Adult Cardiopulmonary Resuscitation in 2007

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This chapter summarises the current knowledge of adult cardiopulmonary resuscitation, and outlines the evidence-based changes to the management of cardiac arrest that have been introduced over the past 2 years.

CARDIAC ARREST OUTCOMES
The vast majority of cardiac arrests still occur in the pre-hospital setting. The proportion of patients who survive their initial resuscitation and then survive to leave hospital varies widely (usually reported as between 20 and 50%). In some individual centre reports no hospital discharge has been reported after initial resuscitation, but the hospital discharge rate has been as high as 83%.

In-hospital cardiac arrests occur at approximately 1-5/1,000 admissions, and the majority of these are expected and occur without attempts at resuscitation. Of those in-hospital arrests where resuscitation was considered appropriate, and attempted, survival also varies considerably, but are surprising good (hospital discharge as high as 42%) despite significant co-morbidities, and are probably related to their early detection and the early arrival of the advanced life support team. The best outcomes from a cardiac arrest (near 100%) occur in the electrophysiology laboratory (where ventricular fibrillation [VF] is often deliberately induced)!

The majority of cardiac arrests in both pre- and in-hospital settings still appear to be of cardiac origin, but the underlying causes, co-morbidities and presenting rhythms vary significantly between studies.

EVIDENCE BASED REVIEW OF RESUSCITATION SCIENCE
The International Liaison Committee on Resuscitation has recently published an international consensus on resuscitation science. The published guidelines of the major resuscitation councils throughout the world (including the Australian Resuscitation Council (ARC): www.resus.org.au) are based on this document. The process for the 2005 consensus on resuscitation science involved the completion of 403 worksheets by 281 international contributors (completed worksheets available at www.c2005.org). An updated consensus on resuscitation science document is planned for publication in 2010.

CHANGES TO THE GUIDELINES
The basic life support changes introduced by the ARC include:
• commencing CPR where there are no signs of life (unconscious/unresponsive, not breathing normally and not moving);
• the provision of two initial breaths instead of five; and
• a uniform compression to ventilation ratio of 30:2 for infants, children and adults (regardless of the number of rescuers).

The general flow of basic life support management is provided in the Australian Resuscitation Council Basic Life Support flow chart (www.resus.org.au). The advanced life support changes include:
• refocusing on the provision of good CPR (including minimising the interruptions to CPR);
• minimising the potential harm associated with ventilation; and
• maximising the likelihood of successful defibrillation (using a single shock strategy and appropriate energy levels) 13.

COMMENCEMENT OF CARDIOPULMONARY RESUSCITATION

The use of a pulse check as a means of determining the need for external cardiac compressions was downplayed in previous guidelines, largely as a result of publications suggesting that even experienced providers have difficulty in assessing the presence or absence of a pulse14. It is recommended that CPR be commenced if the victim has no signs of life (unconscious/unresponsive, not breathing normally and not moving) 12. An appropriately trained ALS provider can check for a central pulse (e.g. carotid) for up to 10 seconds during this period of assessment for signs of life.

EXTERNAL CARDIAC COMPRESSION

Site

The desired compression point for CPR in adults is over the lower ⅔ of the sternum. Compressions that are provided higher than this becomes less effective, and compressions lower than this are also less effective and have an increased risk of damage to intra-abdominal organs.

Rate

The optimal rate of cardiac compression during cardiac arrest in adults has not yet been determined. It is recommended that chest compressions should be performed at a rate of approximately 100 compressions/minute. In a recent human study15, lower rates (e.g. <80) were associated with worse outcomes and higher rates (>120) with more fatigue and no benefits.

Depth

The ideal depth of compression is unknown. It is currently recommended that when performing chest compressions in adults the chest should be compressed by at least 4-5 cm (or approximately one third of its depth). Compression depth is usually inadequate when it is measured in either manikin studies or actual cardiac arrests, and increased depth of compression appears to be associated with higher defibrillation success16.

Minimise interruptions to chest compressions

Interruptions to chest compressions are common, often un-necessary, may be prolonged, and are associated with decreased coronary perfusion pressure and a reduced likelihood of defibrillation success16-18. These effects become apparent within 10 seconds, but appear to be at least partially reversible with the re-commencement of chest compression19. Planned interruptions in compressions (e.g. for rhythm recognition, defibrillation, or intubation) should be minimised.

Compression-ventilation ratio

A single compression: ventilation ratio of 30:2 is recommended for arrested patients without a secured airway (i.e. no ETT). This has been introduced (recognising the lower minute ventilation requirement in the arrested patient) to increase the number of compressions given per minute, minimise the interruptions to chest compressions, and simplify instruction for teaching and skills retention20. The tidal breath should be delivered within 1 second, and the desired tidal volume is one that results in a visible chest rise20. Commencing chest compressions before ventilation, and “Compression only” CPR is recommended if rescuers are unable, not trained, or unwilling to perform ventilation (e.g. rescue breathing).

Monitoring the quality of CPR

Simple monitoring techniques to assess the quality of CPR include observation of the rate, depth and positioning of chest compressions, the rate and depth of ventilation, and palpation of central pulses. Additional monitoring techniques that can be used include:
• end-tidal carbon dioxide (linearly related to cardiac output during cardiac arrest),
• mechanical devices (e.g. for monitoring the depth of compressions) and
• new monitor/defibrillators (e.g. for monitoring the depth and rate of compressions and ventilation).

Feedback from these devices can improve the quality of CPR and should result in improved outcomes\(^2\).

**DEFIBRILLATION**

Defibrillation remains the definitive treatment for ventricular fibrillation, and it requires an appropriate combination of “drug” (defibrillator waveform) and “dose” (energy level). ALS providers can use defibrillators in either manual or automated modes. Recent attention has focussed on the importance of the timing of defibrillation in relation to other interventions.

**Early defibrillation vs. CPR before defibrillation**

In the scenario of recent onset VF, the best outcomes are associated with immediate defibrillation (e.g. in electrophysiology labs or coronary care units). However, in situations where the VF has persisted for more than a few minutes, an initial period of CPR may actually improve the likelihood of shock success and survival\(^19, 22, 23\).

**Waveform for defibrillation**

No specific defibrillator waveform (either monophasic or biphasic) has been consistently shown to improve outcome rates (e.g. return of spontaneous circulation (ROSC) or survival) from cardiac arrest due to ventricular fibrillation\(^24\). The use of biphasic waveforms (e.g. Truncated Exponential or Rectilinear), using equal or lower energy levels, appears at least as effective for termination of VF as monophasic waveforms\(^25, 26\).

**Energy levels**

Recommendations for energy levels (“dose”) to be used for defibrillation vary according to the “drug” (type of defibrillator and specific waveform) that the rescuers are using. Early studies using higher energy levels and monophasic waveforms demonstrated similar survival, but increased heart block. Current recommendations are based on maximising the likelihood of the success of each shock. Published evidence suggests that an escalation of energy levels for subsequent shocks does not improve long term outcomes\(^24, 27\). The recommended energy level for defibrillation in adults where monophasic defibrillators are used is 360 Joules for all shocks. When using biphasic waveforms, the energy level should be set at 200J for all shocks unless there is relevant clinical data for the specific defibrillator that suggests that an alternative energy level provides adequate shock success (eg. >90%).

**Single shock technique**

The use of a single shock strategy for defibrillation is now recommended, rather than deliver up to 3 shocks in a sequence. This strategy involves delivering a single shock and then immediately (re-)commencing CPR, and has been introduced to decrease the interruptions to chest compressions which occur as a result of the repeated assessment of rhythm and signs of life that were inherent in the stacked shock approach\(^24\). The benefits of this strategy are dependent on the quality of CPR, as the next shock will be delayed for at least 2 minutes while CPR is performed.

The Australian Resuscitation Council does however recommend the retention of a stacked shock strategy (up to 3 shocks as necessary) in a specific circumstance: for the first defibrillation attempt in a witnessed arrest, where a manual defibrillator is immediately available, and the time required for rhythm recognition and charging of the defibrillator is short (e.g. < 10 seconds), resulting in the delivery of the (up to) 3 shocks within 30 seconds. All subsequent shocks should be given using a single shock strategy (see [www.resus.org.au](http://www.resus.org.au)).

**ADVANCED LIFE SUPPORT**

Despite suggestive evidence, the provision of ALS (apart from defibrillation) has not clearly been demonstrated to be associated with improved outcomes.
Advanced Life Support flowchart

The recommended sequence of treatment to be followed is shown on the Advanced Life Support flow chart of the Australian Resuscitation Council (www.resus.org.au; see Figure). This flowchart has been designed to assist teaching and as an aide memoire.

Precordial thump

A precordial thump may be of value in a witnessed and monitored arrest due to a shockable rhythm if a defibrillator is not immediately available. It is however not without risks, and it should not delay defibrillation.

BLS for ALS

The provision of good basic life support is an essential part of the advanced life support management of both shockable and non-shockable rhythms. Chest compressions should be continued up until defibrillation, and should be commenced again immediately following defibrillation (without checking the rhythm) and continued for at least two minutes unless signs of life return. In the vast majority of cases where defibrillation has successfully reverted the rhythm into one that could generate a pulse, this is not initially associated with an output. Immediate compressions are not associated with an increased risk of re-fibrillation, and they should be performed in these situations to avoid the detrimental effects of prolonged interruptions in compressions, and maintain the coronary perfusion pressure. After each 2 minutes of CPR (or if signs of life return), the underlying rhythm should be checked, and if a rhythm compatible with a return of spontaneous circulation is observed at this stage, then the pulse should also be checked.

Airway for ALS

Despite minimal supportive data, endotracheal intubation remains the gold standard for airway maintenance and airway protection in CPR. The endotracheal tube provides optimal isolation and patency of the airway, allows suctioning of the airway and also provides access for the delivery of some drugs (e.g. adrenaline, lignocaine and atropine). If the victim is unconscious, has no gag reflex, and a trained operator is available, endotracheal intubation should be performed at the first appropriate opportunity, and the patient ventilated with 100% oxygen. However, attempts at endotracheal intubation should not interrupt cardiac compressions for more than 20 seconds.

Alternatives to the endotracheal tube that have been studied during CPR include the bag-valve mask and other advanced airway devices such as the laryngeal mask airway (LMA) and oesophageal-tracheal combitube. The training and experience of the resuscitation team members, and availability of such devices will determine the appropriate choice for airway adjunct.

Breathing for ALS

The arrested patient has a lower minute ventilation requirement than one in the non-arrested state. Hyperventilation during cardiac arrest in animals is associated with increased intrathoracic pressure, decreased coronary and cerebral perfusion, and a decreased rate of return of spontaneous circulation. After the airway is secured the recommended ventilation rate is 8-10/minute. One way to provide this, and to minimise interruptions to compressions is to use a compression: ventilation of 15:1 once the airway is secured (www.resus.com.au). If there is a concern about potential gas trapping, a period of disconnection from the ventilation circuit may be beneficial. The tidal volume recommended is one that results in a visible chest rise.

Potentially reversible causes

Cardiac arrests can be precipitated or perpetuated by a number of conditions, which if not detected and corrected, may prevent successful resuscitation. These "reversible causes" are categorised in the ALS algorithm as the "4Hs and 4Ts" (www.resus.org.au; see Figure). A number of techniques are available to assist in the diagnosis and exclusion of these conditions (ranging from a good history, through careful clinical examination to investigations and interventions). Echocardiography (both transthoracic and trans-oesophageal) can potentially diagnose (or help exclude) a number of cardiac and non-cardiac reversible causes.
Drugs for cardiac arrest

There are no placebo-controlled studies that show that the routine use of any drugs at any stage during human cardiac arrest increase survival to hospital discharge. Despite this, the guidelines still recommend the use of certain drugs in a number of settings.

Vasopressors

The use of vasoconstrictor drugs to increase the perfusion pressure to heart and brain has not been shown to improve survival. Despite this lack of confirmatory evidence, it is reasonable to continue to routinely use a vasopressor in the management of cardiac arrests. There is insufficient data to support any particular drug or combination of drugs. Adrenaline remains the vasopressor of choice during the management of cardiac arrest (1mg every 3 minutes). Vasopressin (40 units) is an alternative drug, but studies have been unable to demonstrate any consistent benefit.

Anti-arrhythmics

Administration of amiodarone (300mg or 5 mg/kg) for shock refractory ventricular fibrillation has been associated with an increased survival to hospital when compared with either placebo or lignocaine. Either amiodarone or lignocaine (but not both) should be considered in those patients still in ventricular fibrillation after repeated attempts at defibrillation (including attempted defibrillation after the administration of adrenaline) have failed.

Other drugs

Other drugs to be considered during cardiac arrest are listed in the ALS flow chart (www.resus.org.au). These include electrolytes (such as magnesium or potassium), atropine, and sodium bicarbonate. Other specific drugs may be indicated depending on the specific circumstances of the arrest (e.g. electrolyte disorders, drug overdose etc).

POST-RESUSCITATION CARE

Survival after cardiac arrest is largely dependent on the patient's co-morbidities and the initial hypoxic insults to the heart and brain. However it can also be influenced by subsequent complications (including secondary insults and the ensuing systemic inflammatory response).

Induced Hypothermia

It is recommended that unconscious but haemodynamically stable survivors of out-of-hospital cardiac arrests due to ventricular fibrillation should be cooled to 32-34°C for 12-24 hours. A period of induced hypothermia should also be considered for cardiac arrests due to other rhythms, as well as in-hospital arrests.

Several techniques are available to cool patients, ranging from cold intravenous fluids through to commercial devices, and these continue to be evaluated.

Other factors in post-resuscitation care

Multiple factors are almost certainly crucial in the post-arrest period, but studies are limited. Tight blood glucose control may be beneficial but its use remains controversial. Maintenance of cerebral perfusion, adequate oxygenation, treatment of seizures, and good supportive care are likely to be beneficial. Hyperventilation and the resultant cerebral vasoconstriction are potentially harmful. Investigators in Norway were able to double their neurologically intact survival to hospital discharge for out-of-hospital cardiac arrests by introducing a standardised post resuscitation protocol. This protocol focused on:

• the use of therapeutic hypothermia,
• percutaneous coronary interventions (PCI),
• the control of haemodynamics (MAP > 65 mmHg), blood glucose (5-8 mmol/L), ventilation (normocapnia) and seizures.

MEDICAL EMERGENCY TEAMS (MET)

It has long been recognised that in-hospital cardiac arrests are usually preceded by some deterioration in physiological criteria.
Promising data from studies using historical controls (or before-and-after methodology) suggested that the introduction of a Medical Emergency Team response resulted in a number of benefits including reductions in hospital deaths and cardiac arrest rates, and improved outcomes following cardiac arrest\(^30\). Unfortunately, a large prospective cluster-randomised study was unable to demonstrate any statistically significant improvement in outcomes\(^4\). Recent observations have confirmed that minor derangements in vital signs predict adverse clinical outcomes\(^44, 45\). Many of these derangements occur at a level that would not elicit a MET call\(^45\), so ward based systems appear necessary to respond to these factors.

**PREDICTION OF OUTCOME**

It is impossible to accurately predict the degree of neurological recovery during or immediately after a cardiac arrest\(^30, 46\). Clinical examination demonstrating the absence of pupillary response or motor response to pain on day 3, Somato-Sensory Evoked Potentials and electroencephalography offer the best prognostic estimates\(^30, 46\) (www.resus.org.au).

**SUMMARY**

Hopefully with the introduction of a number of changes in the guidelines, improved outcomes after cardiac arrest will follow. The major changes include:

- enhanced basic life support (emphasising quality of CPR and minimising interruptions to chest compressions),
- optimised defibrillation (with an appropriate sequence of CPR, and use of appropriate energy levels for the waveform used),
- early and appropriate advanced life support, and
- increased focus on the period of post-resuscitation care.
Figure. Advanced Life Support flow chart. Reproduced with permission from the Australian Resuscitation Council (www.resus.org.au)

![Advanced Cardiorespiratory Arrest Flowchart](image)

Note:
1. For witnessed arrest, when using a manual defibrillator, give up to 3 stacked shocks at first defibrillation attempt. If further shocks are required these should be single shocks.
2. Default biphasic energy.
REFERENCES


