**Introduction**

Advanced Cardiac Life Support (ACLS), the fourth link in the Chain of Survival, is very dependent on the optimal conduct of the earlier three links in the chain, viz. Early Access, Early CPR and Early Defibrillation for good outcomes. One of the major changes over the years has been in the introduction of post-arrest interventions into the ACLS guidelines. While arrhythmia management had been the cornerstone of previous ACLS guidelines, post-resuscitation interventions (i.e. measures carried out after Return of Spontaneous Circulation or ROSC) to sustain life and increase the chances of being discharged alive from hospital have gradually assumed increasing prominence. The 2011 ACLS guidelines will address the following aspects of the vital fourth link of the chain of survival:

- Immediate actions following cardiac arrest
- Airway
- Breathing (ventilation)
- Supporting the Circulation during cardiac arrest
- Peri-arrest arrhythmias
- Identifying reversible causes
- Post-resuscitation care
- Organ donation.

**Immediate Actions Following Cardiac Arrest**

In most of our communities the majority of cardiac arrest events occur out-of-hospital. In the out-of-hospital environment, the emphasis would be on early recognition of cardiac arrest and access to the emergency medical system, the institution of prompt good quality CPR by the first responder, getting defibrillation done, if indicated and then moving the patient to the Emergency Department (ED) of a medical centre in the earliest possible time, usually by crew of the local emergency ambulance service. Usually care provided by emergency ambulance crew would be in the realm of basic life support and defibrillation using automated external defibrillators. Increasingly, ambulance crew are performing a limited range of advanced life support procedures. Sometimes, though, patients are brought collapsed to hospitals in private cars or other vehicles without having had the benefit of many of the essential pre-hospital interventions. Survival in the group who arrest out-of-hospital is critically dependent on prompt institution of the first three links of the chain of survival by community first responders and second-line ambulance crew. Prompt and appropriate action by these would provide third-line responders, viz. hospital staff, especially those working in EDs, to use the various components of the fourth link in the chain to achieve a successful resuscitation. As is well known, survival in cardiac arrest is time-dependent. Survival decreases at a rate of 7 to 10% with each passing minute after cardiac arrest, if no acute interventions relevant to the first three links in the survival chain are implemented. The low survival currently seen in many communities reflects these gaps in prehospital care. Depending on the level of resuscitation conducted out-of-hospital, ACLS interventions carried out in the ED attempt to salvage as many of these patients as possible. The current survival rate of 2-3 % for all out-of-hospital cardiac arrest patients in Singapore reflects the need to understand these gaps in the community better. In addition, ensuring the best standard of ACLS in the hospital improves the likelihood of increasing salvage of these patients.

Most cardiac arrest patients being managed in EDs of hospitals would have collapsed in the out-of-hospital environment. A small number who arrive alive at the ED collapse shortly after and would also be managed there, in which case, all the links of the chain of survival would have to be implemented promptly for best chances of survival for the patient.

A significant number of patients also sustain cardiac arrest in the in-hospital environment. Ward patients may have had a period of deterioration and an unwitnessed arrest. There could be significant variation in the time of recognition of these cardiac arrests in the hospital. It is important that there be a system of early recognition of those patients who are likely to collapse through use of early warning systems, and of cardiac arrest, too. For all patients who collapse in the hospital, there is a need to ensure the following:

- Immediate recognition of cardiac arrest
- A system of calling for help within ward areas, ambulatory clinics and public areas of the hospital
- Staff who are immediately available to perform chest compressions and ventilation (with devices such as the bag-valve mask or pocket masks)
- Resuscitation equipment, including defibrillator and other devices and drugs to be brought to the patient in the shortest possible time. The listing and layout for these should, preferably, be standardized within each institution.

Various institutions have introduced Medical Emergency Teams (MET) or Cardiac Arrest Teams (CAT) or Code Blue Teams (CBT) to address the need to manage these arrests. There must be an ability to mobilize these teams promptly so that there could be better oversight and management of these resuscitations. However, it is also important to ensure that there is already a strong foundation of good basic and advanced life support skills amongst all staff who have patient care rights. An increasing number of hospitals are working towards all clinical staff to be currently certified in basic life support and all doctors to be trained and certified in advanced life support procedures and recertified on a regular basis.
Airway Control and Management

An open airway is crucial for the delivery of oxygen to the lungs and then to the tissues. Access to the airway needs to be ensured within a few minutes of the start of the resuscitation. Training in airway management is essential to ensure that the resuscitation team is able to secure the airway early and manage the ventilatory aspects of the resuscitation optimally.

Basic airway opening techniques include the following, all or some of which may be used for the collapsed patient.

- Head-tilt, chin lift remains the basic and initial airway opening maneuver. Other techniques usually used and recommended would include the classical or modified jaw thrust. Once opened the airway needs to be cleared of secretions, usually with a blunt-tipped stiff suction catheter.
- The routine use of cricoid pressure is not recommended\(^8\). While it may offer some protection from aspiration and gastric insufflation, it may also impede ventilation and interfere with intubation. If used, pressure should be adjusted, relaxed, or released if it impedes ventilation or placement of an advanced airway.
- Oropharyngeal airways prevent the tongue from occluding the upper airway. It may be used in unresponsive patients (those with no cough or gag reflex), or during bag-mask ventilation.
- Nasopharyngeal airways may be used if a clenched jaw prevents insertion of the oral airway. It has been known to cause bleeding in up to 30% of instances\(^10\) and is to be used with caution in the presence of cranio-facial injury.

Placement of advanced airway (e.g. ETT or supraglottic airway)

As part of advanced airway management, it is crucial that all healthcare workers be proficient in the performance of airway opening and maintenance techniques. However, it must also be remembered that placement of an advanced airway may be associated with a number of potential risks, especially interruption of chest compressions. This would be less likely with use of supraglottic airways. It is, thus, important to ensure SpO2 and ECG monitoring during placement of an advanced airway. Once the airway is in position and secured, the expected standard for confirming correct placement would be

- Bilateral chest expansion
- Demisting of ETT during inspiration
- 5-point auscultation
- Continuous ETCO2 measurement
- Chest X ray

Endotracheal intubation by an unskilled provider can result in the following:

- Trauma to the oropharynx with bleeding sometimes
- Long interruptions to compressions / ventilations with their adverse impact on outcomes.
- Hypoxemia for prolonged periods and the resulting cerebral hypoxia

- Failure to recognize misplacement / displacement of the tube which has been recognized in as many as 6 – 25% of instances\(^11, 12, 13, 14, 15\).

There is, therefore, a need for frequent training and retraining in these procedures to ensure currency of skills. Institutions will need to determine the frequency of such training and maintenance of competence standards for those physicians expected to perform advanced airway placements.

ETT placement has many benefits such as allowing a definitive patent airway, suction of secretions, reliable oxygen delivery and protect from aspiration of gastric contents. It would be indicated when there is inability to ventilate adequately with a bag-valve mask resuscitator or if the patient is in coma or cardiac arrest (absence of protective reflexes)

Supraglottic airways such as the LMA (laryngeal mask airway), Combitube or the Laryngeal tube are alternative procedures that may be used especially by prehospital care providers or by physicians if direct airway control is desired for short periods. Its main advantage is that direct visualization of the glottis is not required and training and skills maintenance are easier.

Breathing (Ventilation)

The basic objective of ventilation in advanced life support is to ensure oxygenation of tissues. There is adequate evidence to demonstrate that ventilation, at least with passive high flow oxygen, leads to higher survivals.

Positive pressure ventilation, especially when associated with high tidal volumes and ventilation rates can potentially lead to increased intra-thoracic pressures, decreased venous return and low cardiac output. The recommended rate of ventilation is 10 breaths per minute.

The recommended tidal volume is 400 – 600 ml. If bag-mask ventilation (BMV) is being used, it is recommended that the user should compress the bag by about one-third\(^16\) which would be just about sufficient to produce a chest rise over 1 second. If given in excess and at higher rates, BMV can result in gastric inflation (which, in turn, elevates the diaphragm, restricts lung movement and restricts chest wall compliance), regurgitation, aspiration and chest infection.

Following insertion of an advanced airway device, it is recommended that continuous chest compressions be given with interposed ventilations once every 6 – 8 seconds (or about 8 – 10 breaths per minute).

Cardiac Arrest management

The principles of good resuscitation practice require clear emphasis. The foundations of advanced cardiac life support include the following:

- Consistent performance of high-quality CPR:
  - Each compression to be at least 5 cm depth and at a rate of 100 per minute with complete chest recoil after each compression
These principles are summarized in the universal algorithm for adult cardiac arrest (Table 1).
complications of central line insertion such as pneumothorax, and bleeding into the pleural space.

- Endotracheal tube administration of drugs is no more recommended because drug levels achieved are suboptimal and doses required to achieve blood levels similar to the IV route are about 3 to 10 times as much\(^{(18,19)}\).

- Circulation time during CPR is prolonged. Drugs need to reach the central circulation and the peripheral vasculature to exert their effects. This requires at least 30 to 60 seconds of good quality chest compressions. Therefore, after each drug administration flush the line with 10 – 20 ml of normal saline and continue CPR for at least 30-60 sec before next shock is given, if needed.

- Common resuscitation drugs to remember:
  - **Adrenaline** will continue to be administered in a dose of 1.0 mg at a dilution of 10 ml (1:10,000 dilution) for bolus administration in asystole, ventricular fibrillation and pulseless electrical activity (PEA). When given as an infusion for bradycardic and hypotensive states it may be infused at an initial rate of 2 – 10 ug/kg/minute and increased stepwise gradually till the desired heart rate is achieved.
  - **Amiodarone** is recommended to be given at a dose of 300mg bolus in VF / pulseless VT. For presentations of haemodynamically stable VT with pulse, the recommended dose is 150 mg over 10 minutes which may be repeated once, and with conversion followed by infusion at 1 mg / minute over 6 hours and then 0.5 mg / minute over the next 18 hours.
  - **Lignocaine** is initially given at a dose of 1 – 1.5 mg / kg / minute bolus in the case of VF / pulseless VT and at the rate of 10 mg / minute in the event of stable VT. With successful conversion, maintenance infusions could be at a rate of 30 to 50 ug/kg/minute
  - **Adenosine** for supraventricular tachycardia (SVT) may be given as a rapid intravenous bolus of 6 mg initially. Failure of initial conversion should prompt a second dose of 12 mg bolus. Each bolus dose must be followed by a saline flush. The patient must be warned of side effects of transient chest tightness and hot facial flushes soon after drug administration. All such patients would require close haemodynamic monitoring.
  - Intravenous **Verapamil**, a calcium channel blocker, may also be used for SVT as an infusion of 1 mg / minute up to a maximum of 20 mg with close haemodynamic monitoring at 2 minute intervals. The infusion is stopped once conversion is achieved. In patients with fast atrial fibrillation, it may be used as a rate control agent when infused at the rate of 1 mg over 3 minutes up to a maximum of 20 mg, again with haemodynamic monitoring.
  - Intravenous **diltiazem** is an alternate calcium channel blocker. For patients with SVT it may be infused at a rate of 2.5 mg / minute up to a maximum of 50 mg with close haemodynamic monitoring at 2 minute intervals. The infusion is stopped once conversion is achieved. In patients with fast atrial fibrillation, it may be used as a rate control agent when infused at the rate of 2.5 mg over 3 minutes up to a maximum dose of 50 mg, again with haemodynamic monitoring.
  - **Dopamine** may be infused intravenously in states of haemodynamically significant bradycardia beginning at rates of 2 ug/kg/minute and increasing stepwise to a maximum infusion rate of 20 ug / kg / minute above which the likelihood of peripheral and splanchic vasodilatation would be significant and undesirable.
  - **Magnesium sulphate** would be indicated as an intravenous dose for patients with polymorphic VT associated with prolonged QT interval (torsades de pointes). It is given as a dose of 1 to 2 gm over 15 minutes.

- Drugs taken off routine use
  - **Atropine** has been removed from the recommended list of pharmacological agents for the treatment of asystole and pulseless electrical activity. There is lack of evidence for its benefit for these conditions. Atropine, however, continues to be the drug of first choice for treatment of haemodynamically significant bradycardia. Though short-acting, it has been clearly demonstrated to improve heart rate and symptoms in such patients. It is given in a dose of 0.6 mg intravenously and may be repeated at 3 to 10 minute intervals up to a maximum dose of 2.4 mg.
  - **Calcium** administration for cardiac arrest is no more recommended regardless of rhythm. However, in patients with hyperkalemia, especially in the presence of ECG changes, intravenous calcium administration in the form of calcium chloride 5 – 10 ml over 2 - 5 minutes or calcium gluconate 15 - 30 ml over 2 - 5 minutes is recommended as a first line agent to stabilize myocardial membranes.
  - **Bicarbonate** infusion as a routine agent in cardiac arrest is not recommended because of reported adverse events during therapy, including decreased coronary perfusion pressure, extracellular alkalosis, hypernatremia, hyperosmolality and excessive production of CO2 with its attendant intracellular acidosis. However, it may be used judiciously in severe metabolic acidosis, hyperkalemia or tricyclic antidepressant poisoning. When used, the initial dose would be 1 – 1.5 ml 8.4% Sodium Bicarbonate per kg body weight. Repeated doses, if given would be at half the initial dose and should only be after at least 10 to 15 minutes of the initial dose. Preferably, bicarbonate therapy should be guided by arterial blood gas measurements. The underlying cause of acidosis should be treated and the effects of this on acid-base status evaluated.
**Ventricular Fibrillation / Pulseless Ventricular Tachycardia**

The management algorithm for VF / Pulseless VT is included in Figure 1. For every cardiac arrest patient with either of these rhythms, CPR should be instituted immediately. Once defibrillator pads or paddles are in place, defibrillation should be given at a dose of 360 joules for monophasic shock and 120 – 360 joules for biphasic shocks. When using biphasic shocks, it is currently recommended that the first shock be in the range 120 – 200 joules. Following each shock, good quality CPR should be continued for 1 – 2 minutes before ECG analysis.

For refractory VF, depending on the capabilities of the defibrillator, and the protocols of the institution, escalating higher energy shocks may be considered, if available. The drugs that may also be used in refractory VF/pulseless VT include adrenaline, amiodarone and lignocaine in the doses described earlier. While all these are going on good quality chest compressions and ventilations must be continued. Successful conversion with ROSC should be followed by an infusion of either amiodarone or lignocaine in the doses recommended.

A single precordial thump may be considered only for witnessed cardiac arrests if it can be given promptly and if a defibrillator is not immediately available for use\(^{(20)}\). It should not delay institution of CPR or defibrillation. It is not recommended for un witnessed arrests.

**Asystole / PEA**

For both conditions the management is very similar. Diagnosis of asystole is also contingent on there being absence of breathing or pulse in an unresponsive patient if all the ECG leads are verified to be correctly connected. The basic principles for the management of these patients would be as follows:

- Immediate application of good quality CPR with monitoring of quality.
- Rhythm checks every 2-3 minutes
- IV adrenaline 1 mg in 10 ml repeated every 3-5 minutes
- Look for reversible causes, especially the following five H’s and five T’s:
  - Hypoxia
  - Hyperkalemia
  - Hydrogen ion acidosis
  - Hypovolemia
  - Hypothermia
  - Tension Pneumothorax
  - Tamponade (Cardiac)
  - Toxic ingestions
  - Thrombosis, pulmonary
  - Thrombosis, coronary

- The five H’s and five T’s are applicable to all types of cardiac arrest and should be actively sought. Once reversible factors are identified, immediate action would be required to correct these so as to provide the best milieu for a successful resuscitation.

**Narrow Complex Tachyarrhythmias**

Patients presenting with supraventricular tachycardia (SVT) usually have sudden onset of symptoms. Diagnosis is made usually after a 12 lead ECG is performed. On attending to such a patient, the following will need to be carried out:

- The patient should be managed in a monitored area with vital signs and ECG monitors. Ensure that the airway is opened and give oxygen if the patient is breathless or has oxygen saturation below 95%
- Determine the patient’s hemodynamic status. Patients whose blood pressure is below 90/60 mm Hg or are very breathless or having altered mental state, signs of shock or in acute heart failure should be deemed as unstable. These patients require synchronized cardioversion beginning at 50 joules biphasic shock and prior sedation with intravenous midazolam.
- If vital signs are stable, non-pharmacological measures may initially be attempted, especially carotid sinus massage or the Valsalva manoeuvre. Failure of such maneuvers would mean that drug administration would be required.
- Intravenous adenosine, verapamil and diltiazem are all acceptable drugs of first choice for the conversion of stable patients with SVT.
- ECG and vital sign monitoring should be continued during the conversion process and for at least two hours thereafter for early detection of recurrence.

Patients presenting with fast atrial fibrillation also have potential for hemodynamic instability. They would also need to be managed in a monitored area.

- If blood pressure is below 90/60 mm Hg or the patient is having altered mental state, signs of shock or in acute heart failure he should be deemed as unstable. Synchronized cardioversion would be required beginning at 50 joules biphasic shock with prior sedation with intravenous midazolam and trans-esophageal echocardiography to rule out atrial thrombi. Prior administration of heparin would also be required.
- For rate control, if the patient is not in heart failure, calcium channel blockers such as verapamil or diltiazem given as slow infusion would be usually effective. For patients in heart failure, the current recommendation would be infusion of amiodarone 300 g over a 40 minute period with frequent monitoring of blood pressure. Intravenous digoxin 0.5 mg infused over 30 minutes would be an alternative.
- For rhythm control, intravenous amiodarone 150 mg over 20 minutes may be administered and repeated if there is failure of conversion with the initial dose. Vital signs monitoring will be required during the infusion.
- For all such patients their anticoagulation status may need to be verified.

**Wide Complex Tachyarrhythmias (Figure 2)**

The initial need is to determine whether the patient is haemodynamically stable. Those who are unstable would be presumed to have ventricular tachycardia and would require immediate synchronized cardioversion beginning at 100 joules biphasic energy.

If the patient is haemodynamically stable, a 12 lead ECG would initially be required.
Patients with monomorphic VT would best be managed with intravenous amiodarone 150 mg given slowly over 10 minutes and repeated if not converted with the first dose.

Alternatively, intravenous lignocaine at a dose of 1 – 1.5 mg / kg body weight may be administered at a rate of 10 mg per minute and the dose repeated, if necessary.

For patients with known SVT with aberrancy, they may be treated as for supraventricular tachycardia.

Patients presenting with polymorphic VT should usually be managed by electrical conversion. If the cause of the polymorphic VT is a long QT (Torsades de Pointes) intravenous magnesium sulphate 1-2 mg over a 15 minute period should also be administered to minimize the chances of recurrence. In patients with polymorphic VT and normal QT interval intravenous amiodarone 150 mg over 10 minutes may also be attempted and repeated if conversion is not achieved.

---

**Fig 2: Management of ventricular tachyarrhythmias**

**Bradyarrhythmias (Figure 3)**

Haemodynamically significant bradyarrhythmias usually present with a heart rate of below 60 per minute and a blood pressure of less than 90/60 mm Hg. Most patients who are asymptomatic would tend to have heart rates even lower than 50 per minute.

All such patients should be managed in a monitored area.

Since hypoxaemia is common in bradyarrhythmiaic patients, all such patients would require 100 % oxygen in the first instance. Ventilator assistance, if required, with ventilatory adjuncts should be considered. Once a 12 lead ECG has been done and the rhythm causing the bradycardia determined pharmacological therapy would be required.

The common drugs that may be used for bradyarrhythmias would be atropine, dopamine infusion, adrenaline infusion. Cardiac pacing would have to be considered for all patients with haemodynamically significant bradycardia. In an emergency situation, transcutaneous pacing (TCP) would be a reasonable option. It needs to be borne in mind that transcutaneous pacing is frequently painful in conscious patient. Preparation of the patient for transcutaneous pacing should also consider concurrent use of analgesics and sedation. TCP is, however, a temporary measure and arrangements would subsequently be made for long-term transvenous pacing in such patients.

---

**Fig 3: Management of patients with bradycardias**

**Post-resuscitation Care**

The care of patients who achieve return of spontaneous circulation is described in detail in a separate paper. It forms an essential component of advanced life support.

**Organ Donation.**

There has been evidence (21, 22, 23, 24) suggesting that functional outcomes of organs from patients deemed to be brain dead as a result of cardiac arrest are not significantly different from donors who are brain dead not due to cardiac arrest. There would be many factors, including medical, social, cultural, legal and ethical issues that will need to be considered when embarking on a program of using viable organs from patients who are brain dead as a result of cardiac arrest. This is an area that needs careful assessment. Potentially, it is an area for addressing community needs for scarce organs.
References


