

## Guideline 11.6 - Equipment and Techniques in Adult Advanced Life Support

### Summary

#### Who does this guideline apply to?

This guideline applies to adults who require advanced life support (ALS).

#### Who is the audience for this guideline?

This guideline is for health professionals and those who provide healthcare in environments where equipment and drugs are available.

#### Recommendations

The Australian and New Zealand Committee on Resuscitation (ANZCOR) make the following recommendations:

1. The highest possible inspired oxygen concentration is used on all patients during cardiopulmonary resuscitation (CPR). Oxygen should never be withheld because of the fear of adverse effects.
2. Either an advanced airway or a bag-mask device may be used for airway management during CPR for cardiac arrest in any setting.
3. Waveform capnography should be used to confirm and continuously monitor the position of a tracheal tube during CPR in addition to clinical assessment.
4. Either a supraglottic airway or tracheal tube may be used as the initial advanced airway during CPR for cardiac arrest in any setting.
5. When ventilating a victim without an advanced airway, ventilation should be continued at a ratio of 30 compressions to 2 ventilations.
6. CPR prompt / feedback devices may be considered for clinical use to provide data as part of an overall strategy to improve quality of CPR at a systems level.
7. ETCO<sub>2</sub> cut-off values alone should not be used as a mortality predictor or for the decision to stop a resuscitation attempt.
8. If cardiac ultrasound is available and can be performed without interfering with standard ACLS, it may be considered to try and identify potentially reversible causes of cardiac arrest.
9. An ITD should not be routinely used in addition to standard CPR.

10. Automated mechanical chest compression devices should not be routinely used to replace manual chest compressions. However, they may be a reasonable alternative to high-quality manual chest compressions in situations where sustained high-quality manual chest compressions are impractical or compromise provider safety.
11. eCPR is a reasonable rescue therapy for selected patients with cardiac arrest when initial standard CPR is failing in settings where this can be implemented.

## Guideline

A wide range of equipment is available for use in ALS. The role of such equipment should be subject to constant evaluation. The use of any item of equipment requires that the operator is appropriately trained and maintains competency in its use. Frequent retraining (theory and practice) is required to maintain both Basic Life Support (BLS) and ALS skills. The optimal interval for retraining has not been established.

Airway adjuncts can be used to facilitate ventilation, to better maintain the airway, or to provide access to the airway (e.g. for suctioning) [Class B; Expert consensus opinion].

### 1.0 | Oxygen during CPR

There are no adult human studies that directly compare maximal inspired oxygen with any other inspired oxygen concentration. In one observational study of patients receiving 100% oxygen and tracheal intubation during CPR, a higher measured PaO<sub>2</sub> during CPR was associated with improved return of spontaneous circulation (ROSC) and hospital admission.<sup>1</sup>

ANZCOR suggests that the highest possible inspired oxygen concentration is used on all patients during CPR (CoSTR 2015 weak recommendation, very low quality evidence)<sup>2</sup>. Oxygen should never be withheld because of the fear of adverse effects.

There is insufficient evidence to support or refute the use of passive oxygen delivery during compression only CPR to improve outcomes (ROSC, hospital discharge rate and improve neurological survival) when compared with oxygen delivery by positive pressure ventilation.

### 2.0 | Airway

#### 2.1 | Airway manoeuvres

The BLS techniques of chin lift and head tilt are covered in [Guideline 4](#).

## **Jaw thrust**

In this technique, the rescuer is commonly positioned at the top of the victim's head, although a jaw thrust may be applied from the side or in front. The jaw is clasped with both hands and the mouth is held open by the thumbs.

Pressure is applied with the index (or middle) fingers behind the angles of the jaw. The jaw is gently thrust upwards and away from the chest, moving the tongue away from the back of the throat. Gentle head tilt may also be necessary to maintain airway patency with this technique.

A jaw thrust may be required in the recovery position if the victim's airway is not patent [Class A; Expert consensus opinion].

## 2.2 | Basic airway adjuncts

Oro- and nasopharyngeal airways have long been used in cardiac arrest, despite never being studied in this clinical context. It is reasonable to continue to use oral and naso-pharyngeal airways when performing bag-mask ventilation in cardiac arrest, but in the presence of a known or suspected basal skull fracture an oral airway is preferred. It is still necessary to use head tilt and jaw support, or jaw thrust [Class B; Expert consensus opinion].

### **Oropharyngeal airway**

Oral airways should be appropriately sized and not be forcibly inserted. They should be reserved for unconscious, obtunded victims. Laryngospasm or vomiting with aspiration may result in those patients who still have a gag reflex [Class B; Expert consensus opinion].

### **Nasopharyngeal airway**

Despite frequent successful use of nasopharyngeal airways by anaesthetists, there are no published data on the use of these airway adjuncts during CPR. One study in anaesthetised patients showed that nurses inserting nasopharyngeal airways were no more likely than anaesthetists to cause nasopharyngeal trauma. One study showed that the traditional methods of sizing a nasopharyngeal airway (measurement against the patient's little finger or anterior nares) do not correlate with the airway anatomy and are unreliable. In one report insertion of a nasopharyngeal airway caused some airway bleeding in 30% of cases. Two case reports involve inadvertent intracranial placement of a nasopharyngeal airway in patients with basal skull fractures. In the presence of a known or suspected basal skull fracture, an oral airway is preferred, but if this is not possible and the airway is obstructed, gentle insertion of a nasopharyngeal airway may be lifesaving (ie. the benefits may far outweigh the risks)<sup>3</sup> [Class B; Expert consensus opinion].

## 2.3 | Advanced airway devices

The endotracheal tube has generally been considered the optimal method of managing the

airway during cardiac arrest. There is evidence that without adequate training and experience, the incidence of complications, such as unrecognized oesophageal intubation, is unacceptably high. Alternatives to the tracheal tube that have been studied during CPR include the bag-valve mask device and advanced airway devices such as the laryngeal mask airway (LMA), i-gel, laryngeal tube, and oesophageal-tracheal combitube (Combitube).

There is insufficient data to support the routine use of any specific approach to airway management during cardiac arrest.

ANZCOR suggests using either an advanced airway or a bag-mask device for airway management during CPR for cardiac arrest in any setting (CoSTR 2015, weak recommendation, very-low-quality evidence).<sup>2</sup>

The choice of airway used should depend on the skills and training of the healthcare provider. Tracheal intubation may result in increased hands-off time in comparison with insertion of a supraglottic airway (e.g. LMA, laryngeal tube) or a bag-mask device. Both a bag-mask device and an advanced airway are frequently used in the same patient as part of a stepwise approach to airway management, but this has not been formally assessed.<sup>2</sup>

There is inadequate evidence to define the optimal timing of advanced airway placement during cardiac arrest.

The airway devices/adjuncts used during a cardiac arrest must be chosen according to local training and availability [Class A; Expert consensus opinion]. To avoid substantial interruptions in chest compressions providers may defer attempts to insert devices/adjuncts until return of spontaneous circulation (ROSC) [Class B; Expert consensus opinion].

## 2.4 | Endotracheal intubation

The only published randomised controlled trial that compared tracheal intubation with BVM ventilation was performed in children who required airway management out-of-hospital. In this study there was no difference in survival-to-discharge rates but it is unclear how applicable this paediatric study is to adult resuscitation.<sup>4</sup> The study had some important limitations, including the provision of only 6 hours of additional training for intubation, limited opportunity to perform intubations, and short transport times. Two studies compared outcomes from out-of-hospital cardiac arrest in adults treated by either emergency medical technicians or paramedics. The skills provided by the paramedics, including intubation and intravenous (IV) cannulation and drug administration, made no difference in survival to hospital discharge.

The reported incidence of unrecognised oesophageal intubation in cardiac arrest ranges from 0-14% with a mean of 4.3%.<sup>2</sup> An additional problem common to any advanced airway is that intubation attempts generally require interruptions in chest compressions. Rescuers must weigh the risks and benefits of intubation versus the need to provide effective chest compressions. The intubation attempt will require interruption of chest compressions, but once an advanced airway is in place ventilation will not require interruption or even pausing of chest compressions.

To avoid substantial interruptions in chest compressions providers may defer an intubation attempt until return of spontaneous circulation (ROSC) [Class B; Expert consensus opinion]. To ensure competence, healthcare systems that utilise advanced airways should address factors

such as adequacy of training and experience, and quality assurance. Providers must confirm tube placement and ensure that the tube is adequately secured [Class A; Expert consensus opinion].

In addition to providing optimal isolation and patency of the airway, intubation allows ventilation with 100% oxygen and suctioning of the airway and also provides possible access for the delivery of some drugs. However, if endotracheal intubation is attempted, ongoing CPR must be maintained, laryngoscopy should be performed during chest compressions and attempts at intubation should not interrupt cardiac compressions for more than 5 seconds [Class A; Expert consensus opinion].

Once an endotracheal tube has been passed:

- Inflate cuff with enough air to prevent a leak
- Confirm placement by assessing chest inflation, auscultation, by direct observation, and waveform capnography. Then, firmly secure the tube.

### **Confirmation of placement of endotracheal tube**

Unrecognised oesophageal intubation is the most serious complication of attempted tracheal intubation. Routine confirmation of correct placement of the tracheal tube should reduce this risk.

Two studies of waveform capnography to verify tracheal tube position in victims of cardiac arrest after intubation demonstrated 100% sensitivity and 100% specificity in identifying correct tracheal tube placement. One of these studies included 246 intubations in cardiac arrest with 9 oesophageal intubations and the other included 51 cardiac arrests with an overall oesophageal intubation rate of 23% but it is not specified how many of these occurred in the cardiac arrest group.

Three studies with a cumulative total of 194 tracheal and 22 oesophageal tube placements demonstrated an overall 64% sensitivity and 100% specificity in identifying correct tracheal tube placement when using the same model capnometer (no waveform capnography) on prehospital cardiac arrest victims. The sensitivity may have been adversely affected by the prolonged resuscitation times and very prolonged transport times of many of the cardiac arrest victims studied. Intubation was performed after arrival at hospital and time to intubation averaged more than 30 minutes.

Studies of colorimetric ETCO<sub>2</sub> detectors, the syringe aspiration oesophageal detector device the self-inflating bulb oesophageal detector device and non-waveform End Tidal CO<sub>2</sub> capnometers show that the accuracy of these devices is similar to the accuracy of clinical assessment for confirming the tracheal position of a tracheal tube in victims of cardiac arrest.

ANZCOR recommends using waveform capnography to confirm and continuously monitor the position of a tracheal tube during CPR in addition to clinical assessment (CoSTR 2015, strong recommendation, low-quality evidence).<sup>2</sup> See also Guideline 11.1.1

It is also recommended that if waveform capnography is not available, a non-waveform carbon dioxide detector, esophageal detector device or ultrasound, in addition to clinical assessment, are alternatives (CoSTR 2015, strong recommendation, low quality evidence).<sup>2</sup>

### **Values and Preferences**

These are strong recommendations despite the low quality evidence, as a high value is placed on avoiding unrecognised oesophageal intubation. In 11 studies assessed, the mean incidence of unrecognised oesophageal intubation in cardiac arrest was 4.3% (range 0–14%).<sup>2</sup>

Additionally, waveform capnography is recommended as it may have other potential uses during CPR (e.g. monitoring ventilation rate, assessing quality of CPR, and alerting the presence of ROSC).

### **Alternatives to endotracheal intubation**

Supraglottic airway (SGA) devices (e.g. LMA, Laryngeal tube, i-gel, Combitube) are generally considered easier to insert than tracheal tubes. They can be inserted without interrupting chest compressions, and their use in cardiac arrest has been increasing. Ten studies have compared a variety of SGA devices with the tracheal tube during out of hospital cardiac arrest.<sup>2</sup>

No studies comparing alternative advanced airway devices and tracheal intubation have been of a high quality and adequately powered to study long term survival. Studies comparing supraglottic airway to tracheal intubation have generally compared insertion time and ventilation success rates. There is insufficient data to support the routine use of any specific approach to airway management during cardiac arrest.<sup>2</sup>

ANZCOR suggests using either a supraglottic airway or tracheal tube as the initial advanced airway during CPR for cardiac arrest in any setting. Supraglottic airways are also a backup or rescue airway in a difficult or failed tracheal intubation (CoSTR 2015, weak recommendation, very-low-quality evidence).<sup>2</sup>

### **Values and Preferences**

In the absence of sufficient data obtained from studies of IHCA, it is necessary to extrapolate from data derived from OHCA. The type of airway used should depend on the skills and training of the healthcare provider. Tracheal intubation requires considerably more training and practice. Attempted tracheal intubation may result in unrecognised oesophageal intubation and increased hands-off time in comparison with insertion of an SGA. Both an SGA and tracheal tube are frequently used in the same patients as part of a stepwise approach to airway management.<sup>2</sup>

## 3.0 | Ventilation

### 3.1 | Bag-Valve-Mask Device

Where difficulty with bag-mask-valve resuscitation is experienced, two trained operators may be required i.e. the first to manage the airway and the second to operate the bag [Class B; Expert consensus opinion].

## 3.2 | Oxygen-Powered Resuscitators

These devices have a limited place but can provide high oxygen concentrations in experienced hands [Class B; Expert consensus opinion]. Devices that do not comply with current Australasian Standards should not be used.

## 3.3 | Mechanical Ventilators

One pseudo-randomised study suggests that use of an automatic transport ventilator with intubated patients may enable the EMS team to perform more tasks while subjectively providing similar ventilation to that of a bag-valve device.<sup>5</sup>

One study suggests that use of an automatic transport ventilator with intubated patients provides similar oxygenation and ventilation as use of a bag-valve device with no difference in survival.<sup>6</sup>

ANZCOR considers that there is insufficient evidence to support or refute the use of an automatic transport ventilator over manual ventilation during resuscitation of the cardiac arrest victim with an advanced airway.

Both manual ventilation and mechanical ventilation have advantages and disadvantages in the initial management of cardiac arrests. These relate largely to the risks of hyperventilation (with manual ventilation), and hypoventilation (with mechanical breaths not being delivered). Irrespective of the mode of delivery of breaths, the adequacy of delivery of those delivered breaths should be regularly assessed [Class B; Expert consensus opinion].

## 3.4 | Hyperventilation may be harmful

Reports containing both a small case series and an animal study showed that hyperventilation is associated with increased intrathoracic pressure, decreased coronary and cerebral perfusion, and, in animals, decreased return of spontaneous circulation (ROSC). In a secondary analysis of the case series that included patients with advanced airways in place after out-of-hospital cardiac arrest, ventilation rates of >10 per minute and inspiration times >1 second were associated with no survival. Extrapolation from an animal model of severe shock suggests that a ventilation rate of 6 ventilations per minute is associated with adequate oxygenation and better haemodynamics than  $\geq 12$  ventilations per minute<sup>8</sup> [Class B; LOE IV].

Eighteen articles involving 31 cases reported unexpected return of circulation (and in some cases prolonged neurologically intact survival) after cessation of resuscitation attempts. One case series suggested that this occurred in patients with obstructive airway disease. Four studies reported unexpected return of circulation in 6 cases in which resuscitation had ceased and ventilation was shown on repeated occasions (or was highly likely) to result in gas trapping and consequent hemodynamic compromise. The authors of all these studies suggested that a period of disconnection from ventilation during resuscitation from PEA may be useful to exclude gas trapping <sup>7</sup> [Class B; LOE IV].

### **Recommendation for frequency of ventilation**

When ventilating a victim without an advanced airway, ventilation should be continued at a ratio of 30 compressions to 2 ventilations, irrespective of the number of rescuers, until an advanced airway is in place.

After an advanced airway (e.g. tracheal tube, LMA, Combitube,) is placed, ventilate the patient's lungs with supplementary oxygen to make the chest rise. During CPR for a patient with an advanced airway in place it is reasonable to ventilate the lungs at a rate of 6 to 10 ventilations per minute without pausing during chest compressions to deliver ventilations. (CoSTR 2015, weak recommendation , very low quality evidence). <sup>2</sup>

Simultaneous ventilation and compression may adversely effect coronary perfusion<sup>9</sup> and has been associated with decreased survival.<sup>10</sup> One starting point to provide consistent ventilation and an adequate minute volume while minimising interruptions to CPR, and minimising the likelihood of excessive ventilation, is to provide one breath after each 15 compressions (delivering the breath during the relaxation phase of compression, without a significant pause)<sup>11</sup> [Class B; Expert Consensus Opinion]. See also Guideline 11.1.1

The adequacy of ventilation with supraglottic airway devices during uninterrupted chest compressions is however unknown. Theoretically, a compression to ventilation ratio of 30:2 may be continued in patients with an advanced airway (ETT, LMA and other supraglottic airways).

This has advantages for simplicity of teaching, allows intermittent assessment of adequacy of ventilation, and also overcomes the problems associated with inefficient ventilation if breaths are delivered at the same time as the peak of the compressions [Class B; Expert consensus opinion].

Use the same initial tidal volume and rate in patients regardless of the cause of the cardiac arrest. Carbon dioxide estimation via arterial blood gas analysis and capnography may assist with monitoring ventilation and assessing quality of CPR, though these are more reliable once ROSC has been achieved [Class B; Expert consensus opinion].



## 3.6 | Monitoring of ventilation

There is insufficient evidence to support or refute the use of peak pressure and minute ventilation monitoring to improve outcome from cardiac arrest. There is indirect evidence that monitoring the respiratory rate with real time feedback is effective in avoiding hyperventilation and achieving ventilation rates closer to recommended values, but there is no evidence that ROSC or survival is improved.<sup>3</sup>

## 4.0 | Circulation

Healthcare providers should perform chest compressions for adults at a rate of approximately 100-120 compressions per minute (CoSTR 2015, strong recommendation, very low-quality evidence)<sup>2</sup> and to compress the lower half of the sternum by approximately 5 cm (approximately 1/3 of the antero-posterior diameter of the chest) (CoSTR 2015, strong recommendation, low-quality evidence).<sup>2</sup> Rescuers should allow complete recoil of the chest after each compression.

When feasible, rescuers should frequently alternate “compressor” duties (i.e. every 2 minutes), regardless of whether they feel fatigued, to ensure that fatigue does not interfere with delivery of adequate chest compressions. It is reasonable to use a duty cycle (i.e. ratio between compression and release) of 50% [Class A; Expert consensus opinion]. CPR with the patient in a prone position is a reasonable alternative for intubated hospitalised patients who cannot be placed in the supine position [Class B; LOE Expert consensus opinion].

Rescuers should minimise interruptions of chest compressions. It is reasonable for instructors, trainees and providers to monitor and improve the process of CPR to ensure adherence to recommended compression and ventilation rates and depths [Class B; LOE III-2]. See also Guideline 11.1.1.

## 4.1 | CPR prompt or feedback devices

Evidence from 22 manikin studies consistently demonstrated that CPR prompt/feedback devices used during CPR improved the quality of CPR performance on manikins. Three additional manikin studies examined the utility of video/animations on mobile phone devices: two studies showed improved checklist scores and quality of CPR and faster initiation of CPR while the third study showed that participants using multi-media phone CPR instruction took longer to complete tasks than dispatcher-assisted CPR. Two manikin studies that used two-way video communication to enable the dispatcher to review and comment on CPR in real time produced equivocal findings.

There is no high level evidence that the use of CPR feedback devices during real time CPR improves survival or return of spontaneous circulation (2015 CoSTR, weak recommendation,

very low quality evidence).<sup>2</sup> One study each in children and adults showed that metronomes improved chest compression rate and increased end-tidal carbon dioxide. Five studies evaluating the introduction of CPR prompt/feedback devices in clinical practice (pre/post comparisons) found improved CPR performance.

There may be some limitations to the use of CPR prompt/feedback devices. Two manikin studies report that chest compression devices may overestimate compression depth if CPR is being performed on a compressible surface such as a mattress on a bed.<sup>14</sup> One study reported harm to a single participant when a hand got stuck in moving parts of the CPR feedback device. A further manikin study demonstrated that additional mechanical work is required from the CPR provider to compress the spring in one of the pressure sensing feedback devices. One case report documented soft tissue injury to a patient's chest when an accelerometer device was used for prolonged CPR. Instructors and rescuers should be made aware that a compressible support surface (e.g. mattress) may cause a feedback device to overestimate depth of compression.<sup>14</sup>

## Recommendations

CPR prompt / feedback devices may be considered for clinical use to provide data as part of an overall strategy to improve quality of CPR at a systems level (CoSTR 2015, weak recommendation, very low quality evidence).<sup>2</sup>

ANZCOR places a higher value on resource allocation and cost effectiveness than widespread implementation of a technology with uncertain effectiveness during real time CPR. We acknowledge that data provided by CPR feedback devices may benefit other victims as part of a broader quality improvement system (2015 CoSTR, Values and Preferences Statement).<sup>2</sup>

## 4.2 | Pacing

Four studies addressed the efficacy of pacing in cardiac arrest. These studies found no benefit from routine pacing in cardiac arrest patients. Use of pacing (transcutaneous, transvenous, needle) in cardiac arrest (in-hospital or out-of-hospital) did not improve ROSC or survival. There was no apparent benefit related to the time at which pacing was initiated (early or delayed in established asystole), location of arrest (in-hospital or out-of-hospital), or primary cardiac rhythm (asystole, PEA). Five case series, a review with two additional case reports, and a moderate sized case series, support percussion pacing in p-wave asystolic cardiac arrest/complete heart block or hemodynamically unstable patients with bradycardia. In these reports, sinus rhythm with a pulse was restored using different pacing techniques.

Electrical pacing is not effective as routine treatment in patients with asystolic cardiac arrest.<sup>3</sup>

The routine use of pacing (electrical or fist) is not recommended.

The use of pacing after cardiac surgery is considered in [Guideline 11.10](#), 'Resuscitation in Special Circumstances'.

## 5.0 | Monitoring during CPR

### 5.1 | Waveform capnography (End-tidal carbon dioxide [ETCO<sub>2</sub>])

Waveform capnography during CPR has potential roles in:

- Confirming tracheal tube placement
- Monitoring the ventilation rate to assist in avoiding hyperventilation
- Assessing the quality of chest compressions during CPR (CO<sub>2</sub> values are associated with compression depth and ventilation rate)
- Identifying ROSC during CPR (by an increased CO<sub>2</sub> value)
- Assessing prognosis during CPR (low CO<sub>2</sub> values may indicate a poor prognosis and less chance of ROSC). Failure to achieve a CO<sub>2</sub> value >10 mmHg after 20 min of CPR is associated with a poor outcome in observational studies.

#### Recommendations

ANZCOR recommends against using ETCO<sub>2</sub> cut-off values *alone* as a mortality predictor, or for the decision to stop a resuscitation attempt (CoSTR 2015, strong recommendation, low-quality evidence).<sup>2</sup>

ANZCOR suggests that an ETCO<sub>2</sub> 10 mm Hg or greater measured after tracheal intubation or after 20 min of resuscitation, may be a predictor of ROSC (CoSTR 2015, weak recommendation, low-quality evidence).<sup>2</sup>

ANZCOR suggests that an ETCO<sub>2</sub> of 10 mm Hg or greater measured after tracheal intubation, or an ETCO<sub>2</sub> 20 mm Hg or greater measured after 20 min of resuscitation may be a predictor of survival to discharge (CoSTR 2015, weak recommendation, moderate-quality evidence).<sup>2</sup>

#### Values and Preferences

ANZCOR has put a higher value on not relying on a single variable (ETCO<sub>2</sub>) and cut-off value when their usefulness in actual clinical practice, and variability according to the underlying cause of cardiac arrest, has not been established. The aetiology (e.g. asphyxia, PE) of cardiac arrest could affect ETCO<sub>2</sub> values, and there is concern about the accuracy of ETCO<sub>2</sub> values during CPR.<sup>2</sup>

## 5.2 | Arterial Blood Gas

There is evidence from 11 studies that arterial blood gas values are an inaccurate indicator of the magnitude of tissue acidosis during cardiac arrest and CPR in both the in-hospital and out-of-hospital settings. The same studies indicate that both arterial and mixed venous blood gases

are required to establish the degree of acidosis.<sup>7</sup>

Arterial blood gas analysis alone can disclose the degree of hypoxemia and highlight the extent of metabolic acidosis. Arterial CO<sub>2</sub> is an indicator of adequacy of ventilation during CPR. If ventilation is constant an increase in PaCO<sub>2</sub> is a potential marker of improved perfusion during CPR.

Arterial blood gas monitoring during cardiac arrest enables estimation of the degree of hypoxemia and the adequacy of ventilation during CPR, but should not interfere with overall performance of good CPR<sup>7</sup> [Class B; LOE II and IV].

### 5.3 | Ultrasound during cardiac arrest

The use of cardiac ultrasound during cardiac arrest may allow identification of many cardiac and non-cardiac causes of cardiac arrest, and three studies have examined the prognostic value of the presence or absence of sonographic cardiac motion in cardiac arrest.

Absence of cardiac motion on sonography during resuscitation of patients in cardiac arrest was highly predictive of death.<sup>3</sup>

One RCT compared the use of cardiac ultrasound during ALS to no use of cardiac ultrasound in adult patients with PEA arrest. This study enrolled 100 patients in a convenience sample and reported return of spontaneous circulation (ROSC) for at least 10 seconds in 34% of patients in the ultrasound group versus 28% in the group with no ultrasound (p=0.52).

#### **Recommendation**

If cardiac ultrasound is available and can be performed without interfering with standard ALS, it may be considered to try and identify potentially reversible causes of cardiac arrest (CoSTR 2015, weak recommendation, very low quality evidence).<sup>2</sup>

### 5.4 | Other techniques and devices for circulatory support during CPR

Several techniques or adjuncts to standard CPR have been investigated and the relevant data was reviewed extensively as part of the 2010 ILCOR Consensus on Science process.<sup>15</sup> The success of any technique depends on the education and training of the rescuers and/or the resources available (including personnel). Techniques reviewed include: Open-chest CPR, Interposed Abdominal Compression CPR, Active Compression-Decompression CPR, Open Chest CPR, Load Distributing Band CPR, Mechanical (Piston) CPR, Lund University Cardiac Arrest System CPR, Impedance Threshold Device, and Extracorporeal Techniques.<sup>15</sup>

Because information about these techniques and devices is often limited, conflicting, or supportive only for short-term outcomes, no recommendations can be made to support or refute their routine use.

While no circulatory adjunct is currently recommended instead of manual CPR for routine use, some circulatory adjuncts are being routinely used in both out-of-hospital and in-hospital resuscitation. If a circulatory adjunct is used, rescuers should be well-trained and a program of continuous surveillance should be in place to ensure that use of the adjunct does not adversely affect survival [Class B; LOE IV].

New evidence for specific techniques to assist circulation during CPR was reviewed in the 2015 ILCOR Consensus on Science process.<sup>2</sup>

Three technologies for which there have been significant developments since 2010 have been considered:

- The impedance threshold device (ITD)
- Automated mechanical chest compression devices
- Extracorporeal CPR (eCPR).

### **(1) The impedance threshold device (ITD)**

For standard CPR, 1 RCT showed no clinically significant benefit in survival from the addition of the ITD.

ANZCOR recommends against the routine use of the ITD in addition to standard CPR (CoSTR 2015, strong recommendation, high quality of evidence).<sup>2</sup>

For Active Compression CPR, 2 RCTs showed no clinically significant benefit in survival from the addition of the ITD to ACD CPR in a total of 421 out-of-hospital cardiac arrests.

Additionally, 2 RCTs did not demonstrate a clinically significant benefit in survival or neurological status from the addition of the ITD to ACD CPR compared with standard CPR.

### **(2) Automated mechanical chest compression devices (ACTs)**

Two RCTs demonstrated no improvement in survival or neurological outcome at 30, 180 days or 1 yr compared with manual CPR. Three RCTs showed variable survival with good neurology at hospital discharge. Of two studies using the load-distributing band one study, showed harm, while the other showed no effect, and one study using the Lund University Cardiac Arrest System (LUCAS) device showed no effect. Five RCTs showed variable results for survival to hospital discharge. One RCT of IHCA showed benefit with use of a piston device compared with manual chest compressions. Two other RCTs of the LUCAS and 1 using a load-distributing band device showed neither benefit nor harm. Seven RCTs looked at the effect of ACDs on establishing ROSC: 2 showed a benefit, 1 showed harm and four showed no effect.

ANZCOR suggests against the routine use of automated mechanical chest compression devices to replace manual chest compressions (CoSTR 2015 weak recommendation, moderate quality of evidence).<sup>2</sup>

ANZCOR suggests that automated 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 (CoSTR 2015, weak recommendation, low quality evidence).<sup>2</sup>

## **Values and Preferences**

ANZCOR believes the emphasis in resuscitation should be on providing high-quality chest compressions with adequate depth, rate and minimal interruptions, regardless of whether they are delivered by machine or human. We acknowledge that application of a mechanical chest compression device without a focus on minimising interruptions in compressions and delay to defibrillation could cause harm.

However, we also acknowledge that 1 large RCT showed equivalence between very high-quality manual chest compressions and mechanical chest compressions delivered with a load-distributing band in a setting with rigorous training and CPR quality monitoring, and we recognise that there are situations where sustained high-quality manual chest compressions may not be practical. Examples include CPR in a moving ambulance, the need for prolonged CPR (eg, hypothermic arrest), and CPR during certain procedures (eg. coronary angiography or preparation for extracorporeal CPR).

### **(3) Extracorporeal CPR (eCPR)**

For IHCA, two observational studies demonstrated improved neurological survival at 180 days, but no difference at 1 year. These studies also showed improved survival at 30 and 180 days, but not at 1 year, and improved outcome (in both survival and neurology) at hospital discharge.

For OHCA, 1 observational study showed improved functional survival with eCPR at 30 and 180 days, and another at 90 days. One of these studies also showed improved survival to hospital discharge, though not in propensity matched samples.

ANZCOR suggests eCPR is a reasonable rescue therapy for selected patients with cardiac arrest when initial standard CPR is failing in settings where this can be implemented (CoSTR 2015 weak recommendation, very low quality of evidence).<sup>2</sup>

### **Values and Preferences**

ANZCOR acknowledges that the published series used selected patients for eCPR and that guidelines for clinical practice should apply to similar populations. We recognise that eCPR is a complex intervention that is not universally available, but we consider that it may be successful in individuals where usual CPR techniques have failed and may also buy time for another treatment such as coronary angiography or percutaneous coronary intervention (PCI).

## 5.5 | Open Chest CPR

There are no published randomised controlled trials and very limited data in humans comparing open-chest CPR to standard CPR in cardiac arrest. Four relevant human studies, 2 after cardiac surgery and 2 after out-of-hospital cardiac arrest, showed that open-chest cardiac massage improved coronary perfusion pressure and increased ROSC. Evidence from animal studies indicates that open-chest CPR produces greater survival rates, perfusion pressures, and organ blood flow than closed-chest CPR. Open-chest CPR should be considered for patients with cardiac arrest in the early postoperative phase after cardiothoracic surgery or when the chest or abdomen is already open. Open chest CPR should also be considered after penetrating chest injuries<sup>15</sup> [Class B; LOE III-2].

## References

1. Spindelboeck W, Schindler O, Moser A, et al. Increasing arterial oxygen partial pressure during cardiopulmonary resuscitation is associated with improved rates of hospital admission. *Resuscitation* 2013;84:770-5.542.
2. Soar J, Callaway C, Aibiki M, Böttiger BW, Brooks SC, Deakin CD, Donnino MW, Drajer S, Kloeck W, Morley PT, Morrison LJ, Neumar RW, Nicholson TC, Nolan JP, Okada K, O'Neil BJ, Paiva EF, Parr MJ, Wang TL, Witt J, on behalf of the Advanced Life Support Chapter Collaborators. Part 4: Advanced life support. 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. *Resuscitation* 2015;95:e71-e1203
3. Deakin CD, Morrison LJ, Morley PT, Callaway CW, Kerber RE, Kronick SL, et al. Part 8: Advanced life support: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. *Resuscitation*. [doi: DOI: 10.1016/j.resuscitation.2010.08.027]. 2010;81(1, Supplement 1):e93-e174.
4. Gausche M, Lewis RJ, Stratton SJ, et al. Effect of out-of-hospital pediatric endo-tracheal intubation on survival and neurological outcome: a controlled clinical trial. *JAMA* 2000;283:783-90.
5. Weiss SJ, Ernst AA, Jones R, et al. Automatic transport ventilator versus bag valve in the EMS setting: a prospective, randomized trial. *South Med J* 2005;98:970-6.
6. Johannigman JA, Branson RD, Johnson DJ, Davis Jr K, Hurst JM. Out-of hospital ventilation: bag-valve device vs transport ventilator. *Acad Emerg Med* 1995;2:719-24.
7. Consensus on Science and Treatment Recommendations Part 4: Advanced life support. *Resuscitation* 2005;67(2-3): 213-47
8. Consensus on Science and Treatment Recommendations Part 2: Adult basic life support. *Resuscitation* 2005;67(2-3):187-201.
9. Swenson RD, Weaver WD, Niskanen RA, Martin J, Dahlberg S. Hemodynamics in humans during conventional and experimental methods of cardiopulmonary resuscitation. *Circulation* 1988;78(3):630-639.
10. Krischer JP, Fine E.G. Weisfeldt ML, Guerci AD, Nagel E, Chandra N. Comparison of prehospital conventional and simultaneous compression-ventilation cardiopulmonary resuscitation. *Crit Care Med*. 1989 Dec;17(12):1263-9.
11. Yannopoulos D, Tang W, Roussos C, Aufderheide TP, Idris AH, Lurie KG. Reducing ventilation frequency during cardiopulmonary resuscitation in a porcine model of cardiac arrest. *Respir Care*. 2005 May;50(5):628-35.
12. Koster RW, Sayre MR, Botha M, Cave DM, Cudnik MT, Handley AJ, et al. Part 5: Adult basic life support: 2010 International consensus on cardiopulmonary resuscitation and emergency cardiovascular care science with treatment recommendations. *Resuscitation*. [doi: DOI: 10.1016/j.resuscitation.2010.08.005]. 2010;81(1, Supplement 1):e48-e70.
13. Soar J, Mancini ME, Bhanji F, Billi JE, Dennett J, Finn J, et al. Part 12: Education, implementation, and teams: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. *Resuscitation*. [doi: DOI: 10.1016/j.resuscitation.2010.08.030]. 2010;81(1, Supplement 1):e288-e330.
14. Perkins GD, Kocierz L, Smith SC, McCulloch RA, Davies RP. Compression feedback devices over estimate chest compression depth when performed on a bed. *Resuscitation*. 2009 Jan;80(1):79-82.
15. Lim SH, Shuster M, Deakin CD, Kleinman ME, Koster RW, Morrison LJ, et al. Part 7: CPR

techniques and devices: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. Resuscitation. [doi: DOI: 10.1016/j.resuscitation.2010.08.026]. 2010;81(1, Supplement 1):e86-e92.