spectrometer and display the results with a number; they do not provide a waveform graphical display of the respiratory cycle on a capnograph.

3. Disposable colorimetric end-tidal CO_2 detectors use a litmus paper to detect CO_2, (for use if no other option available). These devices generally give readings of purple (end-tidal CO_2 < 0.5%), tan (end-tidal CO_2 0.5–2%) and yellow (end-tidal CO_2 > 2%). In most studies, tracheal placement of the tube is considered verified if the tan colour persists after a few ventilations. Although colorimetric CO_2 detectors identify placement quite well in patients with good perfusion, these devices are less accurate than clinical assessment in cardiac arrest patients because pulmonary blood flow may be so low that there is insufficient exhaled CO_2. Furthermore, if the tracheal tube is in the oesophagus, six ventilations may lead to gastric distension, vomiting and aspiration.

Waveform capnography is a sensitive and specific way to confirm and continuously monitor the position of a tracheal tube in victims of cardiac arrest and should supplement clinical assessment (auscultation and visualisation of tube through cords). Waveform capnography will not discriminate between tracheal and bronchial placement of the tube - careful auscultation is essential. Existing portable monitors make capnographic initial confirmation and continuous monitoring of tracheal tube position feasible in all settings, including out-of-hospital, emergency department, and in-hospital locations where tracheal intubation is performed. Waveform capnography is also a sensitive indicator of ROSC and a monitor for the delivery of effective CPR.

The use of waveform capnography to confirm tracheal tube placement is now a standard of care. In the absence of waveform capnography, use a supraglottic airway device if advanced airway management is required.

Waveform capnography during CPR has potential roles in monitoring the ventilation rate to assist in avoiding hyperventilation, assessing the quality of chest compressions during CPR (CO_2 values are associated with compression depth and ventilation rate), identifying ROSC during CPR (by an increased CO_2 value). Also assessing prognosis during CPR (low CO_2 values may indicate a poor prognosis). in observational studies failure to achieve a CO_2 value >10 mmHg after 20 min of CPR is associated with a poor outcome.

Potential problems during tracheal intubation

Anatomical and pathological variations that may make intubation difficult or impossible include receding lower jaw, short neck, poor movement at the atlanto-axial joint, prominent incisors, narrow mouth, stiff neck and trismus. If the vocal cords cannot be seen, do not attempt to insert the tube blindly. Often an intubating bougie can be inserted through the glottis more easily than a tracheal tube and, once in place, the tube may be placed over the bougie and guided (rail-roaded) into the trachea. The intubating stylet may also be used to stiffen and pre-form the curvature of the tube or to guide it into the larynx. Problems during intubation may be caused by:

- Facial burns and trauma - it may be impossible to use BLS techniques or intubate patients with severe facial trauma or thermal injury to the upper airway. In such cases it may be necessary to establish a surgical airway, (e.g. cricothyroidotomy (see below)).
- Upper airway pathology (e.g. tumours, infection, swelling from anaphylaxis, etc).
- Insecure/loose teeth or dental prosthesis - these may be damaged or loosened if undue pressure is placed on them. Good intubation technique should reduce this risk.
- Gastric regurgitation - always have a functioning suction device and wide-bore suction to hand. Cricoid pressure by trained personnel may prevent passive regurgitation and pulmonary aspiration.
- Clenching of teeth - in the early stages of resuscitation good CPR may prevent the profound level of unconsciousness required for tracheal intubation. In this case, use basic airway and ventilation techniques.
- Oesophageal intubation - this should not go unrecognised if tracheal tube placement is confirmed with waveform capnography. If in doubt, take the tube out and re-oxygenate the lungs using a bag-mask.
- Possible cervical spine injury - suspect this in all patients who have a history of major blunt trauma. Use manual inline stabilisation of the head and neck and ensure an experienced operator undertakes the intubation.

Cricoid pressure

Do not use cricoid pressure routinely in cardiac arrest. In non-arrest patients cricoid pressure may offer some measure of protection to the airway from aspiration but it may also impede ventilation or interfere with tracheal intubation. The role of cricoid pressure during cardiac arrest has not been studied. Application of cricoid pressure during bag-mask ventilation reduces gastric inflation. Studies in anaesthetised patients, however, show that cricoid pressure impairs ventilation in many patients, increases peak inspiratory pressures and causes complete obstruction in up to 50% of patients depending on the amount of cricoid pressure (in the range of recommended effective pressure) that is applied. If cricoid pressure is used, adjust, relax or release the pressure if it impedes ventilation or tracheal tube placement.

The cricoid cartilage is immediately below the thyroid cartilage, where it forms a complete ring at the upper end of the trachea. A pressure of 30 N (3 kg) is applied anteroposteriorly, forcing the cricoid ring backwards, which compresses the oesophagus against the vertebral column. Do not apply cricoid pressure if there is active vomiting: it could cause oesophageal rupture.

Aids to intubation

Videolaryngoscopes

Videolaryngoscopes are being used increasingly in anaesthetic and critical care practice. In comparison with direct laryngoscopy, they enable a better view of the larynx and improve the success rate of intubation. Preliminary studies indicate that use of videolaryngoscopes improves laryngeal view and intubation success rates during CPR but further data are required before recommendations can be made for wider use during CPR.

Introducers

If visualisation is difficult, an intubating bougie may be helpful to guide the tracheal tube into the larynx. It is best inserted into the larynx separately - the tube is then passed over it into the trachea. When correctly placed, free passage of the bougie is stopped by the smaller airways of the bronchial tree; a bougie placed accidentally in the oesophagus can be inserted completely, without obvious resistance. Ultimately, when ventilation and intubation are impossible and alternatives (e.g. SGA), are not effective, it will be necessary to perform a cricothyroidotomy (see below).

Whilst descriptions of the advanced airway techniques above have been included, these descriptions are not intended as a substitute for practice on manikins or anaesthetised patients. Tracheal intubation during cardiac arrest should be attempted only by those practicing this procedure regularly.

Suction

Use a wide-bore rigid suction end (Yankauer) to remove liquid (blood, saliva and gastric contents) from the upper airway. This is done best under direct vision during intubation but must not delay achieving a definitive airway. Apply suction to the trachea as briefly as possible and ventilate the lungs with 100% oxygen before and after the procedure. Use fine-bore suction catheters for tracheal suction and pass them directly down the tracheal tube.

Cricothyroidotomy

Occasionally it will be impossible to ventilate an apnoeic patient with a bag-mask, or to pass a tracheal tube or other airway device. This may occur in patients with extensive facial trauma or laryngeal obstruction caused by oedema (e.g. anaphylaxis, or foreign material). In these circumstances, it will be necessary to create a surgical airway below the level

of the obstruction. A tracheostomy is contraindicated in an emergency because it is, time consuming, hazardous and requires considerable surgical skill and equipment. Substantial bleeding can occur.

Surgical cricothyroidotomy provides a definitive airway that can be used to ventilate the patient's lungs until semi-elective intubation or tracheostomy is performed. Needle cricothyroidotomy is a temporary procedure providing only short-term oxygenation. It requires a wide-bore, non-kinking cannula, a high-pressure oxygen source and may cause serious barotrauma. It is prone to failure because of kinking of the cannula, and is unsuitable for patient transfer. Unlike needle cricothyroidotomy, the surgical technique will result in an airway that is protected by a cuffed tube. Higher airway pressures can be generated and tracheal suction is possible. Surgical cricothyroidotomy enables ventilation of the lungs despite complete airway obstruction at, or above, the glottis.

Mechanical Ventilators

There is insufficient evidence to support or refute the use of an automatic transport ventilator over manual ventilation during resuscitation of the cardiac arrest victim with an advanced airway. Both manual ventilation and mechanical ventilation have advantages and disadvantages in the initial management of cardiac arrests. These relate largely to the risks of hyperventilation (with manual ventilation), and hypoventilation (with mechanical breaths not being delivered). Irrespective of the mode of delivery of breaths, the adequacy of delivery of those delivered breaths should be regularly assessed.

Further reading

Australian Resuscitation Council/ANZCOR Guidelines: http://resus.org.au/guidelines/

Roberts K, Whalley H, Bleetman A. The nasopharyngeal airway: dispelling myths and establishing the facts. Emerg Med J 200522(6)394–396.396

Soar J, Callaway CW, Aibiki M, et al. Part 4: Advanced life support: 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. Resuscitation 2015;95:e71-e122.

Soar J, Nolan JP. Airway management in cardiopulmonary resuscitation. Curr Opin Crit Care 2013;19:181-7.

Soar J, Nolan JP, Bottiger BW, et al. European Resuscitation Council Guidelines for Resuscitation 2015 Section 3 Adult Advanced Life Support. Resuscitation 2015;95:99-146.

Summary learning

- Airway patency and ventilating the lungs are important components of CPR.
- Use of simple airway manoeuvres, with or without basic adjuncts, will often achieve a patent airway.
- Give all patients high-concentration oxygen until the arterial oxygen saturation can be measured.
- Supraglottic airways are good alternatives to a bag-mask and are used instead of a bag-mask technique wherever possible.
- Supraglottic airways are used instead of tracheal intubation unless individuals highly skilled in intubation are immediately available. They are also used if attempted intubation is unsuccessful.
- In skilled hands, tracheal intubation is an effective airway management technique during cardiopulmonary resuscitation.
- In unskilled hands, prolonged interruptions of chest compressions, and high risk of failure and other complications (e.g. unrecognised oesophageal intubation) make attempted tracheal intubation potentially harmful.

My key take-home messages from this chapter

Defibrillation

Chapter 9

Contents

Learning outcomes

To enable you to:

- Understand how to safely deliver a shock with an AED or manual defibrillator
- Understand how to minimise pauses in chest compressions during defibrillation

Introduction

Following the onset of ventricular fibrillation or pulseless ventricular tachycardia (VF/pVT), cardiac output ceases and cerebral hypoxic injury starts within 3 min. If complete neurological recovery is to be achieved, early successful defibrillation with return of spontaneous circulation (ROSC) is essential. Defibrillation is a key link in the Chain of Survival and is one of the few interventions proven to improve outcome from VF/pVT cardiac arrest.

The probability of successful defibrillation

There are several factors that need to be taken into account:

1. Time from onset to delivery of shock. 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 by 7–10%. The shorter the interval between the onset of VF/pVT and delivery of the shock, the greater the chance of successful defibrillation and survival.

2. Continuous, uninterrupted chest compressions. Clinical studies have demonstrated that even short interruptions in chest compressions (e.g. to deliver rescue breaths or perform rhythm analysis) significantly reduce 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 following both 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.

3. 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; one study has shown that 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 pads are applied, start chest compressions and ventilation immediately. When bystander CPR is given the decrease in survival is more gradual and averages 3–4% per min from collapse to defibrillation. Bystander CPR doubles 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
- 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 as the absence of VF/pVT at 5 s after shock delivery, (which may include asystole) 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; however, many biphasic defibrillators can measure the transthoracic impedance and adjust the energy delivered to compensate, (impedance compensation). Often defibrillator efficacy is therefore independent of transthoracic impedance. Ensure good contact between self-adhesive pads and the patient's skin. This may be compromised when:

- A transdermal drug patch is on the patient's chest. If it is in the area where self-adhesive pads would be applied, remove the patch and dry the skin. If this is likely to delay defibrillation, place the pads in an alternative position that avoids the patch (see below).
- The patient has a very hairy chest. If a hair removal options are available immediately, use them to remove excessive hair from the area where the electrodes are placed. However, defibrillation should not be delayed if these are not to hand immediately. In very hairy patients, a bi-axillary electrode position may enable more rapid 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/pVT, 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/pVT, 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:

1. 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). This position is preferred for transcutaneous pacing.
2. Each electrode on the lateral chest walls, one on the right and the other on the left side (bi-axillary).
3. 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, just inferior to the right scapula (postero-lateral).

A few patients who present in VF are difficult to cardiovert, (i.e. they either remain in VF or keep developing recurrent VF). In such cases, consider a change in electrode position, (e.g. move from the standard anterior-lateral to an anterior-posterior or bi-axillary position). Ventricular fibrillation recurs in 50% of patients within 2 min of successful termination and in 75% of patients during the entire cardiac arrest.

More patients are presenting with implantable medical devices (e.g. permanent pacemaker, implantable cardioverter defibrillator (ICD)). Medic Alert bracelets are recommended for these patients. These devices and/or electrode leads may be damaged during defibrillation if current is discharged through electrodes placed directly over the device. Place the electrode away from the device (at least 10 cm and if possible up to 15 cm) or use an alternative electrode position (anterior-lateral, anterior-posterior) as described above.

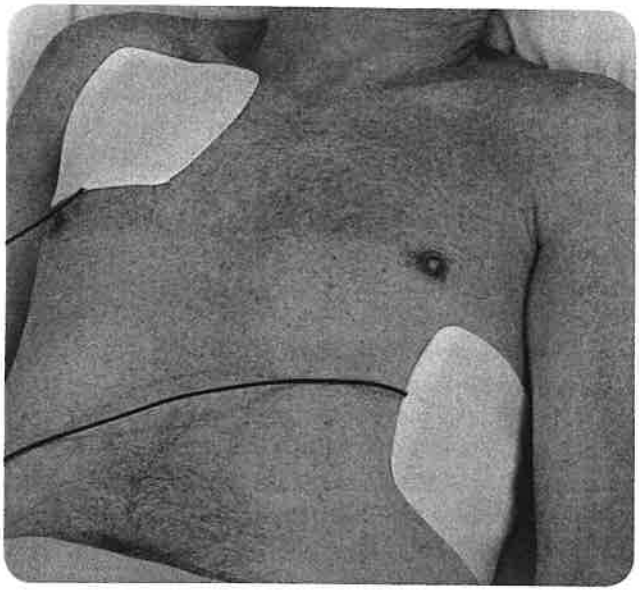


Figure 9.1 Standard electrode positions for defibrillation

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. Attempt defibrillation as soon as possible; no specific period of CPR before rhythm analysis and shock delivery is recommended. As soon as the defibrillator is available it should be used.

Shock sequence

The optimal shock strategy for any survival end-point is unknown. There is no conclusive evidence that a single shock strategy increases rate of ROSC or reduces recurrence of VF compared with three stacked shocks, but given that outcome is improved by minimising interruptions to chest compressions, single shocks are recommended for most situations. The importance of early, uninterrupted chest compressions is emphasised throughout these guidelines, together with minimising the duration of pre-shock and post-shock pauses.

- Continue CPR while a defibrillator is retrieved and applied; as soon as the defibrillator is available, assess the rhythm and attempt defibrillation when indicated.
- During compressions, ensure all other rescuers stand clear other than the individual performing chest compressions.
- Continue chest compressions during charging of the defibrillator.
- When defibrillating ensure that the total interruption to chest compressions is less than 5 s and after defibrillation immediately resume chest compressions.
- Immediately after a shock do not delay CPR for rhythm re-analysis or a pulse check.
- Continue CPR (30 compressions: 2 ventilations) for 2 min until rhythm re-analysis is undertaken and another shock is given (if indicated). Even if the defibrillation attempt is successful, it takes time until the post-shock circulation is established and a pulse is not usually palpable with a perfusing rhythm immediately after defibrillation.
- Patients can remain pulseless for over 2 min. The time before ROSC is achieved can be longer than 2 min in as many as 25% of successful shocks.

Witnessed and monitored VF/pVT cardiac arrest

If a patient has a monitored and witnessed cardiac arrest in the catheter laboratory, coronary care unit, a critical care area, or whilst monitored after cardiac surgery, and a manual defibrillator is rapidly available:

- Confirm cardiac arrest and shout for help.
- If the patient was well perfused and oxygenated pre-arrest
- First shock must be delivered within 20 seconds
- if initial rhythm is VF/pVT, give up to three quick successive (stacked) shocks.
- Rapidly check for a rhythm change and, if appropriate check for a pulse and other signs of ROSC after each defibrillation attempt and start CPR if PEA is found.
- Start chest compressions and continue CPR for 2 min if the third shock is unsuccessful. These (up to) three shocks are counted as the first shock in the ALS algorithm sequence..

This three-shock strategy may also be considered for an initial, witnessed VF/pVT cardiac arrest if the patient is already connected to a manual defibrillator, and was previously well oxygenated/perfused, although 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/pVT.

Shock energies

Deliver the first shock with energy of at least 200 J. The shock energy for a particular defibrillator should be based on the manufacturer's guidance. Those using manual defibrillators should be aware of the appropriate energy settings for the type of device used, but in the absence of this and if appropriate energy levels are unknown, for adults use the highest available shock energy for all shocks.

For subsequent shocks, there remains no evidence to support either a fixed or escalating energy protocol, although an escalating protocol (up to 360 J) may be associated with a lower incidence of refibrillation. Both strategies are acceptable; however, if the first shock is not successful and the defibrillator is capable of delivering shocks of higher energy it is reasonable to increase the energy for subsequent shocks. With manual defibrillators it is also appropriate to consider escalating the shock energy in patients when refibrillation occurs.

Safety

Attempted defibrillation should be undertaken without risk to members of the resuscitation team. This is achieved best by using self-adhesive electrodes, which minimise the possibility of anyone touching the electrode during electrical discharge. 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. There must be no direct or indirect patient contact. Do not hold intravenous infusion equipment or the patient's trolley/bed during shock delivery. The operator must ensure that everyone is clear of the patient before delivering a shock.

There is no evidence that continuous chest compressions during shock delivery increases the chance of achieving ROSC. Furthermore, the latex gloves routinely available and used by healthcare professionals do not provide sufficient protection from the electric current, therefore a shock is delivered only when everyone is clear of contact with the patient.

Safe use of oxygen during defibrillation

In the oxygen-enriched atmosphere sparking from poorly applied defibrillator paddles can cause a fire and significant burns to the patient. The use of self-adhesive electrodes is far less likely to cause sparks than manual paddles – no fires have been reported in association with the use of self-adhesive electrodes. The following are recommended as good practice:

- Take off any free flowing 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. Ensure that the disconnected ventilator tubing is kept at least 1 m from the patient or, better still, switch the ventilator to standby during the period of the resuscitation attempt; modern ventilators generate high oxygen flows when left 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 (AEDs) 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 9.2). 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 9.2 Automated external defibrillator

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. 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 also recommend shocks for VT if the rate and R-wave morphology exceed preset values.

Many manual mode defibrillators and some AED's have the ability to be used in semi-automatic or semi-advisory modes. This function often does not time the duration of the CPR or give prompts, but allows the 'analyse' button to be used. It is effectively a manual mode defibrillator with rhythm analysis option. As such analysis of rhythm can not be achieved during compressions, and is used with the similar technique to AED .

In-hospital use of AEDs

When patients sustain cardiac arrest in unmonitored hospital beds and in outpatient departments, several minutes may elapse before a resuscitation team arrives with a defibrillator. There are no published randomised trials comparing in-hospital use of AEDs with manual defibrillators, and it has been shown that an AED can be used successfully before the arrival of the hospital resuscitation team.

AEDs should therefore be considered for areas of the hospital where there is a risk of delayed defibrillation because of the time taken for a resuscitation team to attend or where staff have no rhythm recognition skills or where they use defibrillators infrequently. In hospital areas where there is rapid access to manual defibrillation, either from trained staff or a resuscitation team, use manual defibrillation in preference to an AED. Ensure that an effective system for training and retraining is in place. Healthcare providers with a duty to perform CPR should be trained, equipped, and authorised to perform defibrillation, and sufficient numbers should be trained to enable the goal of providing the first shock within 3 min of collapse anywhere in the hospital. Hospitals and healthcare facilities should monitor collapse-to-first shock intervals.

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. Public access AED programmes are most effective when implemented in public places with a high density and movement of citizens such as airports, railway stations, bus terminals, sport facilities, shopping malls, and offices where cardiac arrests are usually witnessed and trained CPR providers can quickly be on scene. All AEDs should be clearly identifiable with appropriate signage is a public area. Registration of AEDs for public access, so that dispatchers can direct CPR providers to a nearby AED, may also help to optimise response.

Sequence for use of an AED (or shock-advisory defibrillator)

It is critically important that CPR providers pay attention to AED voice prompts and follow them without any delay.

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

2. If the victim is unresponsive and not breathing normally.

   - ask someone to call for an ambulance or the resuscitation team and collect the AED. 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 pads are attached.

   - 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.
   - push the shock button as directed.
   - continue as directed by voice/visual prompts.

5b. If NO shock is indicated:

   - immediately resume CPR using a ratio of 30 compressions to 2 rescue breaths.

   - continue as directed by 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/can no longer continue.

Notes

- The carrying case with the AED should contain strong scissors for cutting through clothing and possibly a disposable razor for shaving excessive chest hair in order to obtain good electrode contact.

- If ALS providers are using an AED, they should implement other ALS interventions (e.g. advanced airway techniques, ventilation, IV access, drug delivery, etc.) according to local protocols.

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.

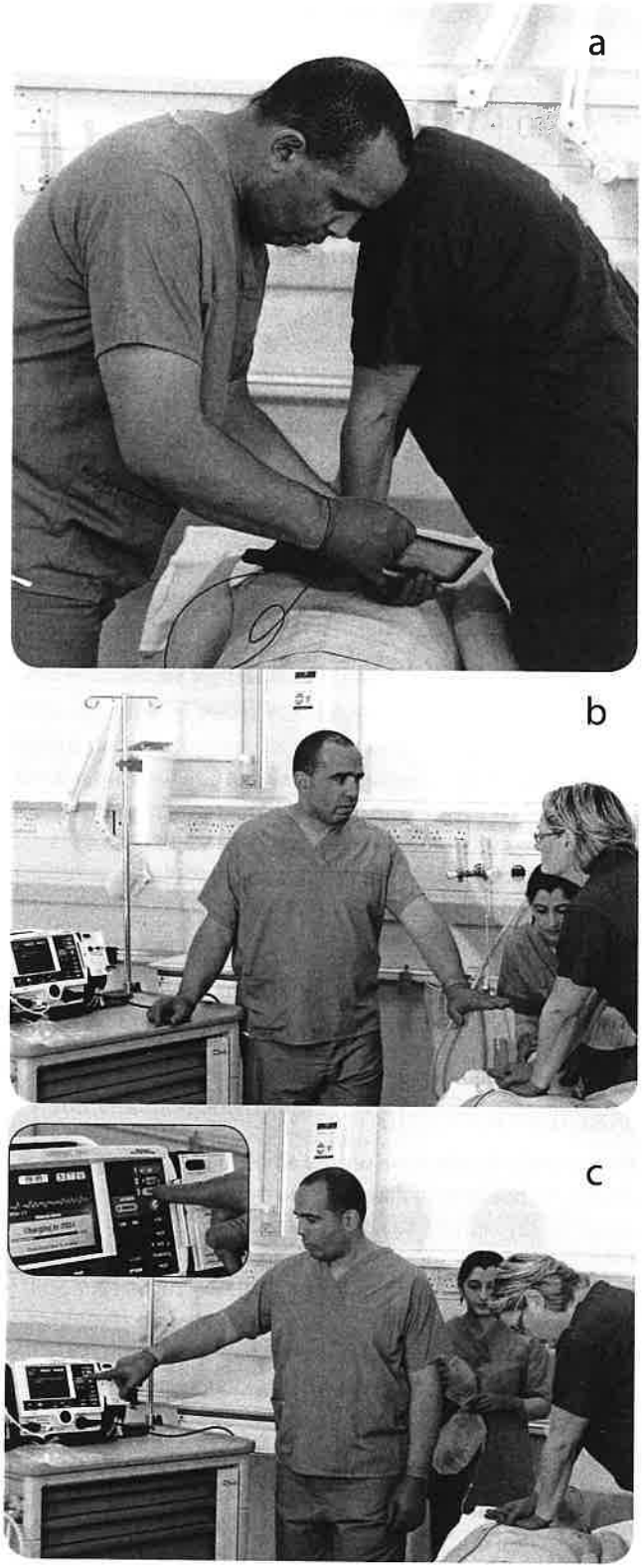
Sequence for use of a manual defibrillator

This sequence is an integral part of the ALS algorithm in Chapter 6.

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

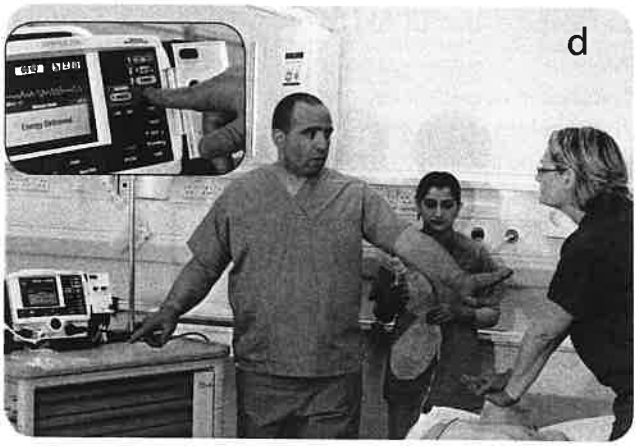
2. Call emergency response/resuscitation team.

3. Perform uninterrupted chest compressions while applying self-adhesive defibrillation/monitoring pads (figure 9a) – one below the right clavicle and the other in the V6 position in the midaxillary line, (usually as indicated on pad placement diagram on the pads).



Figures 9.3 a, b, c, d Operation of a manual defibrillator and efficient CPR

6. Plan actions before pausing CPR for rhythm analysis and communicate these to the team. This pause in chest compressions should be brief (aiming for less than 5 s).
   - A pause is the ideal time to swap the person performing chest compressions to reduce rescuer fatigue so needs to be considered and planned.
7. Without stopping chest compressions; plan to charge defibrillator. Team leader indicates need to perform a rhythm check.



8. Designated person selects the appropriate energy on the defibrillator (200 J biphasic for first shock and may increase to maximum (360 J) for second and subsequent shocks) - then calling "COMPRESSIONS CONTINUE-EVERYONE ELSE STAND CLEAR" (Figure 9b), and to remove (any free flowing) oxygen delivery device as appropriate while pressing the charge button (Figure 9c), simultaneously.
9. Ensure that the rescuer giving the compressions is the only person touching the patient (directly or indirectly). While the defibrillator is charging, confirm all rescuers other than the individual performing the chest compressions is "standing clear" by performing visual safety check including that free flowing oxygen is removed.
10. Once the defibrillator is charged and the safety check is complete, stop chest compressions. Call out/tell the individual doing the chest compressions "HANDS OFF" to pause compressions.
11. When person performing compressions confirms they are clear by stating "I'M SAFE" e.g. by placing both hands in the air, making eye contact and confirming they are clear and it is safe to act.
    - If the compressions person does not clearly indicate they are safe, the defibrillator operator may ask/ challenge him with "ARE YOU SAFE" to confirm.
12. Confirm/Check rhythm (Team Leader confirms VF/VT), if shockable deliver the shock safely (Figure 6.3). (If the patient has had no response to effective compressions and VT is displayed - treat as pulseless VT).
13. Then without reassessing the rhythm or feeling for a pulse, immediately restart CPR (using a ratio of 30:2), starting with chest compressions.
    - Do not reassess the rhythm or feel for a pulse. This pause in chest compressions should be brief and no longer than 5 s.
14. Continue CPR for 2 min; the team leader prepares the team for the next pause in CPR. Do not interrupt compressions until rhythm check, (unless signs of circulation become apparent).
15. If VF/pVT, repeat steps 4 – 12 above and deliver a second shock. Resume chest compressions immediately. Give adrenaline 1 mg IV/IO following the second shock during CPR.

16. Give further adrenaline 1 mg IV/IO after alternate shocks (i.e., alternate 2 minute loops of CPR).

17. If organised electrical activity compatible with a cardiac output is seen during a rhythm check, disarm defibrillator/ dump charge into machine then, seek evidence of ROSC: (check for signs of life, a central pulse and end-tidal CO_2 if available).

    a. If there is ROSC, start post-resuscitation care.

    b. If there are no signs of ROSC, continue CPR and switch to the non-shockable algorithm.

18. If asystole is seen, disarm defibrillator/dump charge into machine then continue CPR and switch to the non-shockable algorithm. The interval between stopping compressions and delivering a shock must be minimised. Longer interruptions to chest compressions reduce the chance of a shock restoring a spontaneous circulation.

Chest compressions are resumed immediately after delivering a shock (without checking the rhythm or a pulse) because:

- 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.
- The duration of asystole before ROSC can be longer than two minutes in as many as 25% of successful shocks.
- 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 usefully induce VF.

Initial presenting rhythm of arrest - shockable rhythm:

- The first dose of adrenaline 1mg IV/IO is given during the 2–min period of CPR after delivery of the second shock.
- Give amiodarone 300 mg after three defibrillation attempts (any three in an arrest and do not need to be sequential).

Initial presenting rhythm of arrest - non-shockable (PEA/ asystole):

- Adrenaline 1 mg IV/IO is given in the first period of CPR.

Repeated doses of adrenaline 1 mg IV/IO are given every alternate loop of CPR once the first dose has been administered irrespective of rhythm.

Do not stop CPR to check the rhythm before giving drugs unless there are clear signs of ROSC.

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 each other (antero-posterior electrode position may be necessary). 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

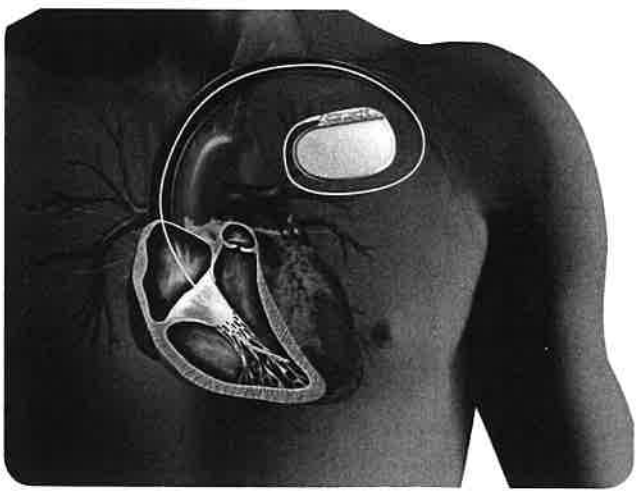
If electrical cardioversion is used to convert atrial or ventricular tachyarrhythmias, the shock must be synchronised with the R wave of the ECG (VF and pVT do not require synchronised shocks). By avoiding the relative refractory period in this way, the risk of inducing VF is minimised. Conscious patients must be anaesthetised or sedated before synchronised cardioversion is attempted. 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.

If synchronisation fails; choose another lead and/or adjust the amplitude. In patients with VT who are unstable, give unsynchronised shocks avoid prolonged delay in restoring sinus rhythm with time spent correcting technology issues.

With some defibrillators, the synchronised mode has to be reset if a second or subsequent shocks are 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/pVT. Energy doses for cardioversion will vary depending on the clinical situation.

Implanted electronic devices

When a patient needs external defibrillation, effective measures to try to restore life take priority over concerns about any implanted device such as a pacemaker, implantable cardioverter-defibrillator, implantable event recorder or neurostimulator. Current resuscitation guidelines are followed, but awareness of the presence of an implanted device allows some additional measures to optimise outcome.



Figures 9.4 Implanted pacemeker (or internal defibrillator) possible position

Cardiac pacemakers and implantable cardioverter-defibrillators

If the patient has an implanted electronic device in the chest wall, choose the position for defibrillator electrode placement carefully. Cardiac pacemakers and implantable cardioverter-defibrillators (ICDs) are usually implanted in the pectoral region, more commonly on the left than the right (figure 9.4). Some people may have subcutaneous ICDs (S-ICDs), which are wholly subcutaneous, with a subcutaneous electrode running parallel to the sternum and the generator usually in a left lateral position (figure 9.5).

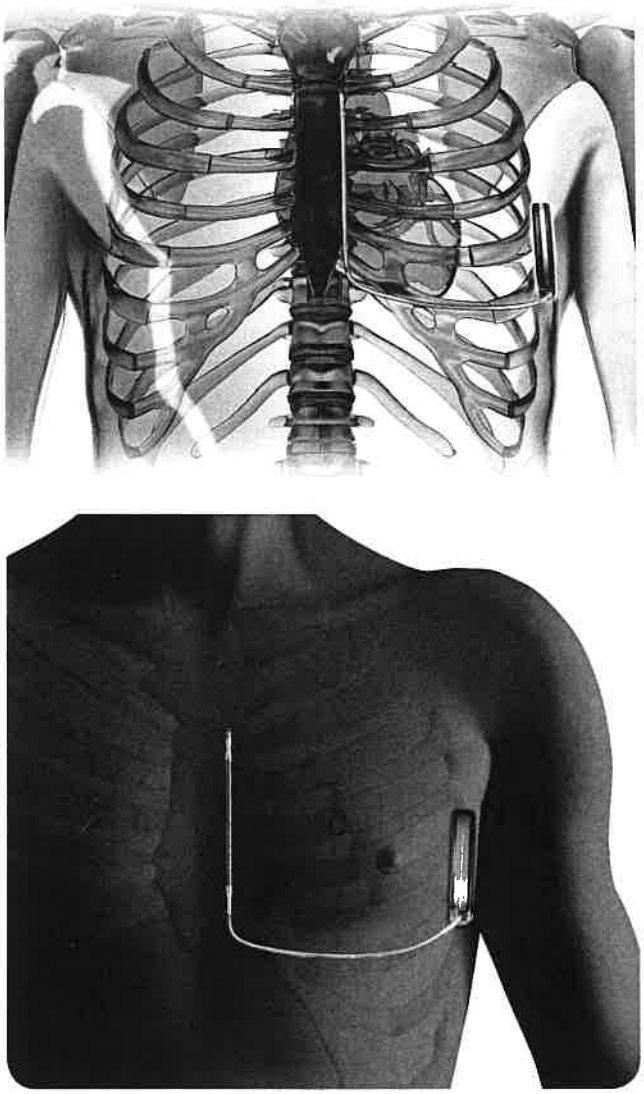


Figure 9.5 Subcutaneous ICDs (S-ICDs)

Magnet placement for the S-ICD is over the implanted device. Application of the magnet flat against the skin for a minimum of 1 second will then initiate beeping tones that indicate arrhythmia detection is suspended. These tones sound for 60 seconds, with shock therapy (and post shock pacing function) suspended until the magnet is removed.

Although modern electronic devices and the implanted electrodes are designed to resist damage by external defibrillation currents, there is a remote possibility of damage when a shock is delivered through a defibrillation pad placed over, or close to, these implanted devices. There is also a theoretical risk of damage to the patient's myocardium due to excess current flow. This may elevate pacing thresholds or damage the myocardium at the electrode-tissue interface.

To minimise this risk, place the defibrillator electrodes away from the pacemaker or ICD generator (at least 10 cm (and ideally up to15 cm)) without compromising effective defibrillation.

If necessary place the pads in the antero-posterior, postero-lateral or bi-axillary position as described above. In people with S-ICDs (or with other devices in a left lateral position) place the external defibrillator electrodes in the antero-posterior position.

During cardiorespiratory arrest in a shockable rhythm, external defibrillation should be attempted in the usual way if the ICD has not delivered a shock, or if its shocks have failed to terminate the arrhythmia.

An implanted ICD gives no warning when it delivers a shock. In some cases there may be an attempt to rapidly pace the rhythm. On sensing a shockable rhythm, an ICD will discharge approximately 40 J (approximately 80 J for subcutaneous devices) through an internal pacing wire embedded in the right ventricle. The precise number of shocks that may be delivered in this situation will vary from one person/device to another, and is often up to eight, sometimes more. The ICD will re-start its discharge sequence if it detects even brief apparent cessation of the tachyarrhythmia (including transient slowing of heart rate below the rate programmed to trigger shocks). This could result in the patient receiving a large number of shocks, causing pain and distress. A ring magnet placed over the ICD will disable the defibrillation function in these circumstances (Chapter 10). Deactivation of an ICD in this way does not disable the ability of the device to act as a pacemaker if it has that capability.

In many devices, placing a magnet over a permanent pacemaker temporarily "resets" the pacer into asynchronous mode; it does not turn the pacemaker off. Although many different branded pacemaker/implantable cardioverter-defibrillator (ICD) magnets are available, rescuers should be aware that, in general , any pacemaker/ICD magnet can be used to inhibit the device. Also, note that the majority of devices have a magnet response; however, some devices can be programmed to not respond to magnet application and thus will need a device programmer to change the parameters.

In some devices, application of a magnet produces a soft beep for each QRS complex detected. If the magnet is left on for approximately 30 seconds, the ICD is disabled and a continuous) tone (or beeping) may be generated. To reactivate the device, the magnet must be lifted off the area of the generator and then replaced. After 30 seconds, the beep returns for every QRS complex.

Following successful resuscitation from cardiac arrest, interrogation of a pacemaker or ICD (by a cardiac physiologist from a pacemaker service) may provide valuable information about the rhythm behaviour that led to the cardiac arrest, as well as providing an opportunity to check lead thresholds and device function. External defibrillation may cause a temporary battery voltage reduction, which could cause the device to enter a reset condition without damaging the device.

Interrogation of the device also allows for checking of the capacitor, verify battery status, shock counters and pacing or shock functions. This is to ensure that the programmable parameters did not change and but also provides the option to set them to new limits following the arrest.

Implantable event recorders (also known as implantable loop recorders and implantable cardiac monitors)

These small devices (about the size of a computer memory stick or smaller) are used to record the heart's rhythm at the time of an event such as transient loss of consciousness. They are usually implanted under the skin on the anterior chest wall, overlying the heart, but occasionally may be placed in the axilla.

They have no connected leads or other attachments and do not deliver any treatment. They present no risk to those giving CPR and no known risk to the patient during defibrillation. As with other devices there is a remote possibility of damage to the device itself by a high-energy shock if a defibrillator pad is placed directly over or close to the device, so careful pad placement (as far away from the device as possible without compromising effective defibrillation) is recommended.

If a person with an implantable event recorder suffers cardiorespiratory arrest, and CPR achieves ROSC, as soon as is clinically appropriate arrange to have the device interrogated (usually by a cardiac physiologist from a pacemaker service) because it may have recorded valuable information about the cardiac rhythm that initiated the arrest.

Implantable neurostimulators

Neurostimulators may be implanted subcutaneously in positions similar to those used for pacemakers and are similar in appearance. They are attached to the 'target' part of the nervous system by a lead, similar to a pacemaker lead. They present no known or likely risk to the patient or to those giving CPR. Similar principles to those used for ICDs are applied with these devices. Some manufacturers advise a minimum distance of 10–15 cm from the implanted device (between the edge of the implanted device and the edge of the defibrillator electrode).

Internal defibrillation

Internal defibrillation using paddles applied directly across the ventricles requires considerably less energy than that used for external 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.

Wearable defibrillator

The wearable defibrillator provides a prophylactic strategy for patients who are at significant risk for VT/VF but may not candidates for immediate ICD implantation. Besides defibrillation, the device may act as a loop recorder that continuously records and transmits via modem both tachyarrhythmias and bradyarrhythmias. This may then provide evidence for ICD if required. The system is capable of

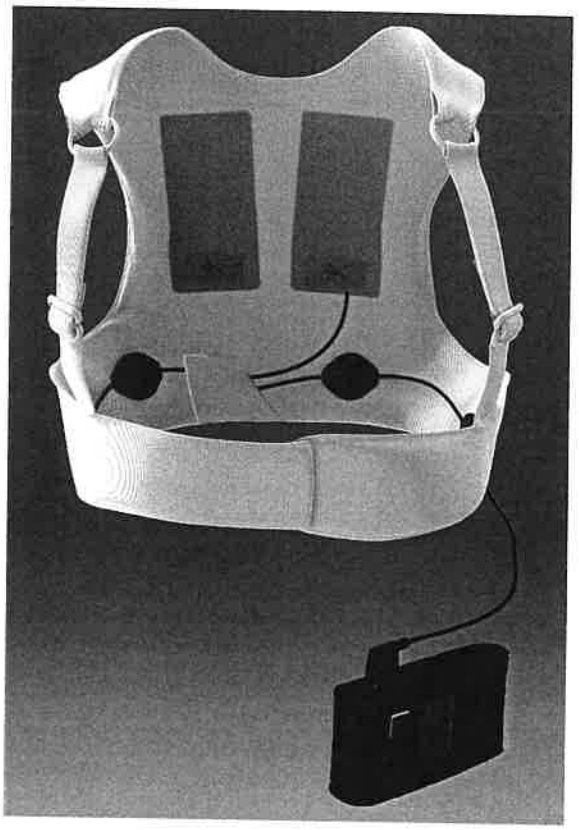


Figure 9.6 Wearable defibrillator

sensing information about the patient, determining whether the patient is experiencing a life-threatening arrhythmia, and if so, deliver life-saving defibrillation.

is worn under clothing. It comes in two parts, a vest that contains electrodes and a small monitor worn at the waist or from a strap. Small sensing electrodes monitor the patient's heart. If a life-threatening rhythm is detected, the device alerts the patient before delivering a treatment shock.

As the device in external it has to be removed when showering and bathing. Also it is more susceptable to movement artefact and included into the system is an escalating alarm system if not interrupted by the wearer will result in shock delivery.

In the event of cardiac arrest and in the presence of a rescue team the device will need removal when a defibrillator is available for use in its place. This will promote rescuer safety.

The wearable defibrillator may be used for patients capable of using it who are considered to be at high risk of VT/VF and need temporary protection from these arrhythmias. Ideally the first shock will revert the rhythm and achieve ROSC. However there is the risk of the rhythm requiring further shocks and prolonged resuscitation.

This has the potential to place them in contact with those performing compressions and with over 200 J of energy delivery possible from these devices all standard defibrillation safety should be considered. If a wearable defibrillator is indicating an imminent shock delivery it would be advisable to stand clear. Immediately an alternate external defibrillator is available for use it must replace the wearable system if required for on-going resuscitation. It is possible to place the defibrillator electrodes in position prior to removal of the vest.

Summary learning

- For the patient in VF/pVT, early defibrillation is the only effective means of restoring a spontaneous circulation.
- When using a defibrillator, minimise interruptions to chest compressions.
- Use at least 150 J for the first shock.
- For manual defibrillators, consider escalating energy levels for refractory and recurrent VF.

My key take-home messages from this chapter

Further reading

Australian Resuscitation Council/ANZCOR Guidelines: http://resus.org.au/guidelines/

A guide to automated external defibrillators (AEDs). Resuscitation Council (UK) and British Heart Foundation. December 2013. https://www.resus.org.uk/publications/a-guide-to-aeds/

Australian Resuscitation Council/ANZCOR Guidelines http://resus.org.au/guidelines/

Cardiovascular implanted electronic devices in people towards the end of life, during cardiopulmonary resuscitation and after death. Guidance from the Resuscitation Council (UK), British Cardiovascular Society and National Council for Palliative Care. March 2015. https://www.resus.org.uk/defibrillators/cardiovascular-implanted-electronic-devices/

Soar J, Callaway CW, Aibiki M, et al. Part 4: Advanced life support: 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. Resuscitation 2015;95:e71-e122.

Soar J, Nolan JP, Bottiger BW, et al. European Resuscitation Council Guidelines for Resuscitation 2015 Section 3 Adult Advanced Life Support. Resuscitation 2015;95:99-146.

Cardiac pacing

Chapter 10

Contents

- Formation and transmission of the heart's spontaneous electrical signals
- Ways in which failure of these may result in a need for cardiac pacing
- Different methods of delivering cardiac pacing in various clinical settings
- How to recognise failure of cardiac pacing and reasons for it
- Safe and effective delivery of CPR for people who have implanted pacemakers or implanted cardioverter-defibrillators (ICDs)
- Consideration of the need for ICD implantation in people resuscitated from cardiac arrest in a shockable rhythm
- Actions needed after the death of a person with an implanted electronic device

Learning outcomes

To enable you to:

- Understand the indications for cardiac pacing in the peri-arrest setting
- Use percussion pacing
- Apply non-invasive, transcutaneous electrical pacing
- Describe the problems that may occur with temporary transvenous pacing and how to correct them
- Manage patients with implanted permanent pacemakers and cardioverter defibrillators in peri-arrest and cardiac arrest settings, and after death

Introduction

In some cardiac arrest or peri-arrest settings, use of cardiac pacing can be life-saving. Non-invasive pacing may be used to maintain cardiac output temporarily while expert help to deliver longer-term treatment is obtained. Non-invasive pacing can be established rapidly and as an ALS provider you should be able to achieve this.

The ALS provider does not need to have a detailed technical knowledge of permanent pacemakers and implanted cardioverter defibrillators (ICDs) but needs to be able to recognise when one of these devices is present, when they are failing, and how the presence of an implanted device may influence the management of a cardiac arrest.

Formation and failure of the heart's electrical signal

The electrical signal that stimulates each normal heartbeat arises in the sino-atrial (SA) node, which can be regarded as the heart's natural pacemaker. This depolarises

spontaneously and regularly, generating an electrical signal without any external stimulus. This behaviour is called 'automaticity', and any cardiac tissue that has this ability is capable of initiating a heartbeat and behaving as a 'pacemaker'. Different parts of the conducting system generate spontaneous signals at different rates (Figure 10.1). The fastest 'pacemaker' will generate the cardiac rhythm and slower natural pacemakers will only take over if the faster ones slow down or stop working. For example, in sinus arrest or extreme sinus bradycardia the atrioventricular (AV) node may take over and provide a junctional escape rhythm and in complete atrioventricular block (complete heart block - CHB) the escape rhythm arises from ventricular myocardium or from conducting tissue below the atrioventricular node.

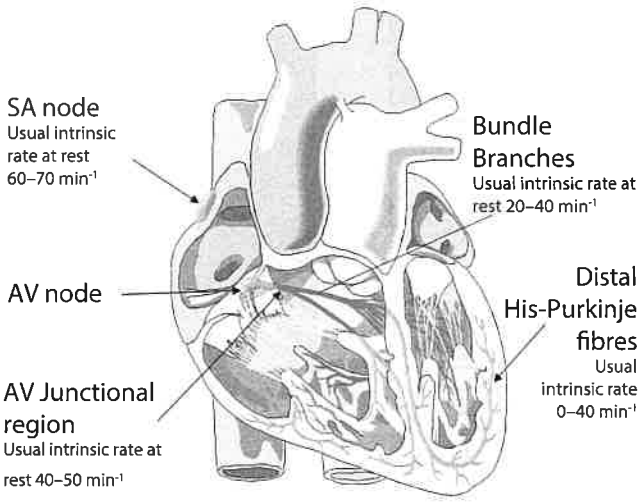


Figure 10.1 Cardiac conducting system

When CHB occurs at the level of the AV node, the most rapid automatic activity arises from cells immediately below the block and these become the new pacemaker. The heart rate produced by these cells is usually, relatively fast (often about 50 min^{-1}). The resulting escape rhythm tends to be relatively stable and relatively unlikely to fail suddenly, and cause asystole.

The QRS complexes resulting from this type of block are narrow because the impulse is transmitted to the ventricles rapidly through an intact bundle of His and bundle branches. This situation may be seen complicating acute inferior myocardial infarction. In this setting, narrow-complex CHB often may not require pacing because the heart rate is not especially slow and the risk of asystole is usually low. Assess the patient (ABCDE) to identify the effect of the bradycardia and any need for treatment.

Complete heart block can occur lower in the conducting system. Examples of causes include:

- degenerative conducting tissue fibrosis
- extensive anteroseptal myocardial infarction affecting all the fibres of the bundle branches
- cardiomyopathies
- calcific valve disease.

Any automatic activity arising below this block in the distal Purkinje fibres or myocardium is likely to be slow and unreliable. In this situation, the resulting QRS complexes are broad, since the impulse passes slowly through ventricular muscle rather than rapidly through the conducting system. This escape rhythm is unreliable and may fail transiently, leading to syncope (Stokes-Adams attack), or fail completely, causing ventricular standstill and cardiac arrest. Broad-complex CHB requires cardiac pacing, and the occurrence of long ventricular pauses (> 3 s) makes this need urgent, as it implies a risk of asystole.

The possible risk of AV block and asystole should always be considered in a person who has presented with syncope and has any ECG evidence of conduction delay (e.g. long PR interval or bundle branch block). Start ECG monitoring and obtain expert assessment for all such patients.

In the peri-arrest setting, pacemakers are used when the heart rate is too slow or unreliable, and not responding to the treatment described in the peri-arrest algorithm for bradycardia (Chapter 11). Pacing will be effective only if the heart is able to respond to the pacing stimulus. In the setting of cardiac arrest the presence of P waves makes this more likely. Pacing is rarely successful in asystole in the absence of P waves and should not be attempted routinely in this situation.

The pacing stimulus may be mechanical, as in percussion pacing, or electrical, as in transcutaneous and transvenous pacing. The use of drugs is generally to accelerate current underlying rate and rhythm and not initiate it.

If a pacing stimulus induces an immediate QRS complex this is referred to as 'capture'. Check that this electrical activity seen on the ECG is accompanied by mechanical activity that produces a palpable pulse.

Methods of pacing

Methods of pacing may be classified as:

Non-invasive

- Percussion pacing ('fist pacing') - if no other option available
- Transcutaneous pacing

Invasive

- Temporary transvenous pacing
- Permanent pacing (using an implanted pacemaker)

Implanted devices that deliver pacing include pacemakers implanted for the treatment of bradycardia, and permit treatment of tachyarrhythmias, biventricular pacemakers implanted for the treatment of heart failure (cardiac resynchronisation therapy) and implanted cardioverter defibrillators (ICDs), which also have a pacemaker function.

Non-invasive pacing

Percussion pacing

When bradycardia is so profound that it causes unconsciousness, percussion pacing (often called 'fist pacing')

has been used in preference to CPR because it is possible to produce an adequate cardiac output with less trauma to the patient. It is more likely to be successful when ventricular standstill is accompanied by continuing P wave activity (Chapter 8). However it is difficult to obtain electrical capture and cardiac output and CPR should not be delayed in cardiac arrest.

How to perform percussion pacing

1. With the side of a closed fist deliver repeated firm thumps to the praecordium, just lateral to the lower left sternal edge.
2. Raise the hand about 20 cm above the chest before each thump.
3. Monitor the ECG and assess whether a QRS complex is generated by each thump.
4. If possible a second person should check whether a pulse is generated by each QRS complex.
5. If initial thumps do not produce a QRS complex try using slightly harder thumps.
6. If this still fails to produce a QRS complex move the point of contact around the praecordium until a site is found that produces repeated ventricular stimulation.

Percussion pacing is not as reliable as electrical pacing in stimulating QRS complexes and works rarely. If percussion is attempted and does not produce a regular pulse promptly, regardless of whether or not it generates QRS complexes, start CPR immediately.

Like CPR, percussion pacing is an emergency measure that is used to try to maintain circulation to vital organs. In this way it may enable either recovery of a spontaneous cardiac rhythm or initiation of transcutaneous or transvenous pacing. It is not a replacement for other pacing methods or CPR when needed.

Transcutaneous pacing

Compared with transvenous pacing, non-invasive transcutaneous pacing has the following advantages:

- It is established very quickly.
- It is easy to perform and requires a minimum of training.
- It can be initiated by healthcare providers including nurses, paramedics and doctors, while waiting for expert help to establish transvenous or permanent pacing.

The major disadvantage of transcutaneous pacing in the conscious patient is discomfort. The pacing impulse stimulates painful contraction of chest wall muscles as well as causing some direct discomfort. Many defibrillators also have ability to deliver transcutaneous pacing. Stand-alone, non-invasive pacing devices may also be available in some hospital departments.

Most transcutaneous pacing systems are capable of demand pacing in which the device detects spontaneous QRS complexes and delivers a pacing stimulus only when it is needed. In this case the device often needs a method to assess the underlying rhythm and a method to deliver the pacing stimulus. Despite the pads on defibrillators being multi-functional the ECG monitoring will need connecting on many systems. A plan for patient sedation may also be needed and appropriate assistance at hand.

How to perform transcutaneous pacing

1. Avoid delay, but pay careful attention to technique in order to increase the chance of success.
2. If necessary, use clippers, scissors or a razor to quickly remove excess chest hair from the skin where the electrode (pad) is to be applied.
3. Ensure that the skin is dry, (particularly where pads are to be placed and between them).
4. If necessary attach ECG monitoring electrodes and leads - these are needed with some transcutaneous pacing devices.
5. In cooperative patients or where possible - use A-P positions (Figure 10.2a–c) place the anterior pad on the left anterior chest wall, beside the sternum, overlying the V2 and V3 ECG electrode positions. Place the posterior pad between the lower part of the left scapula and the spine, at the same horizontal level on the trunk as the anterior pad. These precise positions may not be optimal for cardioversion of atrial tachyarrhythmia, for which the anterior pad is best placed overlying the right sternal border.
6. If resuscitation/CPR is ongoing - position the pads in the 'conventional' right pectoral and apical positions if possible (Figure 10.2 d). For right pectoral and apical positions place one pad over the right pectoral muscle, just below the clavicle. Place the apical pad in the left mid-axillary line, overlying the V6 ECG electrode position. Apply this pad to the chest wall, not over breast tissue. If this is prevented (e.g. by chest trauma or an implanted device in this position) anterior-posterior (A-P) pad positions can be used.
   - If you are using a pacing device that is not capable of defibrillation, use A-P positions for the pacing electrode pads so that defibrillator pads can still be applied in the right pectoral and apical positions.
7. Make sure that you are familiar with the device that you are using and that you know how to operate it. Different transcutaneous pacing devices have different operational features. For example, many require the operator to increase the current delivered with each pacing stimulus until electrical capture is achieved, whilst others use a constant current that cannot be adjusted and a longer pulse duration (of the pacing stimulus) than other devices.

8. Most transcutaneous pacing devices pace the heart in demand mode. The pacemaker will be inhibited if it detects a spontaneous QRS complex. However, if there is movement artefact on the ECG this may inhibit the pacemaker. Avoid causing movement artefact as far as possible. If artefact still appears to be inhibiting the pacemaker, switch the device to deliver fixed-rate pacing.

9. Select an appropriate pacing rate. This will usually be in the range 60–90 min^{-1} for adults, but in some circumstances (e.g. complete AV block with an idioventricular rhythm at 50 min^{-1}) a slower pacing rate of 40 or even 30 min^{-1} may be appropriate in order to deliver pacing only when required during sudden ventricular standstill or more extreme bradycardia, (back up pacing).

11. Tell the patient what is about to occur.

11. If the pacing device has an adjustable energy output set this at its lowest value and turn on the pacemaker. Gradually increase the output while observing the patient and the ECG. As the current is increased the muscles of the chest wall will contract with each impulse and a pacing 'spike' will appear on the ECG (Figure 10.3a). Increase the current until each pacing spike is followed immediately by a QRS complex, indicating electrical capture (typically with a current of 50–100 mA). This means that the pacing stimuli are causing depolarisation of the ventricles (Figure 10.3b). In some circumstances when the need for pacing is urgent starting at the highest energy level and reducing until capture threshold is known is another method of establishing energy requirement. .

12. Check that the apparent QRS complex is followed by a T wave. Occasionally, artefact generated by the pacing current travelling through the chest may look like a QRS complex, but such artefact will not be followed by a T wave (Figure 10.3).

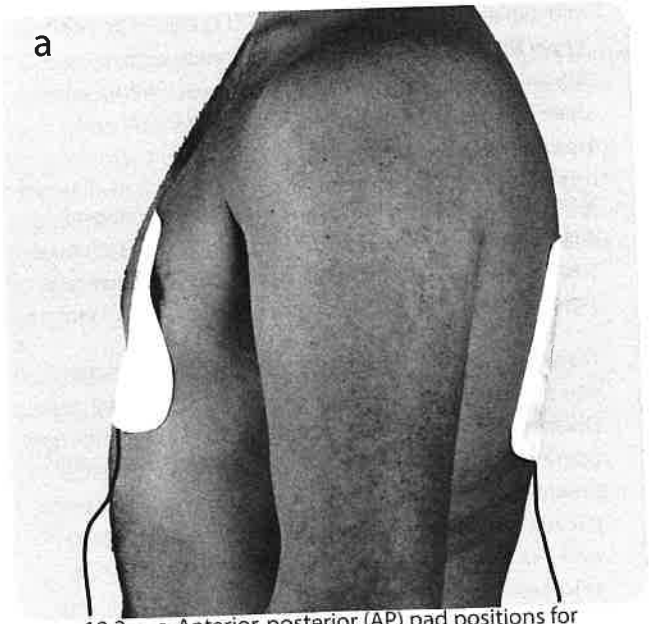


Figure 10.2a - c. Anterior-posterior (AP) pad positions for external pacing.

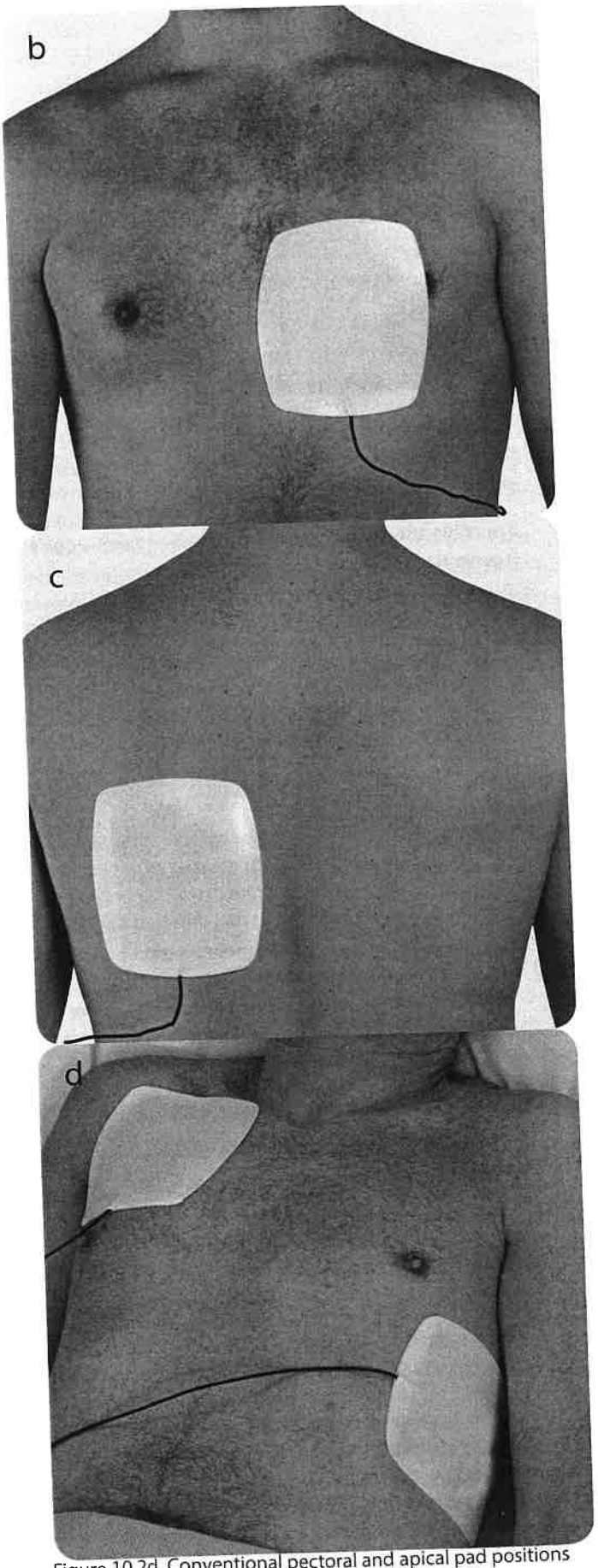


Figure 10.2d Conventional pectoral and apical pad positions can be used for pacing and for defibrillation

13. If the highest current setting is reached and electrical capture has not occurred, try changing the electrode positions. Continued failure to achieve electrical capture may indicate non-viable myocardium, but other conditions (e.g. severe hyperkalaemia) may prevent successful pacing.

14. Having achieved electrical capture with the pacemaker, check that each paced QRS complex is followed by a pulse. A palpable pulse confirms a mechanical response of the heart (i.e. contraction of the myocardium) to the paced QRS complex. At this point set the output 10 mA (or 10%) higher than the threshold to ensure maintenance of capture with respiration, movement, pad usage and other possible small increases in impedance. Good electrical capture that fails to generate a pulse constitutes pulseless electrical activity (PEA). This may be due to severe myocardial failure but consider other possible causes of PEA in these circumstances.

15. Warn conscious patients that they are likely to experience considerable discomfort during transcutaneous pacing. Be ready to give them intravenous analgesia and/or sedation as required, especially if prolonged transcutaneous pacing is needed. If sedation is used, reassess the patient frequently (ABCDE) because sedative drugs may suppress respiratory effort. Sedation in patients may need to occur following efffective pacing to prevent complicating issues related to sedation of a patient with impaired circulation or respiratory effort.

16. There is no hazard from transcutaneous pacing to people who are in contact with the patient. However, there is no benefit in trying to deliver transcutaneous pacing during chest compressions, so it is best to turn off the pacemaker whilst CPR is in progress. If necessary, provide good-quality chest compressions. These can be given and other manual contact with the patient maintained as necessary with transcutaneous electrodes in place.

17. When transcutaneous pacing produces an adequate cardiac output seek expert help immediately to arrange emergency pacing. Transcutaneous pacing is a temporary measure only.

18. To check the underlying rhythm, it is often possible to pause the transcutaneous pacing without adjusting the settings. On release of the pause the pacing restarts.

Invasive pacing

Temporary transvenous pacing

It is rarely appropriate to try to attempt to insert a transvenous pacing wire during a cardiac arrest. In this setting, use non-invasive pacing to attempt to achieve a cardiac output, and then seek expert help with transvenous pacing. Failure of an existing temporary transvenous pacing system may cause cardiac arrest, particularly when the patient is pacing-dependent. Temporary transvenous pacing systems can fail in three ways:

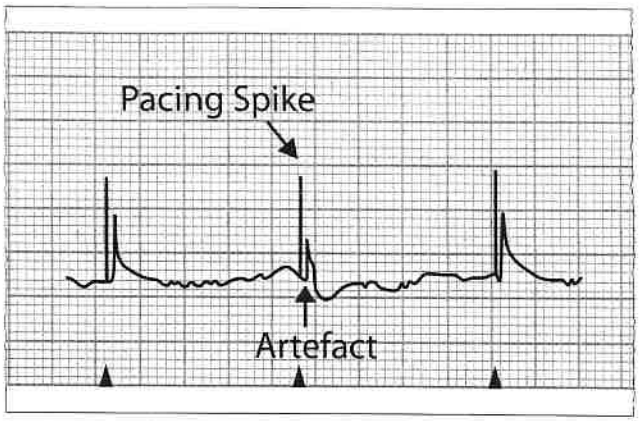


Figure 10.3a Transcutaneous pacing. ECG appearance of pacing spikes without ventricular capture

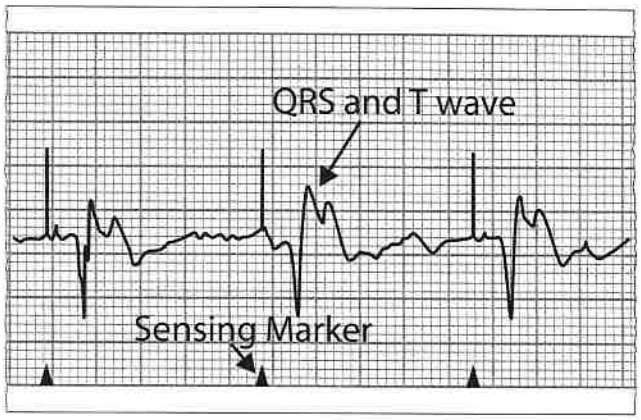


Figure 10.3b. Transcutaneous pacing. ECG shows ventricular capture after each pacing spike

1. High threshold

When a temporary pacing lead is inserted the usual aim is to position its tip in the apex of the right ventricle, where it is least likely to be displaced. After positioning the lead, it is used to pace the heart. The pacing 'threshold' is measured by gradually reducing the voltage delivered by the pacemaker to determine the minimum voltage needed to stimulate the ventricle. The usual aim is to achieve a threshold of < 1.0 V at the time of lead insertion. Higher thresholds suggest that the electrode is not making satisfactory contact with the myocardium, (or well perfused myocardium), so there may be a need to reposition the lead.

It is usual to pace the heart with a 3–4 V stimulus, well above the initial pacing threshold. Over the first days and weeks after insertion of a pacing lead (temporary or permanent) a transient rise in the threshold can be expected.

Check the threshold on temporary pacing leads at least daily to make sure that the output of the pacemaker is well above the threshold. If not, loss of capture may occur. This is seen on the ECG as a pacing spike without a subsequent QRS complex. Loss of capture may be intermittent, so any apparent 'missed beat' of this nature should prompt a repeat check of the pacing threshold.

If loss of capture occurs because of a high threshold, increase the output of the pacemaker immediately to well above the repositioning of the lead may be needed.

threshold. A sudden increase in pacing threshold may be caused by lead displacement, so obtain prompt expert help, as soon as possible.

2. Connection failure

Most temporary transvenous pacing leads are bipolar. One electrode is at the tip of the lead and the second is about 1 cm proximal to the tip. Each electrode is connected by the lead to separate connectors at the other end, outside the patient. These are usually inserted into sockets at one end of a connecting cable that in turn is connected to the terminals of the pacemaker. Make sure that all connections between the lead and the pacemaker are making good, secure contact that is unlikely to be lost easily, for example by minor movement of the lead or cable.

Failure of any of these connections will prevent delivery of the pacing stimulus to the heart, seen on the ECG as absence of a pacing spike. This may be intermittent and symptomless, or may be sudden and total and may result in syncope or cardiac arrest in asystole. When pacing failure is accompanied by loss of the pacing spike on the ECG, check all connections immediately. Check that the pacemaker has not been turned off inadvertently and check that its batteries are not depleted. If no such cause is present another possible explanation is a fracture of a wire within its insulation. This usually causes intermittent pacing failure and the fracture is more likely to be in the connecting cable than in the pacing lead. If this is suspected change the connecting cable immediately.

3. Lead displacement

The tip of an endocardial transvenous pacing lead is usually positioned in the apex of the right ventricle. There should be enough slack in the lead in the right atrium to allow for changes in posture and deep inspiration, but not so much as to encourage displacement of the lead tip.

The tip of a pacing lead may also perforate the wall of the right ventricle and enter the pericardium with little or no apparent change in position on chest radiography. Very rarely, this may cause cardiac tamponade, so consider this possibility if a patient with a recently implanted pacing lead suffers cardiac arrest with pulseless electrical activity.

When displacement or perforation occurs, the ECG will still show a pacing spike, but there is likely to be intermittent or complete loss of capture of the pacing stimulus (when the pacing spike is not followed by a QRS complex). When a pacing lead displaces but remains in the right ventricle it may trigger ventricular extrasystoles or more serious ventricular arrhythmia, including VT and VF. When transvenous pacing fails, there is a risk of ventricular standstill. This may be relatively short-lived and cause syncope, or prolonged and cause cardiac arrest in asystole. In this situation use non-invasive pacing until effective transvenous pacing can be re-established.

Cardiovascular implanted electronic devices

This term refers mainly to implanted pacemakers and implantable cardioverter-defibrillators (ICDs).

Implanted permanent pacemakers

Problems with permanent pacing systems are rare, because the connections between pacing electrodes and the pacemaker are much more secure. Lead displacement may occur as an early complication in the first few days after implantation, but becomes progressively less likely thereafter and rarely occurs more than 4–6 weeks after implantation. Occasional fracture of a permanent pacing lead may occur, usually following trauma such as a fall on to an outstretched arm on the side of the pacemaker. This may cause permanent or intermittent loss of the pacing spike, and paced rhythm from that lead. At faster heart rates pacemakers often have a Wenckebach function making the appearance of an irregular paced rhythm. This pseudo-Wenckebach is not a pacemaker malfunction it is caused when the atrial rate detected exceeds the maximum tracking rate to pace the ventricles. This prevents sensed rapid atrial depolarisation becoming a tachycardia in dual chamber pacemakers.

When assessing a patient using the ABCDE approach check (during 'E') for the presence of an implanted device. These devices are usually implanted below the clavicle, often but not always on the left side. If a device is identified consider whether it is a pacemaker or an ICD and in the case of a pacemaker try to establish whether it was implanted as treatment for bradyarrhythmia or as treatment for heart failure. Be aware also that leadless pacemakers now exist. These are implanted transvenously, entirely within the right ventricle and will not be detectable on clinical examination.

If a patient with an implanted subcutaneous pacemaker or ICD has a cardiac arrest or requires cardioversion, place defibrillation pads at least 10cm (–15 cm) from the device. Devices that are implanted below the left clavicle usually present no problem with the use of standard defibrillator pad positions. If a device has been implanted below the right clavicle or just below the left axilla, use A-P positions for defibrillation or cardioversion if possible.

Biventricular pacing systems

In the past, the usual reason for implantation of a permanent pacemaker was treatment of bradycardia, caused mostly by malfunction of atrioventricular conduction or the sino-atrial node. Over several years there has been increasing use of biventricular pacemakers as 'cardiac resynchronisation therapy' in patients with heart failure. Many of these patients do not need pacing for bradycardia. The aim of these devices is to pace the apex of the right ventricle and the lateral wall of the left ventricle simultaneously in order to improve the co-ordination of left ventricular contraction. These pacemakers require the same precautions during defibrillation and cardioversion as any other pacemaker, but failure of a pacemaker that has been inserted for this purpose will not usually cause any major change in heart rate or any dangerous rhythm abnormality. Some biventricular pacing systems also incorporate an ICD function (see below).

Implantable cardioverter-defibrillators

These devices resemble implanted pacemakers. Older ICDs were larger but with modern technology are getting smaller. Unlike a simple pacemaker, the primary function of an ICD is to terminate a life-threatening tachyarrhythmia. A 'simple' ICD can deliver a shock when it detects VF or very fast VT. Many of these devices are programmed also to deliver critically timed

pacing stimuli to attempt to terminate VT that is not especially fast and is unlikely in itself to cause cardiac arrest, resorting to defibrillation only if the VT accelerates or degenerates into VF. Most ICDs can function as demand pacemakers in the event of bradycardia and some devices will also deliver biventricular pacing for heart failure, as well as delivering defibrillation if required.

National and international guidelines define indications for ICD implantation. These include indications for their use in 'primary prevention' in people who have not experienced cardiac arrest but are at high risk of VF or VT causing sudden cardiac death. ICDs may improve survival in selected patients after major myocardial infarction, selected patients with heart failure and in some people with certain types of inherited cardiac condition.

ICDs are implanted usually in the pectoral region in a similar subcutaneous position to pacemakers. Though these devices may seem complex, the means by which they sense changes in cardiac rhythm is relatively simple, depending mainly on automated detection of very rapid heart rates (from an ECG signal). Consequently, ICDs may occasionally misdiagnose an arrhythmia, or misinterpret other electrical signals, and deliver inappropriate shocks, which are very unpleasant for a conscious patient. If necessary, to prevent inappropriate shocks, ICDs can be disabled temporarily by holding or taping a ring magnet on the skin overlying the device (Figure 10.4). This will also prevent the ICD from recognising and shocking VF and VT. Seek urgent expert help if ICD malfunction is suspected.

If a patient with an ICD has a cardiac arrest that is not terminated by the ICD, deliver CPR in the usual way. It is believed that chest compressions can be delivered without major risk to the rescuer, even if the ICD delivers an internal shock to the patient during chest compressions. However, there have been rare reports of shocks from an ICD causing transient myalgia and paraesthesia in the arms of a person delivering chest compressions. If a shockable cardiac arrest rhythm is present and is not terminated by the ICD, use external defibrillation in a standard way, taking the same precautions with choice of defibrillator pad positions as in a patient with an implanted pacemaker. During CPR, if an ICD delivers repeated inappropriate shocks that are impeding delivery of high-quality CPR consider deactivating the ICD using a ring magnet as above. Do not delay or interrupt CPR while locating or positioning a magnet for this purpose.

Consider the possible requirement for ICD implantation in any patient who has been resuscitated from cardiac arrest in a shockable rhythm outside the context of proven acute ST segment elevation myocardial infarction. All such patients should be referred for assessment by a cardiologist with expertise in heart rhythm disorders before discharge from hospital.

Implanted electronic devices – management after death

When a person dies with an active ICD in place arrange for its deactivation (usually done by a cardiac physiologist) as soon as is reasonably practical. An ICD must be deactivated prior to its removal from the body or performance of an autopsy. Any implanted electronic devices (including pacemakers, ICDs, event ('loop') recorders and neurostimulators) must be removed prior to cremation.

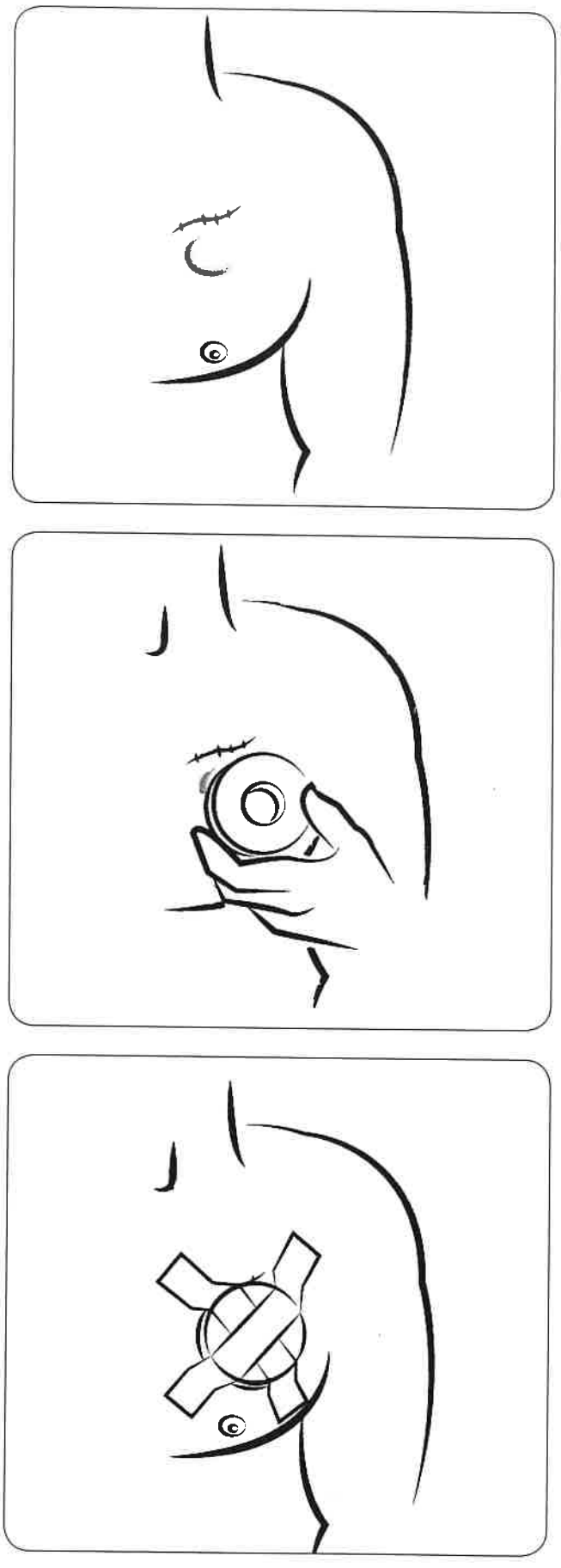


Figure 10.4 An implantable cardioverter-defibrillator can be disabled by taping a ring magnet on the skin overlying the device.

For subcutaneous ICD's the magnet needs to be placed over the device on the left side of the patients chest. Application of the magnet flat against the skin for a minimum of 1 second may initiate beeping tones that indicate arrhythmia detection is suspended. These tones sound for 60 seconds, indicating that shock therapy suspended and any post shock pacing function is also switched off until the magnet is removed.

Summary learning

- Non-invasive pacing can be delivered by an ALS provider and is the immediate treatment for severe bradyarrhythmia that is a potential risk to a patient who does not respond to initial drug treatment
- Non-invasive pacing is a temporary, emergency measure to be used briefly until either a stable and effective spontaneous rhythm returns, or a competent person establishes transvenous pacing
- During resuscitation attempts in patients with implanted pacemakers and ICDs deliver CPR in the usual way, taking care not to place external defibrillator pads over or close to an implanted device
- Consider the possible need for an ICD in patients resuscitated from cardiac arrest in VT or VF, in whom there is a possible risk of recurrence
- Active ICDs should be deactivated as soon as practicable after a person's death. Remove all implanted electronic devices before cremation

My key take-home messages from this chapter

Further reading

Australian Resuscitation Council/ANZCOR Guidelines: http://resus.org.au/guidelines/

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