RESUSCITATION

Chapter 1

LIFE SUPPORT

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INTERNATIONAL RESUSCITATION GUIDELINES 2010

DEVELOPMENT PROCESS

- follows from the 2006 ILCOR guidelines, addressing their deficiencies and incorporating new research
- representation from all of the major resuscitation councils including the Australian Resuscitation Council (ARC)
- no industry support
- specific guidelines and procedures were used to deal with potential conflicts of interest
- multi-stage process allowing feedback from all interested parties during guideline development
- published simultaneously by the European Resuscitation Council (ERC) in *Resuscitation* and the American Heart Association (AHA) in *Circulation* in October 2010

Key points of emphasis

- guidelines emphasise the interventions thought to work
  - uninterrupted cardiac compressions
  - early access to defibrillation where appropriate
  - post resuscitation cooling
- simplification of the guidelines to maximise participation
  - much less emphasis on numbers and techniques
- key messages for both lay and medical providers are
  - early chest compressions
  - push hard
  - push fast
  - minimise interruptions to compression
  - ventilate if you can, especially in children or in arrest not primarily cardiac in origin
  - defibrillate ASAP
  - if ROSC
    - prevent hyperthermia
    - avoid over oxygenation

CARDIAC ARREST

(P-Ex)

CARDIAC ARREST

- incidence approximately 1:1,000/year
  - approximately 2/3 that rate in first year of life
  - rare in children
  - increasing incidence during adolescence and young adulthood
- accounts for 15-20% of all deaths
- approximately 30% due to VF/VT
  - proportion decreasing due to use of AICDs

Incidence and survival

- inversely related in older studies
  - the higher the reported incidence - the lower the reported survival
- reported incidence usually reflects attempts to resuscitate people who have died rather than arrested

Utstein reporting style

- method of uniform reporting and terminology
- developed to standardise research and reporting of out of hospital cardiac arrest
- without uniform style
  - unable to compare different EMS systems
  - cannot conduct multi-system trials

Contents

- glossary of terms related to resuscitation
- template for reporting data from cardiac arrests
  - with definitions for each section of the template
- definitions for events and time intervals
- individual data that should be collected
- recommendations for describing a community's EMS system

BYSTANDER CPR

- cardiac arrests are witnessed in approximately 50% of cases
- bystander CPR occurs in only 20-50% of cases
- bystander CPR significantly improves survival rates
  - 10% decrease in survival/min in without CPR
  - 4% decrease in survival/min with CPR
- wide variations in bystander CPR rates in various communities suggest that education can modify community CPR participation rates

SURVIVAL AFTER CARDIAC ARREST

- highly variable depending on
  - underlying cause
  - location
  - EMS system
  - patient age
- approximately 85% of survivors are able to live independently
- full functional recovery often takes 6-12 months

Time to CPR and defibrillation

- CPR < 3 minutes and ALS < 6 minutes 70% survivors from VF
- CPR > 3 minutes and ALS < 6 minutes 40%
- models suggest that in a primary cardiac arrest without CPR, long term survivors cannot be expected after 8 minute of arrest
  - CPR extends this to 12 minutes
  - defibrillation must be delivered within the 12 minutes to alter outcome
- a system with a 50% community CPR rate, defibrillation by EMT-D's at 5 minutes and ALS care at 10 minutes can produce a > 30% survival rate

Location

Out of hospital

- survival to hospital arrival
  - approximately 35% in total
  - 70% in best systems
  - 15% for VF
  - 2% for asystole
- survival to hospital discharge
  - approximately 5 - 15% in total
  - up to 20% in systems with good AICD access
  - 10 - 35% for VT/VF
  - 5 - 10% for PEA
  - 1 - 10% for asystole
  - 15% for patients with VT/VF **and** witnessed arrest

Hospital general ward area

- out of hospital arrests have a better outcome than most ward in-hospital arrests
- Medical Emergency Teams (MET) in hospital have not been shown to improve the incidence of cardiac arrest, unplanned ICU admissions or unexpected deaths

Hospital critical care areas

- survival approximately 70% in selected CCU and ED populations
  - even higher in Cath lab patients
- lower in ICU patients
  - due to more severe underlying disease

Average in hospital survival

- up to 40% to 28 days
- only 5% to 2 years

Duration of ACLS

- poor outcome if prolonged enough for ACLS medications to be used

Underlying cause

- generally better results from primary cardiac arrhythmias and poisoning than from other causes

Hypotension following ROSC

- associated with significantly worse outcome
  - mortality 85% vs 60% in those without hypotension

Ultrasound

- absence of cardiac kinetic activity has < 5% probability of ROSC
- presence of kinetic activity has an 80% chance of ROSC

Public Perceptions

- 75% survival rate expected by the general public
  - 50% with full recovery
- representative of survival rates on TV

Teaching CPR

- 60% of sudden deaths due to coronary artery disease occur outside hospital
- usually within 2 hours of symptom onset

CPR courses should include instruction on

- primary prevention, i.e. lifestyle, risk factors, symptoms, etc.
- CPR techniques

Goals

- teach public to recognise symptoms, seek prompt attention
- educate about BLS and risk factor modification
- emphasise chain of survival concept
- recognise, activate EMS, BCLS, ACLS

Training

- conventional training usually requires small group training for at least 3 hours
- the CD 30 course appears to be able to adequately teach skills in 30 minutes
  - mannikin used for each participant with an accompanying video
- target relatives or friends of person at risk
  - the most motivated members of the public are often the least likely to need it
- address concerns, re failure, infection, responsibility, anxiety, guilt
- simplify
- feedback

Cost effectiveness

- poor unless targeting providers in high risk areas
  - training and retraining costs
- approximate cost per QALY (Quality adjusted life year)
  - $270,000 for resuscitation after prehospital cardiac arrest
  - $100,000 for the widespread deployment of AEDs in Scotland (likely more expensive in Australia & New Zealand as population density is lower)
  - $75,000 for the use of an implantable defibrillator

Infection risk of CPR

- mannikin surfaces present remote risk of infection
- no report to date of HIV or Hep B transmitted in this way
- no cases of transmission of HIV or HBV have been reported in CPR
- risk of transmission of Herpes, Meningococcus, TB and other respiratory infections, is theoretically greater but still rare
- instances of Herpes transmission have been reported

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Basic Life Support

(P-Ex)

Actions in BLS

(P-Ex)

- acronym of actual actions is DRSCAB
  - however DRSABC is still used for BLS, supposedly to not confuse people!

Establish scene safety/check for danger

Check no signs of life

- unconscious
- unresponsive
  - shake or apply sternal rub in larger children and adults
  - pinch the trapezius in small children
- not moving
- not breathing normally
- bystander recognition of cardiac arrest takes approximately 40 seconds

Shout for help

- attempt to summon help by shouting

- send whoever responds to activate the
  - EMS system for out-of-hospital situations
  - ACLS team for in-hospital cardiac arrests
- ask if an AED is available
- EMS dispatcher will usually assist the bystander to perform CPR

Position the patient

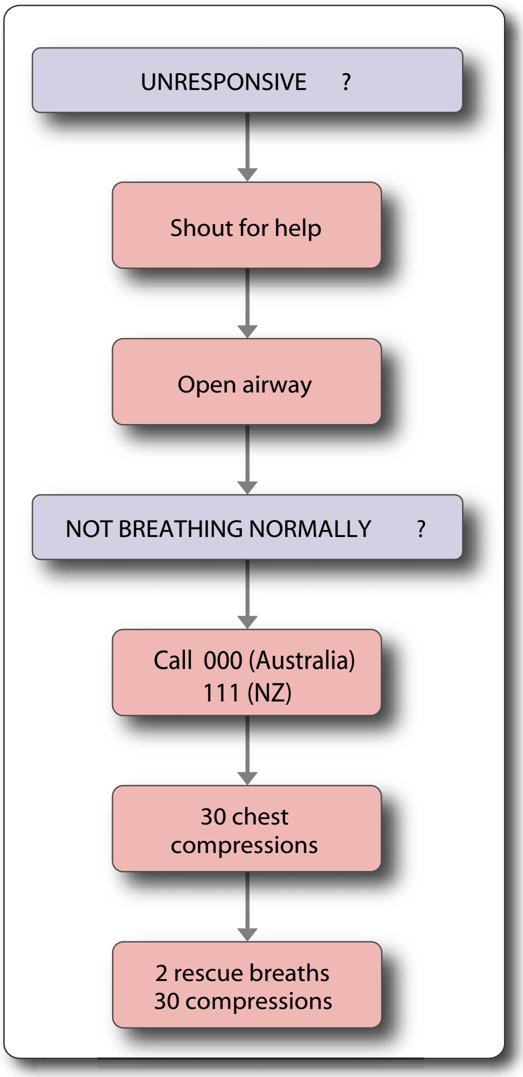
- face up on a firm, level surface
- log roll if spinal cord injury is suspected and sufficient help immediately available

Chest compressions

Airway

Ventilation

FIGURE 1: ADULT BLS ALGORITHM



CHEST COMPRESSION

- the single most important aspect of BLS
- aims to maintain neurological and cardiac function whilst awaiting arrival of AED or ALS capability
- interruption of chest compression should be minimised at all costs as aortic pressure (hence coronary perfusion pressure) drops rapidly after cessation and recovers progressively more slowly after each interruption
- right ventricle also progressively dilates with interruption of chest compressions, making defibrillation less effective

Mechanism of action

- changes thoracic pressure generating forward flow
- approximately 50% of flow is regurgitant across the cardiac valves
- decreases left ventricular size and enables easier defibrillation

Compression without ventilation

- may be used in
  - adult, witnessed, out-of-hospital primary cardiac arrest
  - shockable rhythm
  - < 4 minutes from time of arrest
  - low confidence of operator in performing CPR
- mouth to mouth ventilation often slows compression rate and effectiveness by bystanders
- chest compressions alone may supply sufficient ventilation

Technique

- pressure point is the middle of the chest
  - the inter nipple line is an unreliable surface marker
- ratio of 50% compression / relaxation
- compression rate 100 - 120/min
  - rates > 120/min. are associated with a reduction in compression depth
  - it is more common for the compression rate to be too slow than too fast

Adults

- place patient on firm surface
- operator kneels or stands over the patient (usually on right side)
- use a small step to provide sufficient height above patients in hospital beds
- apply pressure to the sternum with the heel of one hand
  - place a CPR quality measuring pad/puck between your hand an the sternum
  - some monitoring systems can display compression rate and quality
  - some monitoring systems have see through technology, that subtracts the electrical signal from the chest compression to display the underlying rhythm
- place the palm of the other hand on the dorsum of the hand to provide additional force
- interlock fingers of hands to aid stability and power
- apply most force by locking elbows and rocking backwards and forwards
  - uses body weight more than muscle strength
- compression depth 5-6 cm (approximately 20-25% of the average thoracic AP diameter)
  - complete release of pressure between each compression
  - if sufficient force used, hands should just bounce off the chest at the end of compression
  - 10-20% reduction in compression depth occurs by 90 seconds
  - operators do not necessarily feel fatigued, despite decreasingly ineffective CPR
  - ensure smooth changeover of operators that does not interrupt effective compressions
- change operators every 1-2 minutes if possible to prevent fatigue and ineffective compressions

Infants

- single operator
  - use index and middle fingers of dominant hand together to apply compression
  - stabilise head with non dominant hand to prevent neck flexion and airway obstruction
- 2 operators
  - encircle chest with both hands
  - use both thumbs to apply compression

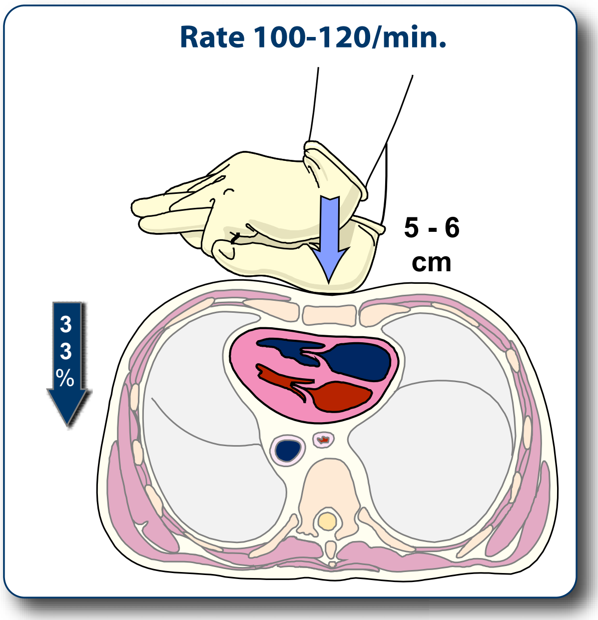
Preschool children

- use heel of one hand to provide compression
- lift the remainder of the hand off the chest wall to prevent compression of the ribs

Older children

- as for adults

FIGURE 2: CHEST COMPRESSION RATE AND DEPTH



Automated compression devices

- various devices available
  - none suitable for children
  - band or aperture size may not be large enough for very obese patients
  - require defibrillation pads to be applied beneath the device
- battery powered thoracic band devices (e.g. Autopulse) more effective than gas powered (Lucas) sternal compression devices
  - thoracic band compresses all of thorax, manual and sternal compression devices mostly compress only the heart
- thoracic band device rate 80 compressions/min
- potential advantages
  - prevents compression fatigue when limited number of rescuers
  - allows effective compression to continue during patient transport
    - CPR on a moving trolley is highly ineffective
    - 60% of CPR in a moving ambulance is ineffective (and an OH&S hazard)
  - allows procedures to be performed without interruption (IV access, PCI (thoracic band device disturbs PCI imaging less than piston device))
  - may increase survival to hospital discharge in prolonged arrests (>10min of CPR)
  - may facilitate earlier defibrillation
- increases ROSC by approximately 10%, but has not yet been shown to improve longer term outcomes in usual situations
- equivalent outcomes to high quality manual CPR
- LUCAS device not demonstrated to have any ROSC or survival benefit in a prehospital RCT

Compression:ventilation ratios

- 30:2 in adults irrespective of number of rescuers
- children
  - 30:2 with one rescuer
  - 15:2 with 2 rescuers
  - 3:1 in neonates in hospital

Effectiveness of compressions

- cerebral blood flow & time to CPR from time of arrest
  - 25% of normal when commenced < 1 minute of arrest
  - 15% at 3 minutes
  - 5% at 5 minutes
- hands off interval > 5 seconds significantly decreases rates of
  - ROSC
  - ETCO2 > 10mmHg
  - relaxation phase (diastolic) arterial pressure of > 20mmHg

Check circulation

- no longer a part of BLS
  - difficult to teach to lay persons
- lay rescuer does not feel for a pulse, but continues CPR until
  - victim starts to move and breath normally
  - AED arrives
  - professional help arrives

AIRWAY

Clearing the airway

- finger sweep no longer recommended because of potential for pharyngeal trauma
- check for a foreign body
- open the mouth by grasping the tongue and lower jaw together with one hand and lifting

Head tilt and chin lift method

- when no respiration detected for 10 seconds
- if no cervical spine injury suspected
- place one hand on the forehead and the other on the chin
- tilt the head backwards using the hand on the forehead
- use the fingers of the other hand to lift the chin forward

Jaw thrust method

- if suspected cervical spine injury
  - then stabilise with sandbags
- maintain the neck in a neutral position
- grasp the angles of the mandible and lift with both hands to displace it forward
- kneel at the head of the patient and rest elbows on the surface on either side of the patient's head
- two rescuers are needed to perform ventilation with the jaw thrust technique
- not usually required for infants

Pocket mask ventilation/airway support

- provides more effective airway opening and ventilation than bag mask in inexperienced hands
- more advanced providers such as lifeguards, ward nurses can use a mask with an oxygen side port that substantially increases FiO_2

Ventilation

- aim to maintain oxygenation until ROSC, not to provide normal ventilation
- increasing evidence that ventilation may do little to change outcome in adults and children with out of hospital primary cardiac arrest
  - may be harmful if it interrupts effective CPR
- improves neurological outcome in children with non cardiac causes of arrest
- agonal gasping respiration often occurs early following arrest and should not be mistaken for normal breathing
  - usually a larger breath than from assisted ventilation
  - assisted ventilation is required as minute volume is usually inadequate
  - spontaneous ventilation can be prolonged by chest compressions alone
- ventilation is more difficult to teach and perform than chest compressions

Begin ventilation

- keep the airway open
- pinch the victim's nostrils closed
- leave dentures in place unless they are loose and obstruct access
- seal your mouth over the victim's mouth
  - if pulse is present and the victim is not breathing, give 8 breaths per minute and monitor the pulse frequently
- give 2 breaths of 0.8-1.2 L
  - each lasting 1 second
  - exhaled air from rescuer provides FiO_2 of about 0.16
- use mouth to nose ventilation if the victim's mouth is damaged or is too large to be covered by the rescuer's mouth
  - blow directly into the victim's nose with the victim's mouth closed
  - open the victim's mouth to allow for passive exhalation
- in infants, cover the infant's mouth and nose with your mouth
- pocket mask (see above) provides a highly recommended alternative
- bag mask ventilation
  - use TV of 600mL
  - inflate the chest over 1 second during a brief pause in CPR
  - time inflation with chest recoil from the last compression
  - deliver 2 breaths after each 30 compressions in adults
  - usually more effective if a second person ensures good bag-skin contact
  - insertion of an LMA is an acceptable alternative if BMV is ineffective
- intubation or LMA insertion
  - early intubation is most likely harmful as some interruption of CPR is usually required
  - best deferred until the patient fails to respond to initial CPR and defibrillation attempts or demonstrates ROSC
  - chest compressions should only be ceased at the time the intubator is about to insert the laryngoscope into the patient's mouth
  - intubation should be completed within 10 seconds of interruption of chest compression, and compressions recommenced as soon as the ETT has passed the cords
  - ventilate at 8-10 breaths per minute, timed between ongoing chest compressions
  - advanced airway techniques reduce periods of ineffective chest compression by approximately 10% absolute as ventilation is easier to perform in synchrony with chest compression

If alone

- EMS system should be activated prior to commencing CPR
- except in children
  - higher incidence of primary respiratory events
  - call first if the collapse is witnessed
  - if unwitnessed call fast

Attach AED (Automatic External Defibrillator)

- use of an AED is now considered a BLS skill and so within the capacity of most hospital staff and trained first aiders

Types of CPR

Closed chest CPR

- the most commonly used
- is the easiest to perform
- requires no special equipment

Cough CPR

- relies on thoracic pump mechanism,
- rhythmic coughing every 1-3 seconds may sustain circulation for short period of time
- only useful in conscious, monitored, patients

Other techniques

- animal studies suggest improved physiological parameters with other techniques
- no evidence of improved outcomes in humans
  - open chest CPR
  - interposed abdominal compression CPR
  - rapid compression CPR
  - simultaneous compression - ventilation CPR
  - active compression - decompression CPR (ACDC-CPR)
- type of CPR used is mostly irrelevant as time from collapse to BLS and ALS are much stronger determinants of survival

Open chest CPR

- better cardiac output than CCCPR
- significantly better cardiac output than CCCPR
  - approximately 2/3 of normal cardiac output possible
  - near physiological aortic and coronary perfusion pressure possible
- strongest indication is for situations where there is primary cardiac pump failure that could be reversible
  - cardiac arrest due to beta blocker/calcium channel poisoning who have arrested, or failed other therapies
- no improvement in outcome if instituted after 20 minutes of standard CPR
  - if attempted, should probably commence no later than after the second cycle of ALS
- may improve initial resuscitation success but not long term survival
- similar in performance to cardiopulmonary bypass via femoro-femoral cutdowns and easier to perform
- technique
  - left lateral thoracotomy - 12cm incision
  - pericardium does not need to be opened for non traumatic arrest
  - AP compression performed with 2 hands, squeezing blood from apex to base
  - one handed techniques should never be used as it is highly likely to damage the RV or atrial, and is ineffective
  - compression rate can be more physiological (i.e.slower)
- drawbacks
  - standard chest compressions need to be interrupted to open the chest - this may take up to a minute
  - mechanical band compression devices need to be removed to open the chest
  - intubation also needs to occur simultaneously
  - apical defibrillation pads need to be repositioned to AP location

Compression - decompression CPR

- no better than standard CPR in survival to hospital discharge
- may have small benefit in increasing survival at one hour in the prehospital setting

CPR in Infants & Children

Circulation

- palpate the brachial or femoral artery when searching for a pulse in infants and small children
  - palpation of the carotid artery is more difficult

Airway

- avoid marked extension of the neck

Position

- perform compression with the index and middle fingers of one hand in small child
- seal both the mouth and the nose

Inflation rate & volume

- in the newborn, use only cheek pressure (mouth air) to inflate the lungs

Airway obstruction

- encourage coughing if still breathing

Infants

- open mouth and remove any visible foreign body
  - do not perform blind finger sweep

Back blows

- balance the infant face down
  - for infants - along your non dominant forearm
  - for children - across your knee
  - hold the head firmly with your hand
- deliver 5 sharp thrusts over the lower 1/3 of the sternum

If unconscious

- give 2 rescue breaths and commence CPR

Complications of CPR

- transmission of infection
  - rare
  - usually minor (not HIV, Hep B/C)
- trauma
  - about half of patients with prolonged CPR sustain chest wall fractures (sternum or ribs), commonly multiple
  - fractures are usually along anterolateral margin of the chest
  - pneumothorax
  - trauma rarely severe enough to influence outcome
- gastric distension
- pneumoperitoneum
- aspiration pneumonia

Pneumoperitoneum

- Nissan fundoplication increases risk as it acts as a one way valve during bag mask ventilation
- tear usually in lesser curvature with lesser omental collection
- signs
  - penile erection
  - lower limb venous engorgement
  - abdominal distension unrelieved by NGT

Treatment

- insertion of a intraperitoneal trocar and relieve the tension
- NGT
  - if blood - laparotomy
  - if no blood - gastroscopy

Contraindications to CPR

- unsuccessful pre-hospital ACLS (with properly positioned tubes)
- known terminal illness not in immediate post-operative period
- obviously unsurvivable injuries
- a valid advance directive
- situation puts rescuers at risk

Prehospital termination of resuscitation

- appropriate when all of the following criteria are met
  - non witnessed arrest
  - no bystander CPR
  - no prehospital defibrillation
  - no return of spontaneous circulation
- a small number of these patients may survive to hospital admission, but none to discharge

Advanced age

- a relative contraindication due to low survival rates
  - 7% in 70-79 year olds
  - 3% in > 80 year olds

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Advanced cardiac life support

(M-Ex)

ACEM curriculum descriptors

- Proactively search for life threatening conditions and perform lifesaving interventions as required

Precordial thump

- importance de-emphasised in 2010 guidelines

Indications

- indicated in adults with witnessed or monitored cardiac arrest
- especially useful in victims of high voltage electrocution
- contraindicated in children

Technique

- clenched fist blow delivered to the centre of the sternum from 25-30 cm above the chest
- delivers only a small amount of energy to the myocardium compared to defibrillation
- occasionally converts VF/VT of less than 1-2 minutes duration to sinus rhythm

Defibrillation

- biphasic defibrillation used since the late 1990's
- monophasic models no longer available despite any proven improvement in survival to hospital discharge from biphasic defibrillation
- minimise 'hands off' period during CPR
  - continue CPR whilst defibrillator charging
  - remove hands from chest only at time of defibrillation, then resume immediately following defibrillator discharge

Initial shock energy

Adults

- 120 J for rectilinear biphasic machines
- 150 - 200 J for biphasic truncated devices
- 200 J if machine type unknown
- 360 J for monophasic (rarely used anymore)
- at previously successful energy setting in recurrent arrhythmias
- approximately 95% effective with a single shock if given immediately
- close to 100% effective with 3 immediate shocks
- only about 50% effective at 3 minutes following onset

Children

- 4 J/kg for all shocks in cardiac arrest

Post-defibrillation

- immediately resume CPR
  - perform a pulse check only if the rhythm is organised
- interrupt CPR to check patient's rhythm only after 2 minutes
  - perform a pulse check only if the rhythm is organised
- ROSC may be recognised by a sustained and sudden increase in ETCO2
  - transient increases can occur following HCO3 therapy
- with the exception of serum [K+], arterial blood gas values during CPR are of no value in directing therapy

VF/Pulseless VT

(also see ALS algorithm)

DC Shock

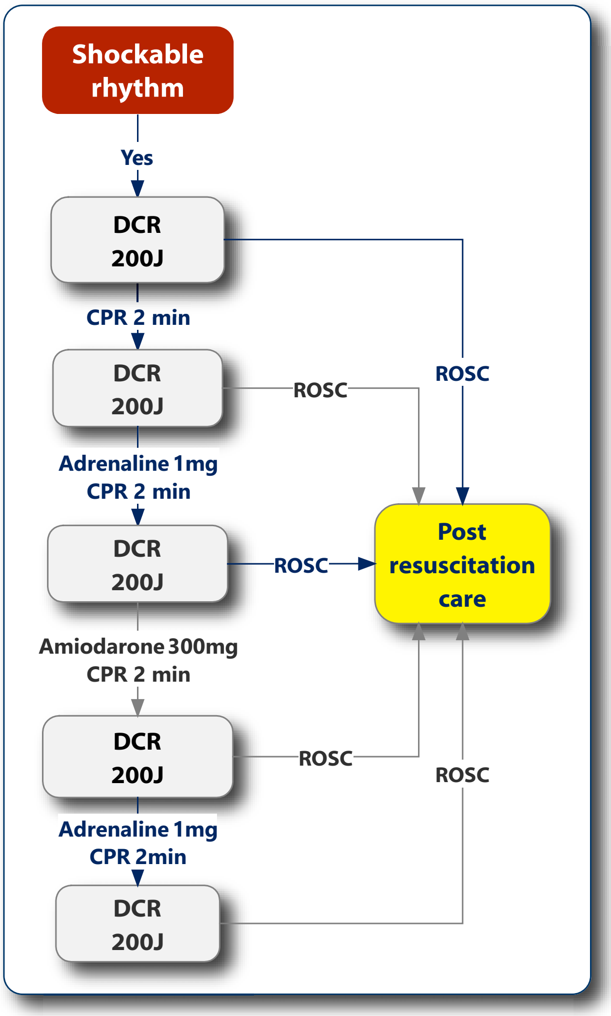
Consider

- advanced airway management
- amiodarone 300 mg
- lignocaine 1.5 mg/kg
- Mg^{2+} 5 mmol
- K^+ 5 mmol
- $NaHCO_3$ 1 mmol/kg

Special circumstances

- variation in standard ALS protocols is usually required for the best chance of survival in some situations
  - ALS guidelines were created mostly to manage out of hospital cardiac arrests, where defibrillation is not immediately available, and the primary cause is cardiac in origin
- primary respiratory causes of arrest (e.g. drowning) require greater emphasis on oxygenation/ventilation
- use HCO_3^- as first line agent in Na^+ channel blocking agent toxicity (e.g. TCAD)
- correct hypokalaemia, hypomagnesaemia if suspected
- profound hypothermia
  - bretylium (if available)
  - magnesium as first line agent
- use calcium if hyperkalaemia suspected
- consider fluid challenge if blood loss suspected
- use Mg^{2+} as a first line agent in torsades de pointes
- overdrive pacing
  - may be effective in pulseless VT
  - is ineffective for VF

Figure 3: Shockable rhythm algorithm



Treat reversible causes
Adrenaline 1mg IV after 4th shock, then every second 2min cycle

- registry data suggests that vasopressin may have greater benefit in arrests where there is severe acidosis than adrenaline

Witnessed monitored VF/pulseless VT

- initial phases of ALS guideline appropriate
- registry data suggest that 3 stacked shocks (i.e. as soon as defibrillator has recharged), with minimal hands off chest compression has better survival than following the ALS guideline
- standard ALS delays the third defibrillation attempt until 6 minutes into the arrest (when it is less effective), instead of delivering it within the first minute, when it is highly likely to be effective

Cardiac arrest in trauma

- closed chest compression highly unlikely to have any benefit
- resuscitation attempts should revolve around restoring circulatory volume or performing thoracotomy to relieve tamponade and compress descending aorta, rather than performing chest compression
- chest compression will likely cause further bleeding if chest/ abdominal trauma present

Cardiac arrest in pregnancy

- activate emergency obstetric response at start of arrest
- apply chest compressions slightly higher on the sternum
- displace the gravid uterus laterally to the left or tilt to left 15-30 degrees
  - CPR ineffective if tilt >30 degrees

- establish IV access above the diaphragm
- consider IV fluid bolus
- cease Mg therapy if in progress then administer 10mL 10% CaCl
  - in case of accidental Mg toxicity
- early intubation as
  - hypoxia develops more rapidly in advanced pregnancy
  - bag mask ventilation difficult
  - high aspiration risk
- remove any fetal monitoring
- consider immediate (post mortem) Caesarian section at 4 minutes post arrest
  - aim for delivery by 5 minutes
    - 70% survival rate neurologically intact
    - 10% survival rate at 10 minutes
    - reported survivors up to 20 minutes post arrest
  - maternal ROSC may occur in up to 50% following Caesarean section (possibly due to improved haemodynamics associated with removal of uterine IVC compression)
- technique of post-mortem Caesarian section
  - sterile preparation and drapes are unlikely to improve survival
  - a scalpel and forceps should be sufficient to effect delivery of the baby
  - midline incision preferred due to the natural diastasis of the recti abdomini in late pregnancy and a bloodless field
- consider open cardiac massage once fetus delivered

Cardiac arrest in sepsis

- has the lowest rate of in hospital survival of all cardiac arrest types
- if arrest occurs despite adequate volume resuscitation, anti-biotics and pressors, survival is close to 0%

Pulseless electrical activity (PEA) / asystole

- non shockable rhythms
- algorithm is largely the same as that for VF/VT other than the lack of DC shocks
- increasing in frequency compared to VF/pulseless VT
  - now accounts for approximately 40% of out of hospital cardiac arrests

PEA

(Dis-Ex)

- previously known as electromechanical dissociation (EMD)
- presence of spontaneous organized cardiac electric activity in the absence of blood flow sufficient to maintain consciousness and absence of a rapid spontaneous return of adequate organ perfusion and consciousness

Epidemiology

- approximately 50% due to a primary cardiac event
- approximately 30% of survivors of PEA have acute coronary occlusions
- higher incidence in patients with underlying pulmonary disease, women and increasing age

Assessment

Causes

- pericardial tamponade
  - myocardial wall rupture
  - type A (proximal) aortic dissection
  - traumatic
- tension pneumothorax
- massive pulmonary embolism
- severe hypovolaemia
- severe acidosis
  - usually only if < pH 6.9
- severe electrolyte abnormalities or drug toxicity
  - causing loss of excitation contraction coupling

Examination

- pallor - blood loss
- cyanosis - pulmonary cause
- no tracheal displacement / symmetrical air entry in the chest - PE
- tracheal displacement, asymmetric breath sounds - tension pneuomothorax
- JVP elevated or low
- signs of recent surgery
- legs - signs of DVT

Management

- BLS / ALS

Treat underlying cause if known

- fluid challenge, especially if JVP low
- most sudden deaths are from haemorrhagic causes (CNS) and blind thrombolysis is not indicated
- bolus thrombolytics if high probability of PE
  - optimum dose unknown
    - 10-50mg of tPA IV bolus
    - 30-50mg tenecteplase (for 60-90kg)
- relieve tension pneumothoraces
  - initial needle decompression
  - finger thracostomies until stable enough to insert an ICC
- HCO_3^- +/- Ca^{2+} if severe acidosis, hyperkalaemia or drug toxicity suspected
- pericardiocentesis / pericardiotomy / thoracotomy if tamponade suspected and traumatic origin

Asystole

(Dis-Ex)

- absence of any spontaneous cardiac electrical activity
- confirm by checking lead integrity and across at least 2 leads
- outcome usually poor (< 1% survival)

Ineffective therapies

- cardioversion for 'occult' VF
  - worsens survival
- pacing
  - usually delays effective CPR

Drug therapy

- each drug delivery dose should be followed by a 20mL NSaline push
- no evidence that any drug therapy alters rate of discharge from hospital alive
  - drug therapy appears to increase the absolute rate of ROSC by approximately 15%
- allow two minutes for distribution of each dose of drug whilst CPR is in progress
  - circulation time during CPR estimated to be approximately 90 seconds
- adrenaline and amiodarone have been shown to increase rate of ROSC and arrival to hospital alive, but not in survival to hospital discharge
  - high dose adrenaline (5-10 mg IV boluses) does not improve survival and may be harmful
- lignocaine is probably harmful
- intraosseous administration is preferred to endotracheal administration, particularly in infants and children

Vasopressin

- does not appear to improve survival compared to

adrenaline
- although recommended as an alternative to adrenaline, it is not commonly used in Australasia
- registry data suggests that vasopressin may have greater benefit in arrests where there is severe acidosis than adrenaline
- a July 2013 European RCT of vasopressin (20 Units) in addition to 1mg of adrenaline for each CPR cycle (3min) demonstrated an improvement in ROSC (84 vs 66%) and hospital survival with good neurological function (14 vs 5%)
  - in addition an initial 40mg IV methyl prednisolone was given after the first CPR cycle and 300mg hydrocortisone given at 4 hours post arrest to survivors
  - applicability to contemporary EM practice is questionable as the trial
    - was conducted prior to current ACLS guidelines
    - comprised of 85% in-hospital (non ED) arrests (75% of which had non cardiac causes for their arrest)
    - had 90% witnessed arrests

Endotracheal delivery
- the route of 'last resort'
- exact appropriate dose unknown
  - thought to be at least 2.5-10 times IV dose
- absorption of adrenaline and lignocaine may be better when diluted with sterile water instead of NSaline

Paediatric therapy

Table 1: Paediatric therapy in cardiac arrest

Therapy	Dose
Compression -ventilation ratio	30:2 basic CPR 15:2 advanced CPR
Defibrillation	4 J/kg
Adrenaline	10 μg/kg
Atropine	20 μg/kg
Amiodarone	5 mg/kg
Lignocaine	1 mg/kg
Mg	0.1-0.2 mmol/kg
HCO3	1 mmol/kg

Ultrasound in cardiac arrest

US pulse check
- more accurate in the 10 seconds window allowed than manual assessment
- up to 35% of asystole is actually PEA on US
- US more accurate than ECG and physical examination
- may prevent premature termination of resuscitation
- technique
  - subcostal 4 chamber view preferred
  - PLAX view if unable to obtain subcostal view
  - cease ventilation during pulse check
- should be able to differentiate between
  - fibrillation (fine movement)
  - PEA (regular)
  - asystole (completely still heart)
- record clip to review after CPR restarted (to minimise CPR interruption) if unclear of rhythm
- can also be used to confirm mechanical capture if pacing used

Cessation of CPR

ROSC
- only once you are sure that adequate perfusion is present
  - patient is moving
  - ETCO2 is rising
  - there is a stable cardiac rhythm of suitable rate

No ROSC
- 20 minutes of CPR without reversible cause and
- non shockable rhythm and
- no ROSC before ED transportation and non witnessed arrest
- trauma and absent evidence of cardiac activity on bedside echocardiography
  - 99% mortality rate if cardiac activity absent
  - 70% mortality rate if cardiac activity present
- absent cardiac activity on US and ETCO2 < 10mmHg after second cycle of ALS
  - estimated to be as close to 0% survival rate

Exceptions
- more prolonged CPR may be warranted in cases of
- poisoning
- asthma
- hypothermia
- pregnancy if post mortem Caesarean section considered
- therapeutic hypothermia is instituted at the scene

Post arrest care

ACEM curriculum descriptors
- Arrange appropriate ongoing supportive management during and after resuscitation
- Initiate advanced invasive temperature control measures

Supportive care

Oxygenation
- oxygenation titrated to SpO_2 of 94-98%
- avoid hyperoxaemia
  - may worsen reperfusion injury
  - hyperoxia is associated with worse survival and neurological outcome following arrest (OR 1.5)

Treat injuries from CPR
- assess for haemothorax / pneumothorax
- provide analgesia if required

Glucose control
- treat blood glucose levels > 10 mmol/L
  - hypoglycaemia must be avoided

Transfusion
- until Hb > 8g/dL

ICU level care
- recommended for a minimum of 72 hours in patients with coma post arrest
- accurate prognosis cannot be provided until 72 hours of this level care, especially if therapeutic hypothermia used
  - cessation of therapy at 24 hours following arrest is usually inappropriate

Figure 4: Adult ALS algorithm

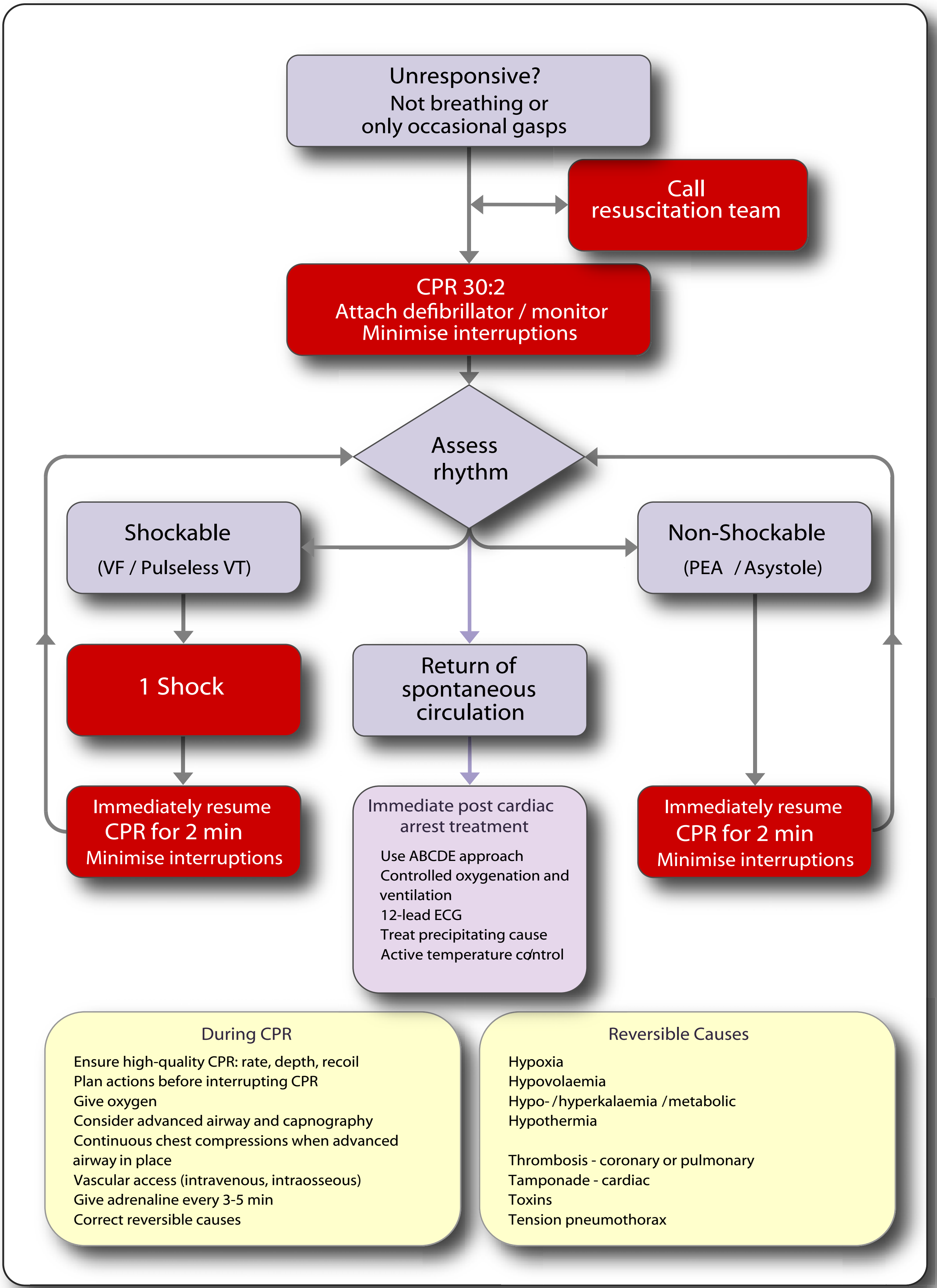
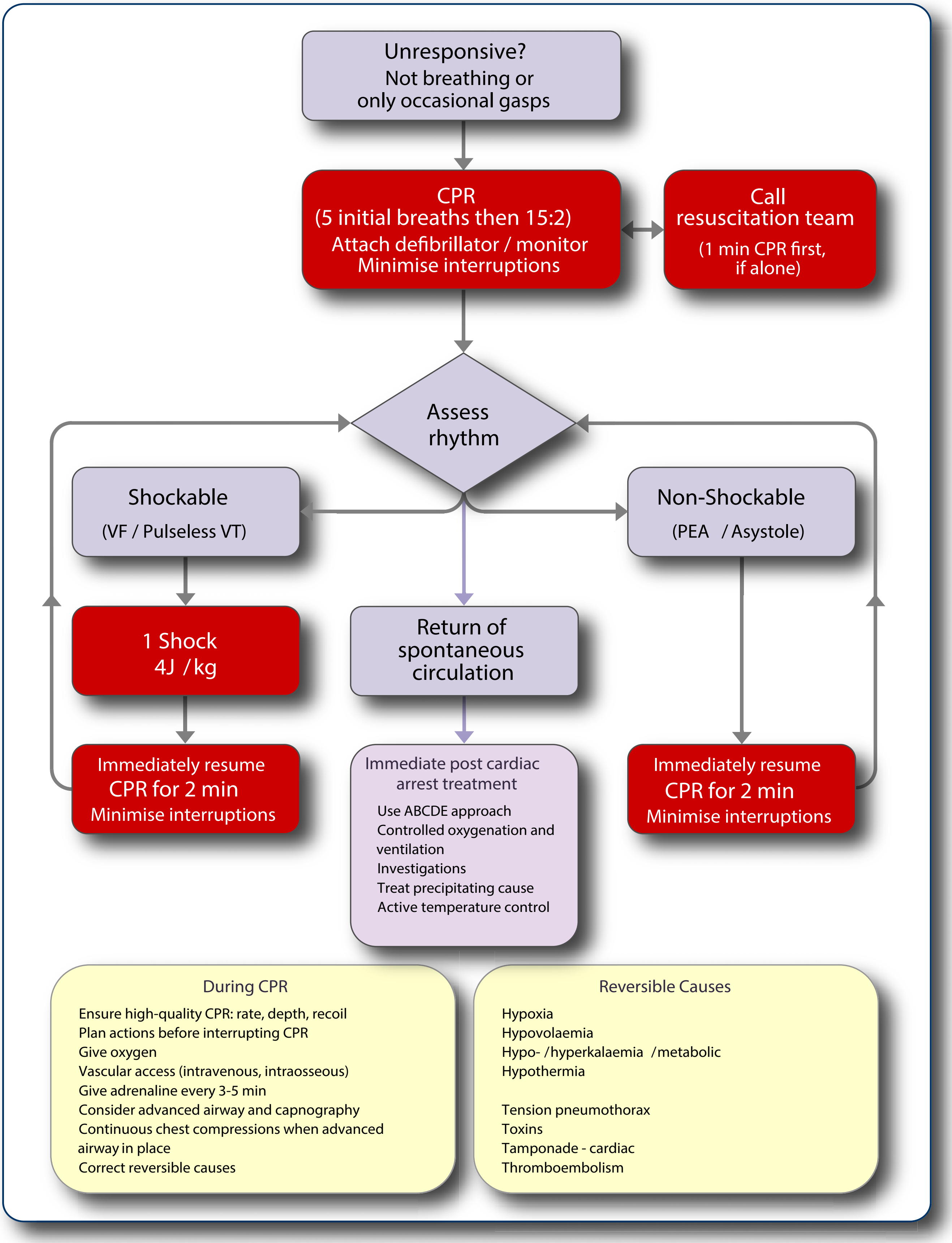


FIGURE 5: PAEDIATRIC ALS ALGORITHM



CARDIAC CARE

Primary percutaneous coronary intervention

- indicated whenever ACS thought to be likely (i.e. whenever a definite other cause has been identified), even if the patient is comatose, in those with sustained ROSC
- ECG changes of STEMI are absent in 25-40% of post arrest patients with acute coronary occlusions
- 80% of patients > 45 years of age have an acute coronary occlusion

- 35 years of age is the crossover point between coronary artery disease being the most likely cause of the arrest and structural, genetic causes being the more likely
- consider in patients with refractory VF if automated chest compression device available and cath lab already open

Maintain cardiac output

- LVEF drops by an average of 10% in the first 24 hours following arrest, then usually starts to recover
- maintain CVP between 8-12mmHg, up to 20mmHg if PEEP used

ECMO

- ECMO and PCI in ongoing arrest may still produce some survivors
  - immediate availability limited in most centres
  - portable devices exist for prehospital use

INDUCED HYPOTHERMIA FOLLOWING CARDIAC ARREST

- results from small early trials suggested that post arrest hypothermia
  - reduced neuronal damage
  - decreased severe disability and death by approximately 15% (absolute) (55 vs 40%) at 6 months
  - improved survival following out of hospital cardiac arrest
  - increased systemic vascular resistance without reducing ejection fraction
  - reduced myocardial oxygen consumption
  - was only of benefit following VF/VT
  - was associated with better outcome, with each 30 minute delay in achieving target temperature associated with a 15% worse outcome
  - had an estimated NNT of 6
- however a large, prospective, randomised trial of patients with out of hospital cardiac arrest (mostly VF/pulseless VT, but also including PEA and asystole) published in December 2013 failed to show any benefit from cooling to 33C compared to 36C
  - however there was active temperature control in both arms
  - there was an 80% bystander CPR rate in this trial, much higher than comparable figures from Australasia
  - the trial only assessed post ROSC hypothermia, not intra-arrest, pre ROSC hypothermia
  - previous trials contained some cases where hyperthermia (which is associated with poor outcome) was present in the control group, and this may have been responsible for the apparent benefit of cooling
  - whilst the implications of this trial are yet to be fully felt, support for therapeutic hypothermia following cardiac arrest to temperatures < 36 degrees is now likely to be limited
  - however the active temperature control and prevention of fever post arrest is still supported

Criteria

- ROSC< 60 minutes after initiation of resuscitation
- persistent absence of response to verbal commands

Not contraindicated in

- pregnancy, but expect fetal bradycardia
  - case reports suggest good maternal and fetal outcomes
- cardiogenic shock

Cooling techniques

- cooling to 32-34C takes approximately 90 minutes to achieve using conventional external cooling methods
  - neuromuscular paralysis helpful
  - usually easier to achieve in patients with lower blood pressures
- maintain therapeutic hypothermia for 24 hours
  - cooling/prevention of hyperthermia for at least 36-72 hours may be needed
  - temperature usually rises following ROSC in survivors, especially following transfer to ICU
- passive rewarming over 8 hours
- one practical method of prehospital cooling is the use of 2 L of ice cold IV NSaline
  - initially thought to be well tolerated
  - more recent evidence suggests 5% increased risk of CCF and re-arrest prior to hospital arrival, as well as slightly lower arrival pH and pO2, although overall functional outcomes not significantly different
  - fluid temperature is closer to 10C when reaching the patient, so it must be given rapidly for it to be effective
  - cooling can be commence during CPR
  - reduces temperature by approximately 1.2C
  - reduces time to obtain a temperature of 34C by approximately 1 hour
- temperature corrected ABG required in hypothermia otherwise paO2 may be overestimated

Intranasal cooling

- using Rhinochill device
  - cooling can be commence during CPR
  - cools the brain rather than the whole body
  - delivers intranasal chilled O_2 from a portable back pack
  - temperature of < 34°C can be achieved in most patients by hospital arrival, 2 hours earlier than in hospital cooling
  - intranasal cooling elements are currently too large to be used in children

Central vascular cooling

- IVTM device
  - requires insertion of special 5 lumen CVC
  - best inserted via Femoral vein
  - circulates saline through 2 lumens of the CVC into an intravascular inflatable thin bladder
  - saline temperature regulated by an external device according to settings
  - warms at approximately 2 degrees/hr
  - cools at approximately 1.5C /hr
  - cost of approximately A$40,000 with catheter costs of approximately A$400 each

Surface cooling systems

- Arctic sun
  - gel pads applied to legs, thorax and abdomen are circulated with water of variable temperature controlled from central reservoir/control panel
  - pads are radio-opaque, safe for defibrillation and MRI compliant
  - temperature controlled by feedback from core temperature thermometer
  - temperature control range 32 - 38.5C
  - warms and cools at a rate of approximately 1C/hr
  - may be more prone to shivering than central cooling methods

THROMBOLYSIS IN CARDIAC ARREST

- not of any benefit in the undifferentiated arrested patient
- reperfusion therapy should still be used if ROSC with good neurological recovery and PCI within 60-90 minutes not available

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"Awake, my heart, to be loved, awake, awake! " - Robert Bridges.