

Prehospital resuscitation



1. [The guideline process](#)
2. [Summary of changes in prehospital resuscitation since the 2010 Guidelines](#)
3. [Introduction](#)
4. [Dispatcher-assisted CPR](#)
5. [Prehospital cardiac arrest clinical care](#)
6. [Recognition of life extinct \(ROLE\)](#)
7. [Post-ROSC management](#)
8. [Patient destination](#)
9. [Team handover and crew debriefing](#)
10. [Audit of out-of-hospital cardiac arrest](#)
11. [References](#)

Authors

Charles Deakin, Simon Brown, Fiona Jewkes, David Lockett, Richard Lyon, Fionna Moore, Gavin Perkins, Mark Whitbread

1. The guideline process

The process used to produce the Resuscitation Council (UK) Guidelines 2015 has been accredited by the National Institute for Health and Care Excellence. The guidelines process includes:

- Systematic reviews with grading of the quality of evidence and strength of recommendations. This led to the 2015 International Liaison Committee on Resuscitation (ILCOR) Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations.^{1,2}
- The involvement of stakeholders from around the world including members of the public and cardiac arrest survivors.
- Details of the guidelines development process can be found in the Resuscitation Council (UK) [Guidelines Development Process Manual](#).
- These Resuscitation Council (UK) Guidelines have been peer reviewed by the Executive Committee of the Resuscitation Council (UK), which comprises 25 individuals and includes lay representation and representation of the key stakeholder groups.

2. Summary of changes in prehospital resuscitation since the 2010 Guidelines

- The team approach is emphasised – the prehospital resuscitation team should ideally comprise four individuals, who between them undertake roles as team leader, manage the airway, and alternate in the delivery of chest compressions and assisting with vascular access and drug delivery.
- Simpler airway devices such as supraglottic airways, including the laryngeal mask airway and i-gel, enable oxygenation and ventilation to be achieved rapidly. They should be used as part of a stepwise airway management pathway. Tracheal intubation should be attempted only by those with adequate training and only if simpler airways prove inadequate.
- There is no evidence that a period of CPR before defibrillation improves success rates and solo responders arriving at a cardiac arrest should prioritise attaching a defibrillator and defibrillation if indicated.
- Mechanical chest compression devices are a reasonable alternative to high quality manual chest compressions in situations where sustained high quality manual chest compressions are impractical or compromise provider safety.
- The use of waveform capnography is emphasised not only to indicate correct placement of a tracheal tube in the airway (and not the oesophagus), but also as a useful indicator of cardiac output and the effectiveness of chest compressions. A sudden increase in the end-tidal carbon dioxide (CO₂) may be an early indicator of return of spontaneous circulation (ROSC).
- After ROSC is achieved, passive cooling is recommended in the prehospital phase.
- The patient should be transferred to the most appropriate hospital for their needs, and this may not always be the nearest hospital. For patients with ST-segment elevation on the ECG the optimal care pathway requires direct transfer to a hospital that can provide immediate primary percutaneous coronary intervention (PPCI) at all times. An arrangement should be in place to receive these patients directly into the cardiac catheterisation laboratory.

3. Introduction

The principles of basic and advanced life support are the same for the prehospital setting but can be limited by a combination of factors including a lack of trained staff, the setting (on scene or during transport), equipment and drugs and physical access to the patient. This section addresses specific prehospital issues that are not covered elsewhere in the Resuscitation Council (UK) Guidelines 2015.

- These guidelines should be read in conjunction with the Resuscitation Council (UK) Resuscitation Guidelines 2015, Association of Ambulance Chief Executives (AACE) and Joint Royal Colleges Ambulance Liaison Committee (JRCALC) UK Ambulance Services Clinical Practice Guidelines,³ and local ambulance service protocols.
- All doses of drugs and fluids refer to those appropriate for adults. Doses for children and the newborn should be modified accordingly.

4. Dispatcher-assisted CPR

Scripted telephone triage is used in the UK to grade the urgency of emergency calls to the ambulance service and dispatch appropriate resources. This is an integral part of the Chain of Survival for cardiac arrest.⁴

Dispatcher-assisted CPR reduces the time to first chest compression in out-of-hospital cardiac arrest (OHCA).⁵ Dispatcher-assisted CPR is considered beneficial and is now more practical with the widespread use of mobile phones, which enable the rescuer to receive instruction whilst staying with the victim,^{6,7} and is enhanced with the 'hands-free' speaker phone function. Telephone instructions to the caller (rescuer) on how to give CPR increases the rate of bystander CPR and reduces the time in starting CPR, with some evidence that this improves outcome from cardiac arrest.⁷

Dispatcher-assisted recognition of cardiac arrest

In the UK, call handlers answering 999 calls generally have no medical training and read triage questions from a screen. The deviation allowed from the precise wording in the question or the advice supplied varies between

dispatch systems. The wording of the questions and the instructions offered must be understood by both the caller and the dispatcher. Medical jargon must be avoided. Some systems allow the dispatcher flexibility in wording to clarify the meaning to the caller, but too much flexibility can cause ambiguity and delay starting dispatcher-assisted CPR.

The recognition of cardiac arrest is difficult over the telephone and is made more difficult as the caller is often distressed, alone and scared.

Absence of breathing in an unconscious person is a good indicator of cardiorespiratory arrest, but many people with cardiac arrest initially gasp (agonal breathing) and the lay rescuer can misinterpret this as breathing.⁸ It is therefore considered better to ask if the victim is “breathing normally” instead of simply “breathing”. Some people with cardiac arrest will have an initial seizure when the heart stops. This can cause confusion and delay the correct diagnosis.

- Training of dispatchers should include the significance of agonal breathing. Dispatchers who understand this are more effective at recognising cardiac arrest.
- Asking whether the person is a known epileptic can help reduce the risk of inadvertent CPR in a person having a seizure.⁹
- Dispatchers should be trained in the management of cardiac arrest in all age groups, so that they are familiar with the instructions that they are giving to the rescuer.
- Dispatchers should be trained to handle very distressed callers.
- Patients who are unconscious and not breathing normally should have the most rapid ambulance response possible.

Dispatcher advice

Following identification of cardiac arrest, dispatchers provide CPR instructions to the caller.¹⁰⁻¹² This dramatically reduces the time to the first chest compression, compared with waiting for the arrival of an ambulance crew. However, delays in giving advice over the phone and/or poor quality CPR will limit these benefits.¹²

- Standardised dispatcher advice to bystanders is recommended to improve the prompt and correct recognition and treatment of cardiac arrest.
- If the phone has a speaker facility, the caller should be told to switch it to speaker as this will facilitate continuous dialogue with the dispatcher including (if required) CPR instructions.¹³

Dispatcher-assisted compression-only CPR

- Dispatcher-assisted CPR should be easy to describe and easy to perform correctly, assisted by the use of a metronome by the dispatcher to ensure correct compression rates.
- When an untrained bystander dials 999, the ambulance dispatcher should instruct him to give chest-compression-only CPR while awaiting the arrival of trained help.
- Bystanders who are trained and competent in CPR with rescue breathing should continue to undertake this, but only if they are confident to do so without dispatcher support.

Untrained rescuers receiving telephone advice are unable to do effective CPR combining rescue breaths and chest compressions.^{14,15} Rescuers may also be more likely to start CPR if they do not have to provide mouth-to-mouth breaths.¹⁶ Compression-only CPR is generally thought to be appropriate in most circumstances.

In adults, dispatcher-assisted compression-only CPR produces better survival rates than conventional CPR.^{11,17,18} In children, where 70% of out-of-hospital cardiac arrests are associated with hypoxaemia, survival is improved if both chest compressions and rescue breaths are delivered.^{19,20} After cardiac arrest in children with a primary cardiac cause, there is no difference in survival after compression-only or conventional CPR – either technique produces better survival rates than no CPR.^{19,20}

Dispatcher-assisted use of automated external defibrillators (AEDs)

- Community first responders, particularly in more rural areas and public access defibrillation schemes are important components of the initial response and should be established wherever possible.

- Registration of defibrillators with the local ambulance services is highly desirable so that dispatchers can direct CPR providers to the nearest AED.

The Resuscitation Council (UK) adult basic life support and AED guidelines recommend that in order to improve survival from cardiac arrest:

1. All school children are taught CPR and how to use an AED.
2. Everyone that is able to should learn CPR.
3. Defibrillators are available in places where there are large numbers of people (e.g. airports, railway stations, shopping centres, sports stadiums), increased risk of cardiac arrest (e.g. gyms, sports facilities) or where access to emergency services can be delayed (e.g. aircraft and other remote locations).
4. Owners of defibrillators should register the location and availability of devices with their local ambulance services.
5. Systems are implemented to enable ambulance services to identify and deploy the nearest available defibrillator to the scene of a suspected cardiac arrest.
6. All out-of-hospital cardiac arrest resuscitation attempts are reported to the National Out-of-Hospital Cardiac Arrest Audit www.warwick.ac.uk/ohcao.

The Resuscitation Council (UK) and British Heart Foundation have produced information endorsed by the National Ambulance Service Medical Directors Group about AEDs and how they can be deployed in the community – [A guide to Automated External Defibrillators \(AEDs\)](#)

AEDs are safe and effective when used by laypeople, even if they have had minimal or no training.²¹ AEDs may make it possible to attempt defibrillation many minutes before professional help arrives. Strengthening the community response to cardiac arrest by training and empowering more bystanders to perform CPR and by increasing the use of AEDs at least doubles the chances of survival and could save thousands of lives each year.^{13,22} Each minute of delay to defibrillation reduces the probability of survival to hospital discharge by 10%. In the UK, fewer than 2% of victims have an AED deployed before the ambulance arrives.²³

5. Prehospital cardiac arrest clinical care

Treatment on scene aims to identify and treat immediate life-threatening problems and achieve ROSC in those who have had a cardiac arrest.

- Remain on scene to achieve ROSC, unless reversible causes that cannot be dealt with on scene are identified and can potentially be treated in hospital.
- Make the decision to transport the patient to hospital as soon as the need for skills and interventions not available on scene is known.
- The deteriorating patient who cannot be stabilised on scene requires early recognition and transport to a suitable hospital (e.g. decompensated patient with penetrating trauma).
- Clinical staff must ensure they are competent and current in the skills that they use. This will be achieved through both training and clinical experience.

The team approach to prehospital resuscitation

Resuscitation requires a system to be in place to achieve the best possible chance of survival. The system requires technical and non-technical skills (teamwork, situational awareness, leadership, decision making).

Allocation of roles

- Appoint a team leader as early as possible; ideally they should be a paramedic or clinician experienced in prehospital resuscitation.
- The team leader should assign team members specific roles, which they clearly understand and are capable of undertaking. This will promote teamwork, reduce confusion and ensure organised and effective management of resuscitation.
- Minimum of four trained staff is required to deliver high quality resuscitation. This will necessitate dispatch of more than one ambulance resource.

- Ensure there is 360° access to the patient ('Circle of Life'):
 - **Position 1:** Airway (at head of patient) – the person must be trained and equipped to provide the full range of airway skills.
 - **Position 2:** High quality chest compressions and defibrillation if needed – at patient's left side. Be prepared to alternate with the operator at position 3 to avoid fatigue.
 - **Position 3:** High quality chest compressions and access to the circulation (intravenous, intraosseous) – at patient's right side.
 - **Position 4:** Team leader – stand back and oversee the resuscitation attempt, only becoming involved if required. The team leader should have an awareness of the whole incident and ensure high quality resuscitation is maintained and appropriate decisions made.

Effective command and control

Effective command and control of a cardiac arrest avoids:

- raised voices
- commands not given clearly
- statements made into 'thin air'
- open-ended communication.

Ensuring high quality CPR

- The team leader must coordinate all roles and ensure that interruptions to chest compressions are kept to a minimum.
- Pauses in chest compressions should be planned by the team whilst chest compressions are ongoing.

Interruptions during CPR are common and associated with worse survival.^{13,24} Common causes of prolonged pauses in chest compression during CPR are:

- advanced airway insertion (tracheal intubation, supraglottic airway)
- pulse checks and cardiac rhythm assessment
- excessive hands-off time during defibrillation.

Airway management during CPR

As a general rule, no more is necessary than that which achieves an open airway sufficient to enable adequate oxygenation and ventilation. Although tracheal intubation has been considered the gold standard in airway management, outcome data, the difficulty of prehospital intubation and the risks of very significant morbidity and mortality (e.g. prolonged desaturation, unrecognised oesophageal intubation, endobronchial intubation) have challenged this concept.^{25,26}

- During CPR clinicians should use the airway technique with which they are most experienced in order to provide adequate oxygenation and ventilation.
- Tracheal intubation in children should be avoided, unless the operator is an expert in this procedure in children.
- During CPR the pause in chest compressions to insert an advanced airway (tracheal tube or supraglottic airway) should be less than 5 seconds.

The optimal airway technique for cardiac arrest is unknown and is likely to depend on the skills of the operator, the anticipated prehospital time and patient-dependent factors. In the UK, a large prehospital trial is ongoing (AIRWAYS-2 trial <http://www.airways-2.bristol.ac.uk>).

Stepwise airway care during CPR

In practice, several airway interventions (e.g. no airway interventions, mouth-to-mouth, bag-mask, supraglottic airway, tracheal intubation) and devices are used in a stepwise manner during CPR and after ROSC.²⁷ Rescuers

should use the skills in which they are proficient. Stepwise airway care provides a progressive approach to obtaining and maintaining an open airway and adequate oxygenation and ventilation.

During a cardiac arrest, it is very important to maintain high quality chest compressions with minimal interruption for airway interventions. Start with a head tilt/chin lift or jaw thrust, using the latter in patients at risk of cervical spine injury.

Simple airway adjuncts

A simple airway adjunct may assist opening the airway.

- Oropharyngeal (Guedel) airways are suitable for unresponsive patients, but will not be tolerated by those who are semi-conscious. If the patient's level of consciousness subsequently improves, remove the airway if it is not being tolerated, in order to prevent gagging and vomiting.
- A nasopharyngeal airway may be better tolerated in a patient with an obstructed airway who is not completely unresponsive and is also suitable for a patient with trismus when the mouth cannot be opened.

Supraglottic airways (SGAs)

There are several different SGAs but they all sit above the larynx, covering the vocal cords and are simpler and quicker to insert than a tracheal tube. They can be inserted with minimal interruption to chest compressions. SGAs are a good alternative to bag-mask ventilation and are associated with less aspiration of gastric contents.²⁸ In the UK, the two commonest used devices are the:

- Laryngeal mask airway (LMA): a number of variations with differing performance are available.
- i-gel: may be easier and quicker to insert than the LMA because of the absence of an inflatable cuff. Leak pressures are comparable to that of the LMA.

Tracheal intubation

The tracheal tube is the most challenging of all airway devices to insert successfully and requires adequate initial training and ongoing practice. At least 50 attempts are required to achieve a 90% success rate and most paramedics are unlikely to have sufficient clinical experience to maintain their skills.²⁵ A recent study of trauma patients documented an overall 64% tracheal intubation success rate and an 11% unrecognised oesophageal intubation rate.²⁹ In a recent study of 628 patients with OHCA in Scotland, intubation attempts were successful in 91% but significant complications occurred in almost 9%.³⁰

There is no evidence that outcome from OHCA is improved by tracheal intubation and several studies have suggested that simpler airway techniques during CPR (i.e. bag-mask, SGA) result in at least as good, if not better, patient outcomes.^{2,24}

Tracheal intubation is safely tolerated only in patients who are unresponsive to stimulation, whether through their underlying condition or achieved through the use of anaesthetic drugs. Most patients therefore who are amenable to non-drug assisted tracheal intubation are those who have suffered a cardiac arrest. In these patients, tracheal intubation (or any airway manoeuvre) should not impede the delivery of uninterrupted chest compressions or delay defibrillation.

- Prehospital drug-assisted intubation should be undertaken only by those who undertake the procedure regularly within an appropriate clinical governance framework, with adequate audit and review of outcomes.

Tracheal intubation – practical considerations

Views of the larynx are often suboptimal because of restricted neck movement/jaw opening, poor lighting, vomit and other airway secretions, poor patient positioning, and difficult access to the patient. The following can help achieve safe and successful prehospital tracheal intubation:

- Ensure 360° access around the patient where possible.
- Ensure all the necessary equipment by the patient as a 'kit dump'.

- Use a checklist to check all equipment is available, allocate roles and make a rescue plan if initial attempts at intubation or ventilation fail.
- Patient positioning: whenever possible, place the patient supine on an ambulance trolley (preferably one that tips head down in case of vomiting). Intubation is easier when the trolley is at the knee level of the person managing the airway.
- Do not routinely use cricoid pressure for tracheal intubation during CPR. In many cases the patient will have already aspirated and cricoid pressure will often make tracheal intubation more difficult.
- Use a bougie, if necessary, over which a tracheal tube can be rail-roaded. A bougie should always be available.
- Choose the correct-sized laryngoscope blade; generally a size 4 MAC blade can be used for most adults. Videolaryngoscopy can help with difficult intubation – a variety of devices are available but require specific training in their use – a good view of the cords on the video screen does not mean tube placement will be easy.
- Secure the tracheal tube immediately after insertion (adult males – 22–23 cm, adult females – 21–22 cm), using a tie, commercial clamp or tape. A tie around the patient's head or neck can decrease venous drainage of blood from the head and brain and increase the intracranial pressure – do not over tighten the tie and consider using tape in patients where intracranial pressure may be raised (e.g. head injury). The same is true for securing SGAs. When moving the patient, hold the tracheal tube, even when it is secured. Regularly check the tracheal tube position during transit to ensure that it has not dislodged.
- During CPR aim to minimise the interruptions to chest compressions for tube placement to less than 5 s – this means doing the initial laryngoscopy whilst compressions are ongoing, a brief pause to optimise the view and pass the tube and then restarting compressions. Plan actions and pauses whilst compressions are ongoing.

Tracheal intubation – complications

There are several significant complications associated with tracheal intubation:

1. Hypoxaemia – pre-oxygenate the lungs before and between intubation attempts.
2. Unrecognised oesophageal intubation – always use waveform capnography to exclude oesophageal intubation and continuously monitor the position of the tracheal tube.
3. Endobronchial intubation – If the tracheal tube is inserted too far, the orientation of the bronchi is likely to result in the tracheal tube passing into the right main bronchus. Insert the tracheal tube to no more than the appropriate length, listen to breath sounds in both axillae, and ensure both lungs are ventilated. Monitor the position of the tube during transit.

Cricothyroidotomy

Cricothyroidotomy is used when efforts at oxygenation and ventilation fail (e.g. can't intubate, can't ventilate (CICV)). It may be performed using a large-bore needle for jet insufflation or by incising the cricothyroid membrane and inserting a tracheal tube. Surgical cricothyroidotomy has a higher success rate and provides more effective ventilation than needle cricothyroidotomy because of the larger airway that can be inserted. Needle cricothyroidotomy is generally of limited effectiveness, but preferable to surgical cricothyroidotomy in children up to about 12 years of age because it is anatomically easier to perform, with less potential damage to the larynx.

Lung aspiration of gastric contents

Aspiration of regurgitated gastric contents into the lungs is common in patients after cardiac arrest and is exacerbated by stomach inflation during rescue breaths. Regurgitation occurs in approximately one third of OHCA, often before the arrival of ambulance personnel.³¹ Pulmonary aspiration after cardiac arrest has been documented in 20% of survivors,³² although the impact on outcome is unclear. Airway management is challenging with whichever airway device is used.

- In patients who have regurgitated gastric contents, use suction and, if possible, left lateral tilt and a head down position. This may not be feasible during CPR.
- Gentle ventilation with a bag-mask (sufficient to just enable the chest wall to rise) minimizes airway pressure and reduces gastric inflation.

- SGA insertion reduces gastric inflation compared with a bag-mask, and tracheal tube insertion abolishes it completely.
- Use a nasogastric tube to decompress the stomach, once the airway and ventilation have been established.

Breathing

Breathing has two main functions: to deliver oxygen to the cells; and to remove waste products of respiration (CO₂).

Initial management

Having opened the airway, the first priority is to rapidly assess, identify and treat reversible causes of impaired breathing.

- Use the Look, Listen and Feel approach to assess for breathing.
- Expose the chest sufficiently to look for signs of injury, chest wall expansion and asymmetry between each side.
- Listening with a stethoscope is difficult in the noisy prehospital environment and the use of ultrasound may assist in the diagnosis of a pneumothorax.
- Feeling for equal chest wall expansion, bony injury or surgical emphysema is useful; the latter in most cases being pathognomonic of a pneumothorax or rupture of a large airway.
- Use pulse oximetry to assess oxygen saturation in patients with a cardiac output. In the prehospital setting, the combination of cold peripheries, and a low cardiac output can make pulse oximetry unreliable.
- If a pulse oximeter probe placed on a finger fails to measure the oxygen saturation, use other anatomical sites (e.g. toes, nose, ear lobes or tongue).

Inspired oxygen concentration (FiO₂)

The optimal blood oxygen value during CPR and after ROSC is unknown. Hypoxia (low tissue oxygen levels) is harmful and some evidence suggests that hyperoxia (high tissue oxygen) can also be harmful.^{2,33}

- During CPR aim to deliver 100% oxygen.
- After ROSC aim for an SpO₂ of 94–98%. Give high-flow oxygen until the oxygen can be reliably measured to enable titration of the FiO₂.
- Oxygen should only be used in newborn resuscitation if the baby has failed to respond to ventilation with air, and titrated to achieve the target oxygen saturation – see [Resuscitation and support of transition of babies at birth](#).^{34,35}

Tension pneumothorax

- Decompress a tension pneumothorax as soon as it is recognised.
- Focused chest ultrasound can be used to supplement clinical signs to diagnose a pneumothorax.

A tension pneumothorax requires immediate treatment. Common causes include penetrating trauma or the sharp edge of a fractured rib. Less commonly, a pneumothorax can be caused by high airway pressures as seen in acute severe asthma, spontaneous rupture of a lung bulla, sudden compression of the chest wall against a closed glottis, or barotrauma from an explosion.

All pneumothoraces begin as a simple pneumothorax, when the intrapleural pressure is minimal and there is no significant respiratory or cardiovascular compromise. This transitions to a tension pneumothorax as air progressively builds up in the pleural cavity, and is accelerated by positive pressure ventilation. By the time physiological compromise is apparent, the tension is significant and will inevitably result in sufficient respiratory and cardiac compromise to cause a cardiac arrest unless quickly treated.

The aim of prehospital management is to relieve the tension and convert a tension pneumothorax to a simple pneumothorax; the latter is generally not life-threatening and will enable the patient to be conveyed to hospital for

definitive care. Management follows a step-wise approach.

- The quickest and simplest initial treatment is needle decompression in the second intercostal space in the midclavicular line or in the fifth intercostal space in the midaxillary line. Needle decompression is only a temporary measure because the cannula may become blocked with blood, kinked or work its way out of the tissue; repeated needle decompression may be necessary if a definitive chest drain has not been inserted and the patient deteriorates again. In patients close to a destination hospital, needle decompression may be sufficient to deliver the patient before the tension pneumothorax recurs. In patients with longer transit times, who are breathing spontaneously, a chest drain incorporating a one-way valve may need to be inserted, usually in the 5th intercostal space in the midaxillary line. The 5th intercostal space may be difficult to locate and a chest drain placed too low risks catastrophic complications. Anatomically, the base of the axilla approximates to the 5th intercostal space and chest drains should not be placed lower than this boundary.
- Make a thoracostomy (5th intercostal space in the midaxillary line) in patients receiving positive pressure ventilation with a tension pneumothorax. A chest drain can then be inserted after hospital arrival.
- It is common for blood to be present within a pneumothorax, but no specific additional treatment other than adequate volume replacement is necessary for this complication.
- A haemothorax does not need to be drained in the prehospital environment. The presence of blood in the intrapleural cavity can tamponade and slow further bleeding and release of this blood through a chest drain risks cardiovascular collapse.

Ventilation

- Avoid hyperventilation during CPR and after ROSC.
- Aim for a normal PaCO₂ in patients with ROSC – waveform capnography can be used to help achieve this.

Hyperventilation reduces venous return to the heart and leads to haemodynamic instability, particularly in patients with hypovolaemia and shock. In those with ROSC following cardiac arrest, hyperventilation can cause re-arrest. Positive end-expiratory pressure (PEEP) also adds to the intrathoracic pressure to exacerbate this effect and should be kept to a minimum, if used at all, particularly in patients with head injury where it decreases cerebral perfusion pressure.

Hyperventilation can result from an excessive tidal volume, respiratory rate, or both. The use of a mechanical ventilator may enable better control of minute volume and minimise hyperventilation, as well as freeing a rescuer from this task.

Minute volume (tidal volume x respiratory rate) determines PaCO₂. The optimal value is not known, but hypocarbia and anything more than mild hypercarbia appear detrimental to outcome. Aim for a PaCO₂ within a normal range, even in a patient with head injury, where hyperventilation-induced vasoconstriction may actually worsen cerebral oxygen delivery.

Circulation

Chest compressions during CPR

- Start chest compressions as soon as cardiac arrest is confirmed.

Full guidance on chest compression technique is provided in [Adult basic life support and automated external defibrillation](#) :

- Place the hands in the centre of the chest, which is the middle of lower half of the sternum.
- Compress the chest to a depth of 5–6 cm.
- Compress the chest at a rate of 100–120 min⁻¹.
- Ensure full release of the chest between chest compressions by avoiding leaning on the chest.
- Perform CPR on a firm surface if possible. Soft surfaces (e.g. mattress) make it difficult to estimate how deep the chest is being compressed and can lead to under compression.
- Minimise interruptions in chest compressions.

- Alternate 30 compressions with 2 ventilations.
- If the patient's trachea is intubated provide continuous chest compressions at 100–120 min⁻¹ with ventilations 10 min⁻¹.
- In patients with an SGA in situ, continuous ventilations may be possible, but if visible chest rise is not seen with each breath, give 2 ventilations after every 30 compressions.
- Try to change the person doing chest compressions every two minutes; ensure the minimum of delay during the changeover.

CPR monitoring, feedback and prompt devices

- CPR feedback and prompt devices (e.g. voice prompts, metronomes, visual dials, numerical displays, waveforms, verbal prompts, and visual alarms) should be used when possible during CPR training.
- Their use during clinical practice should be integrated with comprehensive CPR quality improvement initiatives rather than as an isolated intervention.

CPR monitoring, feedback and prompt devices enable the CPR provider to receive real-time objective feedback on the quality of CPR. These devices have been evaluated in several clinical studies that support their utility to improve the quality of CPR delivered.^{36,37}

Mechanical chest compression devices

- Do not use automated mechanical chest compression devices routinely to replace manual chest compressions.
- Automated mechanical chest compression devices are a reasonable alternative to high quality manual chest compressions when sustained high quality manual chest compressions are impractical or compromise provider safety.^{2,24}
- Avoid interruptions to CPR during device deployment. Healthcare personnel who use mechanical CPR should do so only within a structured, monitored programme, which should include comprehensive competency-based training and regular opportunities to refresh skills.

In 2006, JRCALC highlighted the absence of strong evidence supporting the use of mechanical CPR devices and recommended against their purchase for routine use pending results from large clinical trials <http://www.jrcalc.org.uk/announcements/LUCASForMedDirectors.pdf>. This position was re-iterated by a statement from the Resuscitation Council (UK) in 2013. There have now been three large randomised controlled trials (RCTs) enrolling 7582 patients that have shown no clear advantage for the routine use of automated mechanical chest compression for OHCA using the Lund University Cardiac Arrest System (LUCAS)^{38,39} and AutoPulse device.⁴⁰ Ensuring high quality chest compressions with adequate depth, rate and minimal interruptions, regardless of whether they are delivered by machine or human is important.^{41,42} Mechanical compressions usually follow a period of manual compressions – interruptions to chest compression must be minimised and delays in defibrillation avoided during transition from manual to automatic mode.⁴³ The use of training drills and 'pit-crew' techniques for device deployment are suggested to help minimise interruptions in chest compression.⁴⁴⁻⁴⁶

If an ambulance service has already purchased mechanical chest compression devices, we suggest that their use is limited to those patients requiring transfer to hospital with on-going CPR or prolonged CPR. Such patients might include patients with VF/pVT and suspected acute coronary syndrome, refractory to five shocks (persistence or recurrence of fibrillation) in whom a decision is made to transport to a 'Heart Attack Centre' for emergency coronary angiography and if indicated percutaneous coronary intervention.

Defibrillation

- Attempt defibrillation when a shockable rhythm is identified according to ALS guidelines – see [Advanced life support](#).

Defibrillation is one of the few interventions that improves outcome from sudden cardiac arrest, but its application is time critical. Each minute of delay to defibrillation reduces the probability of survival to hospital discharge by 10%.¹³

Safe use of oxygen during defibrillation

- Ensure any mask and oxygen tubing is more than one metre from the patient's chest when attempting defibrillation.

- If the patient has a tracheal tube or SGA inserted, leave the breathing system connected, or disconnect and ensure it is more than one metre from the patient's chest.

Oxygen is one of the three components of the fire triad (oxygen, ignition, source of combustion) and represents a significant fire risk during defibrillation. In 24% ambient oxygen, the rate of combustion doubles, and increases ten-fold in 30% ambient oxygen. High ambient oxygen concentrations from ventilation circuits have caused fatal fires and explosions. Oxygen can be present in concentrations above ambient due to supplementary oxygen or from an oxygen-powered LUCAS external chest compression device.⁴⁷

Pads versus paddles

- Use self-adhesive defibrillation pads for prehospital defibrillation.

Self-adhesive defibrillation pads provide better contact with the undulating skin surface, reducing the risk of arcing between electrodes (with the concomitant risk of fire) and result in a lower transthoracic impedance than that achieved with paddles, improving the transmyocardial current with some waveforms.

Defibrillation pad positioning

- When the standard antero-lateral defibrillation pad position is not feasible, bi-axillary pad or antero-posterior pad placement is an acceptable alternative.

CPR before defibrillation

- When attending as a solo responder, immediate assessment of the rhythm and defibrillation when indicated, should take precedence over airway or breathing interventions.
- Immediate defibrillation should always be performed in patients where a shockable rhythm is identified on the ECG, irrespective of the amplitude.

There is no convincing evidence that a period of chest compressions before shock delivery improves survival from cardiac arrest with a shockable rhythm, even when the cardiac arrest is unwitnessed.²⁴

Hands-on defibrillation

- Do not touch the patient during shock delivery.

Providing continuous chest compressions during the delivery of the defibrillation shock, hands-on defibrillation can minimise peri-shock pause and enable continuation of chest compressions during defibrillation. The benefits of this approach are not proven and further studies are required to assess the safety and efficacy of this technique. Standard clinical examination gloves (or bare hands) do not provide a safe level of electrical insulation.⁴⁸

Defibrillation in difficult situations

There are several situations in which the rescuer is at greater risk from leakage current and subsequent injury from accidental electrocution during defibrillation. However, in patients with a shockable rhythm, immediate defibrillation is potentially life-saving.

Defibrillation on wet surfaces

Defibrillation of a patient on a wet surface is safe providing the rescuer is not in contact with the patient. If the patient is wet, ensure that self-adhesive defibrillation electrodes make good contact – if necessary, dry the patient's skin. Poor contact risks ineffective defibrillation and arcing between electrodes.

Defibrillation on metal surfaces

Defibrillation of a patient on a metal surface is safe, providing the rescuer is not in direct contact with the patient. Metal surfaces ensure that any leakage current is completely conducted through the metal and away from any bystanders or rescuers.

Defibrillation in flight

Certification of the defibrillator and aircraft for in-flight defibrillation should be discussed with the aircraft operator to ensure safety of the aircraft operating systems. Defibrillation in an aircraft or helicopter is safe because the metal surface in contact with the patient ensures that any leakage current is conducted away from the rescuers.

The use of oxygen in the confined space of a cabin may result in raised ambient concentrations of oxygen and a theoretical increased risk of fire, although to date there are no case reports of an aircraft fire caused by

defibrillation. It would be prudent however to keep oxygen use to a minimum in aircraft cabins and other confined spaces.

Vascular access

- During CPR chest compression, defibrillation and airway interventions take priority over vascular access.
- Peripheral intravenous (IV) cannulation is the preferred option for vascular access.
- Intraosseous (IO) access is an alternative option.

Obtain IV access if this has not been done already. Peripheral venous cannulation is quick and relatively easy and is preferable to central venous access as the initial cannulation site. Although peak drug concentrations are higher and circulation times are shorter when drugs are injected into a central venous catheter compared with a peripheral cannula, insertion of a central venous catheter requires interruption of CPR and is associated with several potential complications. Drugs injected peripherally must be followed by a flush of at least 20 mL of fluid and elevation of the extremity for 10–20 s to facilitate drug delivery to the central circulation.

Some services recommend that clinicians make no more than two attempts at gaining IV access (max 2 min). If IV access is considered too difficult or cannot be established, consider gaining IO access. Follow the instructions for the intraosseous device used. Several studies indicate that IO access is safe and effective for fluid resuscitation, drug delivery and induction of general anaesthesia.

Continuous waveform capnography during CPR

- Waveform capnography must be used whenever tracheal intubation is undertaken.
- Waveform capnography may also be considered for patients ventilated via an SGA, although end-tidal CO₂ values can be less reliable because of leaks around the cuff during chest compression.

The role of waveform capnography during CPR includes:

- Ensuring tracheal tube placement in the trachea (see above).
- Monitoring ventilation rate during CPR and avoiding hyperventilation.
- Monitoring the quality of chest compressions during CPR. End-tidal CO₂ values are associated with compression depth and ventilation rate and a greater depth of chest compression will increase the value.⁴⁹ Whether this can be used to guide care and improve outcome requires further study.⁵⁰
- Identifying ROSC during CPR. An increase in end-tidal CO₂ during CPR can indicate ROSC and prevent unnecessary and potentially harmful administration of adrenaline in a patient with ROSC.⁵⁰⁻⁵³ If ROSC is suspected during CPR, withhold adrenaline. Give adrenaline if cardiac arrest is confirmed at the next rhythm check.
- Prognostication during CPR. Precise values of end-tidal CO₂ depend on several factors including the cause of cardiac arrest, bystander CPR, chest compression quality, ventilation rate and volume, time from cardiac arrest and the use of adrenaline. Values are higher after an initial asphyxial arrest, with bystander CPR and decline over time after cardiac arrest.^{50,54,55} Low end-tidal CO₂ values during CPR have been associated with lower ROSC rates and increased mortality, and high values with better ROSC and survival.^{50,56,57} The inter-individual differences and influence of cause of cardiac arrest, the problem with self-fulfilling prophecy in studies, our lack of confidence in the accuracy of measurement during CPR, and the need for an advanced airway to measure end-tidal CO₂ reliably limits our confidence in its use for prognostication. The Resuscitation Council (UK) recommends that a specific end-tidal CO₂ value at any time during CPR is not used alone to stop CPR efforts. End-tidal CO₂ values should be considered only as part of a multi-modal approach to decision-making for prognostication during CPR.

Refractory out-of-hospital cardiac arrest

A few patients who present in VF/pVT are difficult to treat and can have persistent VF/pVT. In such cases, consider changing the electrode position (i.e. move from the standard anterior-lateral to an anterior-posterior or bi-axillary position).

Recurrent episodes of VF occur in most patients who present with a shockable rhythm, even after it is successfully cardioverted. VF recurs in 50% of patients within 2 min of successful termination and in 75% of

patients during the entire cardiac arrest. Give amiodarone (300mg IV) after three defibrillation attempts, irrespective of whether those episodes are concurrent or separate.

Should the patient remain in VF, inject amiodarone as directed by the ALS guidelines and transport the patient as soon as possible, with ALS and defibrillation continued on route. Defibrillation and performing effective chest compressions whilst moving these patients to the ambulance and then to hospital is difficult. If necessary, stop the ambulance while further therapy is given. Mechanical chest compressions should be considered for transfer.

Disability (neurological) issues

- Do not use the presence of fixed dilated pupils during CPR to determine the chances of successful recovery from cardiac arrest.

Neurological assessment while a patient is in cardiac arrest and receiving ALS, including the presence of fixed dilated pupils, does not provide any guidance on whether the outcome of resuscitation will be successful in terms of neurological recovery.

Prehospital neonatal (less than 28 days of age) resuscitation

The resuscitation of a newborn in the community is invariably unexpected as high risk deliveries are usually planned to take place in hospital. The increasing numbers of home births may result in more unexpected cases of neonatal resuscitation. The resuscitation of a newborn in the community essentially follows that undertaken in secondary care – see [Resuscitation and support of transition of babies at birth](#).^{34,35} Summon emergency help early if there is any doubt about the wellbeing of the baby. Key steps include:

- Minimise delays on scene.
- Alert the hospital to the impending arrival of the baby and mother.
- The mother and baby will require separate vehicles if the baby requires resuscitation.
- Remember to cut and clamp the cord.
- Keep the baby warm.
- Dry the term or near-term infant, remove the wet towels, and cover the infant with dry towel.
- Significantly preterm infants and those requiring resuscitation are best placed, without drying, into polyethylene wrapping. Food grade plastic bags can be useful for this.^{58,59}
- In infants of all gestations, the head should be covered with an appropriately sized hat.
- Babies who do not need resuscitation may be moved with the mother and skin to skin contact with the baby and mother covered will help to keep the baby warm.
- Monitor the baby's breathing in transit.
- If the baby requires assisted ventilation, bag-mask ventilation is preferred. Tracheal intubation is generally avoided because of the high likelihood of initial tube misplacement or tube dislodgement during transfer. Tiny tubes also block easily and it is difficult to detect this in a small baby (especially if it is wrapped up) in the back of an ambulance. The procedure inevitably causes delay in transfer and the exposure required allows the baby to become cold. Most babies, even those born prematurely will respond to effective mask ventilation.
- Start resuscitation with air, and give supplementary oxygen guided by pulse oximetry – see [Resuscitation and support of transition of babies at birth](#).

Prehospital resuscitation in children

Cardiorespiratory arrest occurs less frequently in children compared with adults, hence both healthcare professionals and lay people are less likely to be involved in paediatric resuscitation. Most cardiorespiratory arrests in children are not caused by primary cardiac problems but secondary to other causes, mostly respiratory insufficiency. The priority with paediatric resuscitation is therefore usually to reoxygenate the child. See the sections on [Paediatric basic life support](#) and [Paediatric advanced life support](#). Specific considerations include:

- Children are likely to have severe underlying illness or injury that can only be managed adequately in hospital and it is therefore particularly important not to delay on scene.

- Bag-mask ventilation is the recommended first line method for achieving airway control and ventilation in children.
- Supraglottic airways may provide a useful alternative when bag-mask ventilation is not possible.
- Tracheal intubation is seldom indicated unless an individual with appropriate skills is able to perform the procedure. Even then, the benefits must be weighed up carefully, as it may prolong the time on scene. The journey time to the hospital, skills available at the scene and clinical condition of the patient, including the risk of aspiration, should be considered.
- Difficulties with ALS procedures (e.g. establishing vascular access), must not delay the transfer of the child to hospital – continue good quality BLS as the priority. Attempt ALS procedures en route if practical, stopping briefly only if essential (e.g. while attempting cannulation).
- Use paediatric pads for defibrillation of children under 8 years. If these are not available, adult electrodes placed in an antero-posterior orientation will suffice. Use of defibrillators in a manual mode is optimal, but where only an automatic mode is available (AED), it is still preferable to analyse the rhythm and deliver a shock if prompted to do so rather than withholding defibrillation.
- For single responders, opening the airway and providing effective ventilation takes priority over attaching a defibrillator.
- Gaining rapid vascular access in children is often quickest using an intraosseous needle. This should be used in preference to an intravenous cannula unless a suitable site for venous cannulation is immediately apparent.
- Children become hypothermic easily because of their large surface area to volume ratio. It is important to keep them as warm as possible before, and during, transfer.

Resuscitation in special situations

Drowning

In the UK, there are approximately 350 accidental deaths from drowning each year. Drowning is commonest in males aged 20–30, and occurs mostly in inland waters (e.g. lakes, rivers) and during summer months.

Water rescue

- Whenever possible, bystanders should attempt to save the drowning victim without entry into the water. Talking to the victim, reaching with a rescue aid (e.g. stick or clothing), or throwing a rope or buoyant rescue aid may be effective if the victim is close to dry land.
- Rescue can present significant risk to the rescuer, but a sensible risk assessment is necessary to ensure that potentially survivable victims are rescued promptly.
- If entry into the water is essential, take a buoyant rescue aid, flotation device or boat. It is safer to enter the water with two rescuers than alone.
- Submersion durations of less than 10 min are associated with a very high chance of a good outcome, and submersion durations of more than 25 min are associated with a low chance of good outcome.
- In the UK combined emergency services guidance recommends review of search and rescue efforts at 30 and 60 min from when the emergency services arrive on scene (Figure 1). Extended rescue efforts up to 90 min may be appropriate for children or those submerged in icy cold water, although the protective effects of extreme hypothermia are unlikely to be sufficient in the UK where water is insufficiently cold to cool rapidly and provide neuroprotection.
- Trained individuals should only consider in-water ventilation (with the support of a buoyant rescue aid) if there is likely to be a delay in reaching land or a rescue craft.
- Remove the victim from the water promptly. The chances of a drowning victim sustaining a spinal injury are very low. Spinal precautions are unnecessary unless there is a history of diving in shallow water, or signs of severe injury after water-slide use, water-skiing, kite-surfing, or watercraft racing. No more than 0.5% of these patients have a cervical spine injury and rescue takes precedence over cervical spine protection. If the victim is pulseless and apnoeic, remove them from the water as quickly as possible while attempting to limit neck flexion and extension. If concerns exist about cervical spine injury in the non-arrest patient, limit cervical spine flexion and extension as much as possible and use a scoop stretcher for immobilisation and transfer.

- Hypovolaemia after prolonged immersion can cause cardiovascular collapse/arrest on removal from water, especially if the victim is upright. Aim to keep the victim in a horizontal position during and after retrieval from the water.

Resuscitation after water rescue

- Check for a response by opening the airway and checking for signs of life. The drowning victim rescued from the water within a few minutes of submersion is likely to exhibit abnormal (agonal) breathing. Do not confuse this with normal breathing.
- Bystander CPR is particularly important in these patients as they will be hypoxic. If the bystander is trained or able, dispatcher-assisted CPR advice should include rescue breaths. In these patients, compression-only CPR is likely to be ineffective and should be avoided.
- Give five initial rescue breaths, supplemented with oxygen if available.
- If the victim has not responded to initial ventilations, place them on a firm surface before starting chest compressions.
- Massive amounts of foam caused by mixing moving air with water and surfactant can sometimes come out of the mouth of victims. If this occurs, continue rescue breaths/ventilation until a rescuer with sufficient expertise can intubate the trachea.
- Follow standard ALS protocols.
- Consider the early use of a mechanical chest compression device when a prolonged resuscitation attempt is to be undertaken.
- Hypothermia is common after drowning. If the victim's core body temperature is $<30^{\circ}\text{C}$, limit defibrillation attempts to three (delivered at maximum defibrillator output), and withhold IV drugs until the core body temperature increases $>30^{\circ}\text{C}$. Withhold adrenaline, and amiodarone until the patient has been warmed to $>30^{\circ}\text{C}$. Between $30\text{--}35^{\circ}\text{C}$, the intervals between drug doses should be doubled when compared with normothermia intervals. Above $>35^{\circ}\text{C}$, standard drug protocols should be used. Prehospital rewarming is of limited effectiveness in unconscious patients, but use of heating blankets and a warm ambient environment should be considered.

Opioid overdose

- In known opioid overdose associated with respiratory depression, respiratory arrest, or to help diagnose suspected opioid overdose, the usual initial adult dosage of naloxone hydrochloride is 400–2000 mcg IV, given at 2–3 min intervals and titrated to response.
- Naloxone may be given for cardiac arrest associated with opioid overdose, but its benefit is uncertain.
- If no response is observed after a total of 10 mg IV naloxone, consider a non-opioid related drug or other process.
- If the IV route is not available, naloxone may be given by IM, IO, SC or intranasal routes. Additional doses may be necessary if the patient's level of consciousness falls, or if the patient's respiratory rate decreases again, because the half-life of naloxone can be shorter than the opioid causing the respiratory depression.
- Only give as much as is necessary to achieve an adequate respiratory rate, as an excessive dose, particularly in chronic opioid users, can cause agitation and occasionally seizures.

Cocaine toxicity

- Follow standard ALS guidelines for the resuscitation of patients with cocaine toxicity.
- Seizures associated with cocaine toxicity should be managed according to standard protocols with benzodiazepines.

Cocaine can cause intense sympathetic stimulation, resulting in coronary artery spasm and subsequent myocardial infarction.

Cardiac arrest in pregnancy

Deaths related to pregnancy are relatively rare in the UK. The fetus must always be considered when an adverse cardiovascular event occurs in a pregnant woman. Fetal survival usually depends on maternal survival so initial

resuscitation efforts should focus on the pregnant mother.

Haemorrhage, embolism (thromboembolic and amniotic fluid), hypertensive disorders of pregnancy, abortion and genital tract sepsis account for most deaths directly associated with pregnancy.⁶⁰ In the UK, maternal deaths (death during pregnancy, childbirth, or in the 42 days after delivery) between 2009 and 2012 were associated with cardiac disease, neurological conditions, psychiatric conditions, and malignancies.⁶¹ A quarter of pregnant women who died in the UK had sepsis, and 1 in 11 had influenza.

Significant physiological changes occur during pregnancy. Blood volume and cardiac output increase, together with minute ventilation and oxygen consumption. At about 20 weeks, compression of the abdominal aorta and inferior vena cava by the gravid uterus can reduce distal blood flow and venous return, resulting in reduced cardiac output and hypotension. The evidence for specific interventions for the treatment of cardiac arrest in pregnancy is weak.^{2,62,63}

Prevention of cardiac arrest in pregnancy

- Use the ABCDE approach to identify and treat the underlying cause (e.g. rapid recognition and treatment of sepsis, including early intravenous antibiotics).
- Place the patient in the left lateral position or manually displace the uterus to the left.
- Give high-flow oxygen, guided by pulse oximetry and aim to correct hypoxaemia.
- Establish IV access and give a fluid bolus (250 mL) if there is hypotension or hypovolaemia.
- Seek expert help early and transport the patient to the nearest appropriate hospital with minimal delay. Obstetric, anaesthetic and neonatal specialists should be involved early in the resuscitation.

Modifications for cardiac arrest in pregnancy

- Start resuscitation according to standard ALS guidelines.
- The hand position for chest compressions may need to be slightly higher (2–3 cm) on the sternum for patients with advanced pregnancy (e.g. >28 weeks).⁶³
- Manually displace the uterus to the left to minimise inferior vena cava compression.
- Add left lateral tilt only if this is feasible. The patient's body will need to be supported on a firm surface to enable effective chest compressions (e.g. a full length tilting operating table). Aim for between 15–30°. Even a small amount of tilt may be better than no tilt. The angle of tilt used needs to permit high quality chest compressions and if needed caesarean delivery of the fetus (see below).
- If tilting on a firm surface is not possible maintain left uterine displacement and continue effective chest compressions with the patient supine.
- Defibrillation energy levels are as recommended for standard defibrillation. If left lateral tilt and large breasts make it difficult to place an apical defibrillator electrode, use an antero-posterior or bi-axillary electrode position.
- Consider using a tracheal tube 0.5–1.0 mm smaller than usual as the trachea can be narrowed by oedema and swelling. SGAs are a suitable alternative in the prehospital setting and may provide a more rapid means of oxygenation than potentially prolonged intubation attempts.
- Establish IV access as soon as possible, preferably at a level above the diaphragm.
- Identify and correct the cause of the arrest using 4 Hs and 4Ts as appropriate.
- If resuscitation attempts fail to achieve ROSC, consider an immediate caesarean section to deliver the fetus. Aim to deliver the infant within 5 min of the mother's cardiac arrest. This may benefit the mother from 20 weeks gestation onwards, when aortocaval compression can be significant, and benefit the newborn infant from 24 weeks gestation.

Anaphylaxis

- Follow standard ALS guidelines for the resuscitation of patients with cardiac arrest and known or suspected anaphylaxis, including IV adrenaline.
- Give immediate IM adrenaline according to current anaphylaxis guidelines to prevent cardiorespiratory arrest.

- If IV or IO access cannot be established rapidly, give IM adrenaline if cardiorespiratory arrest has occurred recently.

Adrenaline is the most important drug for the treatment of an anaphylaxis.⁶² As an alpha-receptor agonist, it reverses peripheral vasodilation and reduces oedema. Its beta-receptor activity dilates the bronchial airways, increases the force of myocardial contraction, and suppresses histamine and leukotriene release. Adrenaline is most effective when given early after the onset of the reaction. The benefit of 0.5 mg IM adrenaline in cardiorespiratory arrest is uncertain, but it is unlikely to be harmful, and may be helpful when given early, and if despite clinically appearing to be in cardiorespiratory arrest, the patient still has a very low cardiac output.

Asthma

- Follow the current British Thoracic Society/SIGN Asthma Guidelines to prevent cardiac arrest.⁶⁴
- Follow standard ALS guidelines for the resuscitation of patients with cardiac arrest associated with asthma.
- If IV or IO access cannot be established rapidly, give IM adrenaline if cardiorespiratory arrest has occurred recently.
- When the appropriate skills are available intubate the trachea to enable ventilation of stiff lungs and avoid gastric insufflation.
- Identify and treat tension pneumothorax with needle decompression or thoracostomy as appropriate.
- Some case reports have reported ROSC in patients with air trapping when the tracheal tube was disconnected.⁶² If dynamic hyperinflation of the lungs is suspected during CPR, compression of the chest while disconnecting tracheal tube may relieve air trapping. Although this procedure is supported by limited evidence, it is unlikely to be harmful in an otherwise desperate situation.

Cardiac arrest associated with asthma results from respiratory exhaustion, respiratory acidosis and impaired venous return caused by high intrathoracic pressures. It may also be precipitated by a tension pneumothorax that is, on rare occasions, bilateral. If there is a history of a severe asthma attack leading to cardiac arrest, adrenaline 0.5 mg IM can be given early, if IV access is not immediately available. The benefit of IM adrenaline in cardiorespiratory arrest is uncertain, but it is unlikely to be harmful, and may be helpful when given early, and if despite clinically appearing to be in cardiorespiratory arrest, the patient still has a very low cardiac output.

Mass casualty incident

When the demand placed by an incident on emergency medical services outstrips supply, a major incident is deemed to have occurred. During a major incident, the aim of medical services is to 'do the most, for the most'. The medical response to a major incident needs to be planned, organised and rehearsed in a multidisciplinary environment (National Ambulance Resilience Unit –<http://naru.org.uk>).

The declaration of a major incident needs to be made early and cascaded to all emergency services. Early information about major incidents is usually communicated with the use of mnemonics, such as METHANE (or CHALETS):

There is little international consensus on the management of major incidents but the UK Advanced Life Support Group Major Incident Medical Management & Support (MIMMS®) system has been adopted by many international EMS systems. Initial management is described by the CSCATTT system.

Command & Control	<i>Established across all emergency services</i>
Safety	<i>Of oneself, the scene, the patient</i>
Communication	<i>Using runners, radio, data & telephone systems</i>
Assessment	<i>Of the scene</i>
Triage	<i>Using triage sieve and triage sort</i>
Treatment	<i>Usually only life-saving procedures</i>
Transport	<i>By the appropriate means, to the appropriate hospital</i>

Chemical, Biological, Radiological, Nuclear (CBRN) incidents

- The key priority of the first medical personnel on arrival at a CBRN incident is to ensure all emergency service control centres are alerted and specialist resources are summoned early.
- If there is one casualty, rescuers may approach as usual. If there are two casualties, only approach with caution, considering all options. If there are three or more casualties, one should not approach. Instead withdraw, contain the scene, report the situation, isolate oneself and await specialist resources.

Although CBRN incidents are often considered together as incidents that require 'special' management, they have little in common. Biological incidents may be triggered by possible large scale exposure to a biological incident (e.g. 'white powder' incidents) but since all agents have an incubation period, victims rarely present at the same time in the same place. Radiological and nuclear incidents are usually immediately apparent and require a national response.

Prevention of environmental contamination and evacuation are key. Chemical incidents have historically had major implications for prehospital providers. A chemical incident may initially present with patients in a peri- or actual cardiac arrest. Proper scene management of chemical incidents is crucial for preventing further exposure and incident escalation. Early pattern recognition of chemical agent syndromes is vital, and prehospital care providers should be aware of the constant threat of this type of incident. These can result from terrorist action, industrial and chemical incidents, as well as isolated cases of toxic exposure.

The signs of a CBRN incident can often be subtle or delayed and emergency medical personnel should always be vigilant for abnormal situational or patient factors that raise suspicion of a CBRN incident. Exposure to a CBRN agent can occur through direct contact, inhalation, injection, ingestion or irradiation. A patient in cardiac arrest as a result of a CBRN incident should only be approached and treated once the risk to rescuers is known.

Personal protection

- Rescuers must not approach potential casualties unless adequate personal protective equipment (PPE) is worn.

Personal protection is paramount if a CBRN incident is suspected. The immediate vicinity around a potential CBRN incident site, requiring specialist PPE to be worn, is described as the 'hot zone'. In some cases, this may require the wearing of gas-tight suits with integrated breathing apparatus. If in doubt, the rescuer should withdraw to a place of safety until the CBRN threat can be accurately identified and the necessary PPE brought to scene. Entering a CBRN scene without adequate PPE puts the rescuer at risk of harm and also risks spread of contamination. A CBRN patient will need decontamination prior to being able to receive advanced medical care.

Scene management

- Only personnel with correct PPE are permitted to enter the hot and warm zones and only decontaminated patients are permitted to leave these zones.

The CBRN scene is contained with an enforced cordon as early as possible to prevent spread of contamination. Hot, warm and cold zones need to be clearly cordoned and controlled.

Decontamination

- Wherever possible, patients should be decontaminated at scene.

This will require specialist resources, which reduce the risk of contamination spread, particularly to local hospitals. However, patients may self-present for medical care so local hospitals should have a pre-rehearsed plan for decontaminating patients on arrival. Removal of clothing and placing in a well-ventilated area removes the majority of chemical agents.

Traumatic cardiac arrest

Survival from out-of-hospital cardiac arrest associated with trauma is uncommon, but survival rates as high as 6–7% have been reported.^{62,65} The main aim of prehospital management of traumatic cardiac arrest is to rapidly identify and treat reversible causes. These commonly include airway obstruction, hypoxaemia or hypoventilation, and tension pneumothorax.

A few patients may have a cardiac arrest of cardiac origin, but then sustain major trauma as a result. In these cases, outcome is likely to depend on the well-established prognostic indicators of early CPR and defibrillation, as well as the nature and severity of any injuries. The traumatic cardiac arrest treatment algorithm (Figure 2) describes the key steps. Adherence to the key steps in this algorithm can lead to survival.^{65,66} This algorithm aims to rapidly identify and correct reversible causes of traumatic cardiac arrest.

- Transport of traumatic cardiac arrest patients from the scene to hospital with on-going CPR is usually futile and key interventions need to be performed as soon as possible, usually on-scene.

Diagnosis of traumatic cardiac arrest

- Assess for agonal, abnormal or absent breathing, and the absence of a central pulse to confirm cardiac arrest. This should be a rapid check and should take less than 10 s.

The diagnosis of traumatic cardiac arrest is clinical. Agonal, abnormal or absent spontaneous respiration and absence of a central pulse should immediately prompt entry into the algorithm if there is a possibility that the cardiac arrest could be traumatic in origin. Recognition of the peri- or cardiac arrest state should take less than 10 s and not be delayed to initiate monitoring. Providers of emergency care must understand that resuscitation from cardiac arrest is not always futile and survival from traumatic cardiac arrest has improved considerably over the past decade.

When to start and stop resuscitation after traumatic cardiac arrest

- When death can be categorically confirmed (e.g. decapitation, rigor mortis), do not start resuscitation.
- If the patient is in cardiac arrest on arrival of the ambulance crew, resuscitation can be stopped in blunt traumatic cardiac arrest when the patient meets the following criteria:
 - unwitnessed cardiac arrest
 - apnoeic
 - pulseless
 - no organised cardiac electrical activity
 - no pupillary light reflexes on arrival
- If resuscitation has started, use the following criteria to stop resuscitation:
 - likely reversible causes of traumatic cardiac arrest have been treated
 - no ROSC after 20 min of ALS.

If a patient is witnessed by the EMS crew to have a cardiac arrest following trauma (or blunt or penetrating nature), consider termination of the resuscitative effort if the patient has not responded to 20 min of ALS. The exceptions are for pregnancy, where the patient should be transported and resuscitative hysterotomy considered, children, and where hypothermia may be a contributory factor.

The peri-arrest patient with trauma

Victims of major trauma can present in a peri-arrest state. Cardiovascular instability, including bradycardia, profound hypotension or rapidly decreasing blood pressure, loss of peripheral pulses, together with a deteriorating conscious level should immediately alert the emergency care provider of imminent cardiac arrest. Rapid, targeted interventions aimed at correcting reversible causes can prevent cardiac arrest. In cases where the patient is still self-ventilating, early drug-assisted tracheal intubation may be warranted. Although cardiac arrest secondary to hypovolaemia is usually unsurvivable, aggressive management of the hypovolaemic peri-arrest patient with blood and blood products, in combination with surgical intervention, can result in survival.

Basic/Advanced Life Support for traumatic cardiac arrest

- Start basic and, if available, advanced life support immediately.
- Haemorrhage control and volume replacement should be carried out simultaneously.

Chest compressions provide some blood flow during cardiac arrest and should be continued whilst the history and mechanism of injury have been accurately established. In profound hypovolaemia, chest compressions are likely to be minimally effective because of poor cardiac filling and external compression of an empty heart.⁶⁷ Immediate diagnosis of hypovolaemia can be difficult and, if in doubt, chest compressions should be continued. The patients with the best chance of survival are normovolaemic and cardiac compressions can be at least partially effective while reversible causes are addressed simultaneously. Standard BLS/ALS without urgent attention to reversible causes is unlikely to result in ROSC (unless the cardiac arrest is of 'medical origin'). Advanced life support interventions for traumatic cardiac arrest such as tracheal intubation and the use IV/IO adrenaline should be as for a medical cardiac arrest.

Traumatic versus medical cardiac arrest

Establishing the cause of cardiac arrest may not be straightforward. A primary medical arrest can occur prior to a patient suffering a traumatic insult. Such patients may initially appear to have had a traumatic cardiac arrest but have minimal, if any, injuries. Primary medical cardiac arrests resulting in falls from height or whilst driving are examples that can typically result in rescuers suspecting cardiac arrest of traumatic origin. Pay close attention to a witness history and an accurate scene assessment to establish the course of events and mechanism of injury. If there is a possibility that the patient has had a primary medical cardiac arrest, follow standard BLS and ALS guidelines.

Penetrating trauma

Patients with penetrating wounds to the chest, epigastrium or between the scapulae resulting in cardiac arrest either have cardiac tamponade and obstructive shock or have an empty heart as a result of hypovolaemia.⁶⁸ For the patient to have any chance of survival, resuscitative thoracotomy should be performed immediately when trained personnel are on-scene.^{66,69} Any delay in undertaking resuscitative thoracotomy will decrease the patient's chance of survival.

Resuscitative thoracotomy

Resuscitative thoracotomy is associated with a significant survival rate in patients with cardiac tamponade and is the only surgical intervention that can result in neurologically good outcome in traumatic cardiac arrest following penetrating chest trauma. This is likely to be particularly successful where cardiac arrest is caused by cardiac tamponade and a simple cardiac wound.⁷⁰ In most emergency medical service (EMS) systems, thoracotomy is undertaken only in the emergency department. EMS crews must move at-risk patients quickly to where thoracotomy is available.⁷¹

Resuscitative thoracotomy undertaken in the prehospital setting does not aim to treat all the possible causes of cardiac arrest following penetrating chest trauma. It aims to treat simple cardiac wounds that have resulted in cardiac tamponade. In most cases of traumatic cardiac tamponade, there is a considerable volume of clotted blood and needle pericardiocentesis is likely to be ineffective. Thoracotomy and formal pericardotomy are needed. In cases of traumatic cardiac arrest, patients may also benefit from high quality, internal cardiac massage to achieve ROSC. Resuscitative thoracotomy should be considered for patients with penetrating torso trauma with less than 15 min of CPR and patients with blunt trauma with less than 10 min of prehospital CPR.

Resuscitative thoracotomy in traumatic cardiac arrest from blunt trauma is much less likely to be successful and injuries present are more likely to be complex and less amenable to prehospital treatment. The availability of blood for immediate transfusion may improve outcome in these patients but further research is required in this area.

Reversible causes of traumatic cardiac arrest

The 4 Hs and 4Ts approach will highlight the common causes of treatable traumatic cardiac arrest:

- Hypovolaemia,
- Hypoxia (Oxygenation)
- Tension pneumothorax
- Tamponade – cardiac

Patients with traumatic cardiac arrest commonly have one or more injuries resulting in severe hypovolaemia, critical hypoxaemia, tamponade or tension pneumothorax, either in isolation or concurrently. Each of these conditions needs to be addressed simultaneously by the prehospital team and active management commenced.

Hypovolaemia and fluid replacement

- Immediately control active external haemorrhage by applying direct pressure to bleeding wounds.
- Where bleeding from isolated wounds has been effectively controlled, volume re-expansion should follow. Recent military experience has focussed on aggressive management of compressible haemorrhage with the use of pressure dressings, topical haemostatic agents and tourniquets.⁷²
- Haemorrhage into pelvic and long bone fractures can be significant. Splint fractures of the pelvis and long bones and if there is a suspicion of a pelvic fracture, apply a pelvic binder to reduce the pelvis to an anatomical position taking care to minimise patient movement. Reduce long bone fractures to an anatomical position and apply splints.

Prehospital fluids

A peri-arrest patient, or one with established traumatic cardiac arrest as a result of hypovolaemia, is unlikely to achieve ROSC unless haemorrhage control is performed in combination with volume replacement. In traumatic cardiac arrest where hypovolaemia may be a contributing factor, commence fluid infusion as soon as IV/IO access is established.

In the peri-arrest or post-ROSC trauma patient, restoring the blood pressure to normal values may increase bleeding.⁷² In adults, give fluid in 250 mL boluses only until a radial pulse is palpable. In patients with penetrating chest trauma, titrate fluid to a carotid pulse.⁷³

In patients who have arrested from hypovolaemia, large volumes (2–3 L) of fluid (preferably blood) may be needed to achieve ROSC. Assess the patient for signs of spontaneous circulation after each 250 mL bolus of fluid is infused.

Minimise the volume of crystalloid or colloid that is administered using warmed blood (packed red cells) in preference when available.⁷⁴ Prehospital activation of hospital major transfusion protocols should diminish the time required for the patient to receive blood products.⁷⁵ Fluid replacement in bleeding patients is only a holding measure until definitive surgical control can be achieved and delays in out-of-hospital are invariably associated with a poor outcome. Aim to leave the scene with the patient as soon as possible.

Tranexamic Acid

A large, high quality randomised clinical trial demonstrated the benefit of giving tranexamic acid to trauma patients with suspected haemorrhage. In the study, death caused by bleeding was reduced if tranexamic acid was given within 3 h of injury.⁷⁶

- Give adult trauma patients with suspected haemorrhage a prehospital dose of tranexamic acid 1g IV/IO over 10 min.⁶⁰

Hypoxaemia

Airway management and optimising oxygenation are important. Major trauma victims are likely to have a high oxygen requirement or may have been apnoeic for a period following blunt traumatic injury. Initial attention should be paid to high quality, basic airway management with cervical spine control, using airway adjuncts if required. Attention to basic airway management is vital in the unconscious trauma patient who is at risk of airway compromise.

Secure a definitive airway by insertion of a cuffed tracheal tube as early as possible. In the prehospital phase of care, use an SGA if drug-assisted intubation is not available. A tracheal tube enables the delivery of high concentration oxygen, protects against airway soiling and enables provision of positive pressure ventilation. Paediatric intubation is undertaken only by those with appropriate training and experience in the procedure. During CPR, use 100% oxygen. In peri-arrest or post-ROSC patients, titrate the inspired oxygen concentration to achieve an SpO₂ of 94–98%.⁷⁷

Tension pneumothorax

Actively look for and exclude a tension pneumothorax in cases of traumatic cardiac arrest. Manage any open pneumothorax or sucking chest with a dressing that enables air to be released from the pleural cavity. Bilateral needle chest decompression is rapid and within the skill set of most EMS personnel and should be performed immediately. However, needle decompression is of limited value in traumatic cardiac arrest.^{78,79} A proportion of patients will have a chest wall thickness greater than length of a 14-gauge cannula placed in the second intercostal space, in the mid-clavicular line, creating the misconception that the problem has been treated.^{80,81} Cannulae are also prone to kinking or blockage.⁸²

Tracheal intubation, positive pressure ventilation and formal chest decompression will effectively treat tension pneumothorax in patients with traumatic cardiac arrest. Simple thoracostomy is straightforward and used in several prehospital physician services. This consists of a simple incision and rapid dissection into the pleural space in the positive pressure-ventilated patient.⁸³⁻⁸⁵ Chest tube insertion is carried out after the resuscitation phase. Tube thoracocentesis requires additional equipment, takes longer to perform and creates a closed system that has the potential to re-tension. Chest drain tubes may become blocked with lung or blood clots and have the potential to kink.⁸⁶

6. Recognition of life extinct (ROLE)

The Association of Ambulance Services Chief Executives (through the Joint Royal Colleges Ambulance Liaison Committee, Ambulance Service UK Clinical Practice Guidelines),³ and the joint statement from the British

Medical Association, the Resuscitation Council (UK) and the Royal College of Nursing both provide guidance on decisions concerning starting and stopping CPR.⁸⁷

Before starting or during resuscitation, a clinician should decide whether attempted CPR is appropriate for the individual in the current circumstances.

In the presence of cardiorespiratory arrest, and in the absence of a documented do-not-attempt cardiopulmonary resuscitation (DNACPR) decision or advance decision to refuse treatment (ADRT), ambulance clinicians should start CPR unless the patient has a condition unequivocally associated with death.

When not to start CPR

The UK Ambulance Service Clinical Practice Guidelines lists the following situations as those that are unequivocally associated with death:³

- Decapitation
- Massive cranial and cerebral disruption
- Hemicolectomy (or similar massive injury)
- Incineration (>95% full thickness burns)
- Decomposition/putrefaction
- Rigor mortis and hypostasis.

Special care should be taken with rigor mortis. There may be other situations (e.g. following ingestion of certain drugs) that may cause a patient to have abnormal rigidity in the moments directly after a cardiac arrest.

Every decision about CPR must be based on the individual person's circumstances. In a cardiac arrest the patient has inevitably lost the capacity to contribute to decision-making. It is the responsibility of the senior responsible clinician to decide whether or not to attempt CPR. If the patient has recorded their refusal of CPR in an ADRT that is legally binding on a clinician (England & Wales - Mental Capacity Act 2005), if they are satisfied that it is valid in the current circumstances. Otherwise a clinician may be guided by a recorded DNACPR decision.

If a person is known to be in the final stages of an advanced and irreversible condition, in which attempted CPR would be both inappropriate and unsuccessful, CPR should not be started. Even in the absence of a recorded DNACPR decision, experienced clinicians may be able to recognise this situation and make an appropriate decision, based on clear evidence that they should document. Where there is doubt, it may be necessary to start attempted CPR and to review whether or not to continue in the light of any further information received during the resuscitation attempt.

All decisions to attempt CPR, withhold CPR or stop CPR must be based on the best interests of the patient. These should be guided by what the patient would have chosen for themselves if they had had the capacity to decide. If the patient has appointed a legal representative (e.g. Power of Attorney) to make such decisions on their behalf that person must be consulted (if they are present or contactable immediately at the time of the arrest). Otherwise, whenever possible, decisions should take into account the views of the patient's family or others close to the patient. Their role is to guide clinicians as to the patient's previously expressed beliefs and wishes, and their own views, but it is crucial that they understand that they are not being asked to decide whether to start, to withhold or to stop CPR. That decision must be made by the senior clinician. In any cardiac arrest the best interest of the patient remain paramount. Consultation with others or attempts to contact others must not be allowed to compromise the chances of recovery by delaying CPR that is or may be appropriate.

When to stop CPR

In most patients where ROSC is not achieved on scene, despite appropriate ALS and treatment of any potentially reversible causes, little is to be gained from transferring these patients to hospital. Conveying a patient in cardiac arrest to hospital is not easy, through the logistics of having to move a patient down stairs, off the floor or into an ambulance, each of which may cause an interruption in chest compressions as well as the risks associated with manual handling. Conveying a patient in a vehicle traveling under emergency conditions is not without risk to the patient and the clinical team.

Asystole for more than 20 min

The UK Ambulance Service Clinical Practice Guidelines (2013) state that where a patient has had persistent asystole for more than 20 min, despite ALS, and where drowning, hypothermia, poisoning or overdose, and pregnancy have been excluded, it is appropriate for the resuscitation attempt to be stopped.³

Pulseless electrical activity

The decision about when to stop a cardiac arrest where pulseless electrical activity (PEA) persists is less clear and is not currently within the UK Ambulance Service Clinical Practice Guidelines (2013).³ The reported survival to discharge rate for PEA is very low (one UK registry reported this to be 4.2 %). There is limited evidence to support when one should terminate a PEA cardiac arrest, but the length of time in arrest without life support, the absence of reversible causes and co-morbidities are important factors to consider when making this decision.

Ventricular fibrillation

Where practical, transport patients with persistent VF or pVT to a cardiac arrest centre with ongoing CPR, because further in-hospital treatment may occasionally be successful.

Communication with relatives

Offer relatives the opportunity to be present during the resuscitation attempt, providing their physical presence and behaviour does not interfere with clinical care. Although priorities during the management of a cardiac arrest lie with the patient, it is important to consider the relatives who may also be present. Relatives are also patients in this setting and sensitive treatment of relatives may help the mourning process and minimise subsequent grief. Explain to the relatives as soon as possible during the resuscitation, the gravity of the situation and the care that is being administered. If a decision is made to terminate the resuscitation attempt, consider inviting the relative(s) to be with the patient before CPR is stopped (if they are not already present) so that they can spend time with their loved one before they die.

7. Post-ROSC management

See [Post-resuscitation care](#) section for more details.

General principles

The focus of post-ROSC management is directed at optimising perfusion of the brain and heart using the ABCDE approach.

Undertake monitoring including:

- blood pressure
- continuous ECG monitoring
- 12-lead ECG where appropriate
- pulse oximetry
- continuous waveform capnography.

Measure the patient's blood glucose and temperature.

Haemodynamic management

Following ROSC, patients are usually haemodynamically unstable, often hypotensive and may have further arrhythmia. Aim for a systolic blood pressure of 90–100 mmHg. A 250 mL IV/IO bolus of 0.9% saline is appropriate should the patient be hypotensive, repeated as necessary.

In the event of symptomatic bradycardia, give atropine according to current bradyarrhythmia guidelines (see [Peri-arrest arrhythmias](#)). If ineffective, consider external pacing. If the patient has an unstable cardiac rhythm such as VT (with a pulse) or complete heart block, treat as directed by current guidelines (i.e. external pacing for heart block and cardioversion for sustained VT).

In the event of severe hypotension despite fluids and correction of arrhythmia, consider inotropic support. Boluses of adrenaline 0.1 mg IV may be titrated against blood pressure. This should be undertaken only in the setting of robust governance where telephone medical support is available.

If the 12-lead ECG shows ST segment-elevation transport the patient to a hospital capable of delivering PPCI, regardless of the patient's conscious level.

Ventilation

Switch from manual to mechanical ventilation of the lungs, ensuring that there is adequate rise and fall of the patient's chest.

- Waveform capnography is mandatory for intubated patients.
- Aim to maintain the SpO₂ at 94–98% and the end-tidal CO₂ at 4.6–6 kPa (35–45 mmHg). End-tidal CO₂ values may be lower in patients with a poor cardiac output.

Targeted temperature management

The benefits of therapeutic hypothermia for post-arrest patients are unclear, but immediate temperature management aims to achieve a core temperature no higher than 36.0 °C. Passive cooling is appropriate for these patients. Do not cover the patients in blankets etc. and maintain the internal ambulance temperature no higher than ambient. Do not infuse cold intravenous fluids rapidly for cooling alone.

Glucose management

- Treat hypoglycaemia with 10% glucose IV/IO, in boluses of 100 mL, as directed by current guidelines.³ Be sure to recheck the blood glucose after each dose.
- Children are more prone than adults to hypoglycaemia – check their blood glucose as soon as possible.

The combative patient

Following ROSC, patients may be cerebrally irritated and combative. Exclude hypoglycaemia and hypoxaemia. These patients may benefit from formal anaesthetic management, but incremental doses of IV diazepam or midazolam may be indicated, with appropriate telephone medical support if advanced medical care is not available on scene.

Seizure control

Seizures that do not self-terminate within a few minutes may be treated with a benzodiazepine, titrated to effect. The administration of diazepam or midazolam is carried out in line with UK Clinical Practice (JRCALC) or local service clinical guidelines. Seizures and muscle twitching may occur in as many as 40% of patients in the immediate post-resuscitation phase. They are more common in patients whose GCS remains low. Seizures increase cerebral metabolism up to 3-fold and can worsen brain damage after cardiac arrest.

Transporting the patient to hospital

Ongoing resuscitation whilst moving the patient to the ambulance and delivering CPR in a moving ambulance is sub-optimal. Aim to achieve ROSC on scene. Once ROSC has been achieved or when a decision has been made to transport with ongoing CPR, aim to leave the scene as soon as possible.

When the decision is made to transport the patient with ROSC, maintain the patient in a position most likely to optimise cerebral perfusion:

- supine
- feet first if coming down stairs
- slightly head up (30°) once in the vehicle.

Assess the patient using the ABCDE approach before leaving scene and transport the patient to the nearest appropriate hospital.

8. Patient destination

Cardiac arrest centres

Following ROSC, there is wide variation in hospital outcomes from OHCA.⁸⁸ Increased hospital volume is linked to patient outcomes for trauma care, through critical care and PPCI for ST elevation myocardial infarction (STEMI). For OHCA, it seems that the provision of specialist services is more important than the number of OHCA patients treated.⁸⁹ Such specialist services mainly involve the provision of expert post-resuscitation care, PCI, heart rhythm specialists and device implantation.^{90,91}

The NICE quality standards state that:⁹²

- Adults with acute STEMI who present within 12 hours of onset of symptoms have primary percutaneous coronary intervention (PCI), as the preferred coronary reperfusion strategy, as soon as possible but within 120 minutes of the time when fibrinolysis could have been given.
- Adults who are unconscious after cardiac arrest caused by suspected acute STEMI are not excluded from having coronary angiography (with follow-on primary percutaneous coronary intervention (PCI) if indicated).

The London Ambulance Service evaluated a system that allowed ambulance clinicians to autonomously convey OHCA STEMI patients who achieve ROSC directly to a Heart Attack Centre (a hospital offering immediate PPCI services at all times) and documented excellent outcomes (66% survival to discharge).⁹³ Improvements in survival have also been reported with immediate PCI in patients resuscitated from cardiac arrest due to suspected acute coronary syndrome regardless of whether or not ST-segment elevation is present.⁹⁴ Ambulance services should provide care pathways that ensure the direct transfer of patients following cardiac arrest with both STEMI and NSTEMI to regional Heart Attack Centres.

Pre-alerting

When transporting a patient in cardiac arrest, or once ROSC has been achieved, it is essential that the receiving hospital has as much notice as possible of the impending arrival. When pre-alerting, ensure that you identify the hospital, department and name of the person receiving your message.

- Pass the patient details in a structured way so that key information is not forgotten. Typically, this is done using the ATMIST mnemonic:

ATMIST	
Medical	Trauma
Age	Age
Time of onset	Time of incident
Medical complaint/history	Mechanism of injury
Investigations (brief examination of findings)	Injuries (top to toe)
Vital Signs (first set and significant changes)	Vital Signs (first set and significant changes)
Treatment, including ETA and any specialist resources needed on arrival	Treatment, including ETA and any specialist resources needed on arrival

Most patients will be conveyed to an emergency department and taken directly to the resuscitation room where a handover from the ambulance to hospital clinician will take place. In the event that the patient is conveyed to a specialist centre such as a Heart Attack Centre, it is key when passing pre-alert clinical information that the patient's Glasgow Coma Scale score is stated, especially if it is reduced, so that the receiving team can ensure that all the relevant expertise (e.g. an anaesthetist) is available when the patient arrives.

9. Team handover and crew debriefing

Handover

Background

The aim of any handover is to achieve the efficient communication of high quality clinical information at any time when the responsibility for patient care is transferred.⁹⁵ The quality of this handover can have an impact on patient care. There is significant variation in the quality of handovers from prehospital to emergency department medical teams and the handover following OHCA is particularly challenging, as a lot of information needs to be communicated to the hospital team at a time when resuscitation may be ongoing.

Barriers to effective handover

Barriers to an effective handover include a lack of structure, duration of handover, gaining the attention of receiving medical staff, lack of training, noise and other distractions, and difficulty recalling important multiple facts and complex information.⁹⁶

Effective handover

- Use a handover template to facilitate the rapid transfer of information during resuscitation (e.g. ATMIST – see above).

To use a handover template effectively, keep the information under each of the titles short, clear and concise. To reinforce the structure of each handover section, announce the titles before the section information. Consider using a written template and practice your handover prior to hospital arrival. Speak loudly and clearly using the template headings; pauses will enable important points to be understood and assimilated. Be concise and try and limit the handover. Adjuncts to handover such as pictures from the scene can be extremely useful. If you have taken them, show them to the hospital team leader.

Debriefing

Following an out-of-hospital resuscitation attempt, an immediate debrief with the attending EMS team can be valuable.⁹⁷ A 'hot' debrief can provide a valuable learning opportunity and also ensure the welfare of the prehospital team. Debriefing in a structured manner is particularly useful to explore non-technical elements of resuscitation such as communication, leadership and team working. Ideally, the debrief is led by a person trained and capable of leading the session in a non-threatening, constructive manner.

Close communication between the receiving hospital and the EMS team at a later date can be useful to further feedback on the likely cause of arrest and course of in-patient care. Further, more detailed debriefs may be required at a later date.

Further long-term contact with survivors can be invaluable for improving quality of prehospital resuscitation. Meeting survivors can be a very positive experience for the respective EMS crew and can generate 'survivor envy' in colleagues who then strive to perform better.

10. Audit of out-of-hospital cardiac arrest

Quality of CPR/defibrillator downloads

Modern defibrillators include the ability to obtain downloads of data related to the quality of CPR. The systematic analysis of such data and provision of feedback to ambulance clinicians is feasible in the NHS and improves the quality of CPR.⁹⁸ ILCOR recommends the adoption of such technologies as part of an overall quality improvement initiative.⁹⁹

Out-of-Hospital Cardiac Arrest Outcomes (OHCAO) database

Ongoing, systematic collection and analysis of data about out-of-hospital cardiac arrest and bystander CPR is essential to the planning, implementation, and evaluation of effective CPR programs. The British Heart Foundation and Resuscitation Council (UK) established a national OHCAO registry in partnership with the National Association of Ambulance Medical Directors and University of Warwick. The OHCAO registry www.warwick.ac.uk/go/ohcao collects process and outcome information based on the international Utstein template about patients who are treated by ambulance services for cardiac arrest.¹⁰⁰ The registry will provide a tool to support local quality improvement initiatives and will facilitate measuring the impact of the interventions described above.

Prehospital – hospital data linkage

The OHCAO Registry provides a unique dataset of process and outcome variables for cardiac arrest. The value of this information can be strengthened by linking data collected by ambulance services to data collected from hospitals. The key to successful data linkage is the collection of NHS number by Ambulance Services. Linkage of

OHCAO data with Hospital Episode Statistics (HES), Intensive Care National Audit and Research Centre (intensive care interventions) and cardiac interventions (PCI and implantable defibrillators) will allow future evaluation of system characteristics and patient outcomes across health settings (Figure 3).

[Back to top](#) NICE has accredited the process used by Resuscitation Council (UK) to produce its Guidelines development Process Manual. Accreditation is valid for 5 years from March 2015. More information on accreditation can be viewed at www.nice.org.uk/accreditation

11. References

1. Nolan JP, Hazinski MF, Aicken R, et al. Part I. Executive Summary: 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. *Resuscitation* 2015;95:e1–e32.
2. 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.
3. Association of Ambulance Chief Executives and Joint Royal Colleges Ambulance Liaison Committee (JRCALC). UK Ambulance Services Clinical Practice Guidelines. London. London 2013.
4. Bobrow BJ, Panczyk M, Subido C. Dispatch-assisted cardiopulmonary resuscitation: the anchor link in the chain of survival. *Curr Opin Crit Care* 2012;18:228–33.
5. Scott G, Olola C, Gardett I, Clawson J. Shorter dispatcher-assisted CPR time-to-compression using the latest dispatch protocol. *Resuscitation* 2014;85:e161.
6. Tanaka Y, Taniguchi J, Wato Y, Yoshida Y, Inaba H. The continuous quality improvement project for telephone-assisted instruction of cardiopulmonary resuscitation increased the incidence of bystander CPR and improved the outcomes of out-of-hospital cardiac arrests. *Resuscitation* 2012;83:1235–41.
7. Nolan JP, Soar J. Dispatcher-assisted bystander CPR: a KISS for a kiss. *Lancet* 2010;376:1522–4.
8. Bang A, Herlitz J, Martinell S. Interaction between emergency medical dispatcher and caller in suspected out-of-hospital cardiac arrest calls with focus on agonal breathing. A review of 100 tape recordings of true cardiac arrest cases. *Resuscitation* 2003;56:25–34.
9. Clawson J, Olola C, Heward A, Patterson B. Cardiac arrest predictability in seizure patients based on emergency medical dispatcher identification of previous seizure or epilepsy history. *Resuscitation* 2007;75:298–304.
10. Rea TD, Eisenberg MS, Culley LL, Becker L. Dispatcher-assisted cardiopulmonary resuscitation and survival in cardiac arrest. *Circulation* 2001;104:2513–6.
11. Rea TD, Stickney RE, Doherty A, Lank P. Performance of chest compressions by laypersons during the Public Access Defibrillation Trial. *Resuscitation* 2010;81:293–6.
12. O'Neill JF, Deakin CD. Evaluation of telephone CPR advice for adult cardiac arrest patients. *Resuscitation* 2007;74:63–7.
13. Perkins GD, Handley AJ, Koster KW, et al. European Resuscitation Council Guidelines for Resuscitation 2015 Section 2 Adult basic life support and automated external defibrillation. *Resuscitation* 2015;95:81–98.
14. Cheung S, Deakin CD, Hsu R, Petley GW, Clewlow F. A prospective manikin-based observational study of telephone-directed cardiopulmonary resuscitation. *Resuscitation* 2007;72:425–35.
15. Dawkins S, Deakin CD, Baker K, Cheung S, Petley GW, Clewlow F. A prospective infant manikin-based observational study of telephone-cardiopulmonary resuscitation. *Resuscitation* 2008;76:63–8.
16. Sayre MR, Berg RA, Cave DM, Page RL, Potts J, White RD. Hands-only (compression-only) cardiopulmonary resuscitation: a call to action for bystander response to adults who experience out-of-hospital sudden cardiac arrest: a science advisory for the public from the American Heart Association Emergency Cardiovascular Care Committee. *Circulation* 2008;117:2162–7.
17. Hallstrom A, Cobb L, Johnson E, Copass M. Cardiopulmonary resuscitation by chest compression alone or with mouth-to-mouth ventilation. *N Engl J Med* 2000;342:1546–53.

18. Svensson L, Bohm K, Castren M, et al. Compression-only CPR or standard CPR in out-of-hospital cardiac arrest. *New England Journal of Medicine* 2010;363:434-42.
19. Goto Y, Maeda T, Goto Y. Impact of dispatcher-assisted bystander cardiopulmonary resuscitation on neurological outcomes in children with out-of-hospital cardiac arrests: a prospective, nationwide, population-based cohort study. *J Am Heart Assoc* 2014;3:e000499.
20. Kitamura T, Iwami T, Kawamura T, et al. Conventional and chest-compression-only cardiopulmonary resuscitation by bystanders for children who have out-of-hospital cardiac arrests: a prospective, nationwide, population-based cohort study. *Lancet* 2010;375:1347-54.
21. Breckwoldt J, Schloesser S, Arntz HR. Perceptions of collapse and assessment of cardiac arrest by bystanders of out-of-hospital cardiac arrest (OOHCA). *Resuscitation* 2009;80:1108-13.
22. Hasselqvist-Ax I, Riva G, Herlitz J, et al. Early cardiopulmonary resuscitation in out-of-hospital cardiac arrest. *N Engl J Med* 2015;372:2307-15.
23. Deakin CD, Shewry E, Gray HH. Public access defibrillation remains out of reach for most victims of out-of-hospital sudden cardiac arrest. *Heart* 2014;100:619-23.
24. 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.
25. Deakin CD, Clarke T, Nolan J, et al. A critical reassessment of ambulance service airway management in prehospital care: Joint Royal Colleges Ambulance Liaison Committee Airway Working Group, June 2008. *Emerg Med J* 2010;27:226-33.
26. Soar J, Nolan JP. Airway management in cardiopulmonary resuscitation. *Curr Opin Crit Care* 2013;19:181-7.
27. Voss S, Rhys M, Coates D, et al. How do paramedics manage the airway during out of hospital cardiac arrest? *Resuscitation* 2014;85:1662-6.
28. Stone BJ, Chantler PJ, Baskett PJ. The incidence of regurgitation during cardiopulmonary resuscitation: a comparison between the bag valve mask and laryngeal mask airway. *Resuscitation* 1998;38:3-6.
29. Lockett DJ, Healey B, Crewdson K, Chalk G, Weaver AE, Davies GE. Advanced airway management is necessary in prehospital trauma patients. *Br J Anaesth* 2015;114:657-62.
30. Lyon RM, Ferris JD, Young DM, McKeown DW, Oglesby AJ, Robertson C. Field intubation of cardiac arrest patients: a dying art? *Emerg Med J* 2010;27:321-3.
31. Simons RW, Rea TD, Becker LJ, Eisenberg MS. The incidence and significance of emesis associated with out-of-hospital cardiac arrest. *Resuscitation* 2007;74:427-31.
32. Virkkunen I, Ryyanen S, Kujala S, et al. Incidence of regurgitation and pulmonary aspiration of gastric contents in survivors from out-of-hospital cardiac arrest. *Acta Anaesthesiol Scand* 2007;51:202-5.
33. Stub D, Smith K, Bernard S, et al. Air Versus Oxygen in ST-Segment-Elevation Myocardial Infarction. *Circulation* 2015;131:2143-50.
34. Wyllie J, Perlman JM, Kattwinkel J, et al. Part 7: Neonatal resuscitation: 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. *Resuscitation* 2015.
35. Wyllie J, Jos Bruinenberg J, Roehr CC, Rüdiger M, Trevisanuto D, B. U. European Resuscitation Council Guidelines for Resuscitation 2015 Section 7 Resuscitation and Support of Transition of Babies at Birth. *Resuscitation* 2015.
36. Perkins GD, Travers AH, Considine J, et al. Part 3: Adult basic life support and automated external defibrillation: 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. *Resuscitation* 2015;95:e43–e70.
37. Hostler D, Everson-Stewart S, Rea TD, et al. Effect of real-time feedback during cardiopulmonary resuscitation outside hospital: prospective, cluster-randomised trial. *BMJ* 2011;342:d512.
38. Rubertsson S, Lindgren E, Smekal D, et al. Mechanical chest compressions and simultaneous defibrillation vs conventional cardiopulmonary resuscitation in out-of-hospital cardiac arrest: the LINC randomized trial. *JAMA* 2014;311:53-61.
39. Perkins GD, Lall R, Quinn T, et al. Mechanical versus manual chest compression for out-of-hospital cardiac arrest (PARAMEDIC): a pragmatic, cluster randomised controlled trial. *Lancet* 2015;385:947-55.
40. Wik L, Olsen JA, Persse D, et al. Manual vs. integrated automatic load-distributing band CPR with equal survival after out of hospital cardiac arrest. The randomized CIRC trial. *Resuscitation* 2014;85:741-8.

41. Stiell IG, Brown SP, Nichol G, et al. What is the optimal chest compression depth during out-of-hospital cardiac arrest resuscitation of adult patients? *Circulation* 2014;130:1962-70.
42. Wallace SK, Abella BS, Becker LB. Quantifying the effect of cardiopulmonary resuscitation quality on cardiac arrest outcome: a systematic review and meta-analysis. *Circ Cardiovasc Qual Outcomes* 2013;6:148-56.
43. Soar J, Nolan JP. Manual chest compressions for cardiac arrest--with or without mechanical CPR? *Resuscitation* 2014;85:705-6.
44. Spiro JR, White S, Quinn N, et al. Automated cardiopulmonary resuscitation using a load-distributing band external cardiac support device for in-hospital cardiac arrest: a single centre experience of AutoPulse-CPR. *Int J Cardiol* 2015;180:7-14.
45. Ong ME, Quah JL, Annathurai A, et al. Improving the quality of cardiopulmonary resuscitation by training dedicated cardiac arrest teams incorporating a mechanical load-distributing device at the emergency department. *Resuscitation* 2013;84:508-14.
46. Lerner EB, Persse D, Souders CM, et al. Design of the Circulation Improving Resuscitation Care (CIRC) Trial: a new state of the art design for out-of-hospital cardiac arrest research. *Resuscitation* 2011;82:294-9.
47. Deakin CD, Paul V, Fall E, Petley GW, Thompson F. Ambient oxygen concentrations resulting from use of the Lund University Cardiopulmonary Assist System (LUCAS) device during simulated cardiopulmonary resuscitation. *Resuscitation* 2007;74:303-9.
48. Petley GW, Cotton AM, Deakin CD. Hands-on defibrillation: theoretical and practical aspects of patient and rescuer safety. *Resuscitation* 2012;83:551-6.
49. Hamrick JL, Hamrick JT, Lee JK, Lee BH, Koehler RC, Shaffner DH. Efficacy of chest compressions directed by end-tidal CO₂ feedback in a pediatric resuscitation model of basic life support. *J Am Heart Assoc* 2014;3:e000450.
50. Sheak KR, Wiebe DJ, Leary M, et al. Quantitative relationship between end-tidal carbon dioxide and CPR quality during both in-hospital and out-of-hospital cardiac arrest. *Resuscitation* 2015;89:149-54.
51. Bhende MS, Thompson AE. Evaluation of an end-tidal CO₂ detector during pediatric cardiopulmonary resuscitation. *Pediatrics* 1995;95:395-9.
52. Sehra R, Underwood K, Checchia P. End-tidal CO₂ is a quantitative measure of cardiac arrest. *Pacing Clin Electrophysiol* 2003;26:515-7.
53. Pokorna M, Necas E, Kratochvil J, Skripsky R, Andrlík M, Franek O. A sudden increase in partial pressure end-tidal carbon dioxide (P(ET)CO₂) at the moment of return of spontaneous circulation. *J Emerg Med* 2010;38:614-21.
54. Heradstveit BE, Sunde K, Sunde GA, Wentzel-Larsen T, Heltne JK. Factors complicating interpretation of capnography during advanced life support in cardiac arrest-A clinical retrospective study in 575 patients. *Resuscitation* 2012;83:813-8.
55. Lah K, Krizmaric M, Grmec S. The dynamic pattern of end-tidal carbon dioxide during cardiopulmonary resuscitation: difference between asphyxial cardiac arrest and ventricular fibrillation/pulseless ventricular tachycardia cardiac arrest. *Crit Care* 2011;15:R13.
56. Grmec S, Krizmaric M, Mally S, Kozelj A, Spindler M, Lesnik B. Utstein style analysis of out-of-hospital cardiac arrest--bystander CPR and end expired carbon dioxide. *Resuscitation* 2007;72:404-14.
57. Kolar M, Krizmaric M, Klemen P, Grmec S. Partial pressure of end-tidal carbon dioxide successful predicts cardiopulmonary resuscitation in the field: a prospective observational study. *Crit Care* 2008;12:R115.
58. Belsches TC, Tilly AE, Miller TR, et al. Randomized trial of plastic bags to prevent term neonatal hypothermia in a resource-poor setting. *Pediatrics* 2013;132:e656-61.
59. Leadford AE, Warren JB, Manasyan A, et al. Plastic bags for prevention of hypothermia in preterm and low birth weight infants. *Pediatrics* 2013;132:e128-34.
60. Say L, Chou D, Gemmill A, et al. Global causes of maternal death: a WHO systematic analysis. *Lancet Glob Health* 2014;2:e323-33.
61. MBRRACE-UK: Mothers and Babies: Reducing Risk through Audits and Confidential Enquiries across the UK. Saving Lives, Improving Mothers' Care - Lessons learned to inform future maternity care from the UK and Ireland Confidential Enquiries into Maternal Deaths and Morbidity 2009-2012/2014.

62. Truhlar A, Deakin CD, Soar J, et al. European Resuscitation Council Guidelines for Resuscitation 2015 Section 4 Cardiac Arrest in Special Circumstances. *Resuscitation* 2015;95:147–200.
63. Lipman S, Cohen S, Einav S, et al. The Society for Obstetric Anesthesia and Perinatology consensus statement on the management of cardiac arrest in pregnancy. *Anesth Analg* 2014;118:1003-16.
64. SIGN 141 British guideline on the management of asthma. 2014. at <http://www.sign.ac.uk/pdf/SIGN141.pdf>.
65. Lockey DJ, Lyon RM, Davies GE. Development of a simple algorithm to guide the effective management of traumatic cardiac arrest. *Resuscitation* 2013;84:738-42.
66. Davies GE, Lockey DJ. Thirteen survivors of prehospital thoracotomy for penetrating trauma: a prehospital physician-performed resuscitation procedure that can yield good results. *J Trauma* 2011;70:E75-8.
67. Stockinger ZT, McSwain NE, Jr. Additional evidence in support of withholding or terminating cardiopulmonary resuscitation for trauma patients in the field. *J Am Coll Surg* 2004;198:227-31.
68. Coats TJ, Keogh S, Clark H, Neal M. Prehospital resuscitative thoracotomy for cardiac arrest after penetrating trauma: rationale and case series. *J Trauma* 2001;50:670-3.
69. Lockey DJ, Davies G. Pre-hospital thoracotomy: a radical resuscitation intervention come of age? *Resuscitation* 2007;75:394-5.
70. Shimazu S, Shatney CH. Outcomes of trauma patients with no vital signs on hospital admission. *J Trauma* 1983;23:213-6.
71. Seamon MJ, Haut ER, Van Arendonk K, et al. An evidence-based approach to patient selection for emergency department thoracotomy: A practice management guideline from the Eastern Association for the Surgery of Trauma. *J Trauma Acute Care Surg* 2015;79:159-73.
72. Harris T, Thomas GO, Brohi K. Early fluid resuscitation in severe trauma. *BMJ* 2012;345:e5752.
73. Deakin CD, Low JL. Accuracy of the advanced trauma life support guidelines for predicting systolic blood pressure using carotid, femoral, and radial pulses: observational study. *BMJ* 2000;321:673-4.
74. Cera SM, Mostafa G, Sing RF, Sarafin JL, Matthews BD, Heniford BT. Physiologic predictors of survival in post-traumatic arrest. *Am Surg* 2003;69:140-4.
75. Rainer TH, Ho AM, Yeung JH, et al. Early risk stratification of patients with major trauma requiring massive blood transfusion. *Resuscitation* 2011;82:724-9.
76. Crash-trial collaborators, Shakur H, Roberts I, et al. Effects of tranexamic acid on death, vascular occlusive events, and blood transfusion in trauma patients with significant haemorrhage (CRASH-2): a randomised, placebo-controlled trial. *Lancet* 2010;376:23-32.
77. O'Driscoll BR, Howard LS, Davison AG. BTS guideline for emergency oxygen use in adult patients. *Thorax* 2008;63 Suppl 6:vi1-68.
78. Mistry N, Bleetman A, Roberts KJ. Chest decompression during the resuscitation of patients in prehospital traumatic cardiac arrest. *Emerg Med J* 2009;26:738-40.
79. Warner KJ, Copass MK, Bulger EM. Paramedic use of needle thoracostomy in the prehospital environment. *Prehosp Emerg Care* 2008;12:162-8.
80. Deakin CD, Davies G, Wilson A. Simple thoracostomy avoids chest drain insertion in prehospital trauma. *J Trauma* 1995;39:373-4.
81. Leigh-Smith S, Harris T. Tension pneumothorax--time for a re-think? *Emerg Med J* 2005;22:8-16.
82. Holcomb JB, McManus JG, Kerr ST, Pusateri AE. Needle versus tube thoracostomy in a swine model of traumatic tension hemopneumothorax. *Prehosp Emerg Care* 2009;13:18-27.
83. Aylwin CJ, Brohi K, Davies GD, Walsh MS. Pre-hospital and in-hospital thoracostomy: indications and complications. *Ann R Coll Surg Engl* 2008;90:54-7.
84. Davis DP, Pettit K, Rom CD, et al. The safety and efficacy of prehospital needle and tube thoracostomy by aeromedical personnel. *Prehosp Emerg Care* 2005;9:191-7.
85. Lockey D, O'Brien B, Wise D, Davies G. Prehospital thoracostomy. *Eur J Emerg Med* 2008;15:283.
86. Spanjersberg WR, Ringburg AN, Bergs EA, Krijen P, Schipper IB. Prehospital chest tube thoracostomy: effective treatment or additional trauma? *J Trauma* 2005;59:96-101.
87. British Medical Association the Resuscitation Council (UK) and the Royal College of Nursing. Decisions relating to cardiopulmonary resuscitation. A joint statement from the British Medical Association, the

Resuscitation Council (UK) and the Royal College of Nursing. London: British Medical Association; 2014.

88. Perkins GD, Cooke MW. Variability in cardiac arrest survival: the NHS Ambulance Service Quality Indicators. *Emerg Med J* 2012;29:3-5.
89. Callaway CW, Schmicker R, Kampmeyer M, et al. Receiving hospital characteristics associated with survival after out-of-hospital cardiac arrest. *Resuscitation* 2010;81:524-9.
90. Kozinski M, Pstragowski K, Kubica JM, et al. ACS network-based implementation of therapeutic hypothermia for the treatment of comatose out-of-hospital cardiac arrest survivors improves clinical outcomes: the first European experience. *Scand J Trauma Resusc Emerg Med* 2013;21:22.
91. Bosson N, Kaji AH, Niemann JT, et al. Survival and neurologic outcome after out-of-hospital cardiac arrest: results one year after regionalization of post-cardiac arrest care in a large metropolitan area. *Prehosp Emerg Care* 2014;18:217-23.
92. Harker M, Carville S, Henderson R, Gray H, Guideline Development G. Key recommendations and evidence from the NICE guideline for the acute management of ST-segment-elevation myocardial infarction. *Heart* 2014;100:536-43.
93. Fothergill RT, Watson LR, Viridi GK, Moore FP, Whitbread M. Survival of resuscitated cardiac arrest patients with ST-elevation myocardial infarction (STEMI) conveyed directly to a Heart Attack Centre by ambulance clinicians. *Resuscitation* 2014;85:96-8.
94. Dumas F, Cariou A, Manzo-Silberman S, et al. Immediate percutaneous coronary intervention is associated with better survival after out-of-hospital cardiac arrest: insights from the PROCAT (Parisian Region Out of hospital Cardiac ArresT) registry. *Circ Cardiovasc Interv* 2010;3:200-7.
95. Yong G, Dent AW, Weiland TJ. Handover from paramedics: observations and emergency department clinician perceptions. *Emerg Med Australas* 2008;20:149-55.
96. Thakore S, Morrison W. A survey of the perceived quality of patient handover by ambulance staff in the resuscitation room. *Emerg Med J* 2001;18:293-6.
97. Couper K, Perkins GD. Debriefing after resuscitation. *Curr Opin Crit Care* 2013;19:188-94.
98. Lyon RM, Clarke S, Milligan D, Clegg GR. Resuscitation feedback and targeted education improves quality of pre-hospital resuscitation in Scotland. *Resuscitation* 2012;83:70-5.
99. Finn J, Bhanji F, Bigham B, et al. Part 8: Education, implementation, and teams: 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. *Resuscitation* 2015;95:e205-e207.
100. Perkins GD, Jacobs IG, Nadkarni VM, et al. Cardiac arrest and cardiopulmonary resuscitation outcome reports: Update of the Utstein resuscitation registry templates for out-of-hospital cardiac arrest. doi:10.1016/j.resuscitation.2014.11.002.