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Part 2: Adult basic life support

International Liaison Committee on Resuscitation

The consensus conference addressed many questions related to the performance of basic life support. These have been grouped into (1) epidemiology and recognition of cardiac arrest, (2) airway and ventilation, (3) chest compression, (4) compression—ventilation sequence, (5) postresuscitation positioning, (6) special circumstances, (7) emergency medical services (EMS) system, and (8) risks to the victim and rescuer. Defibrillation is discussed separately in Part 3 because it is both a basic and an advanced life support skill.

There have been several important advances in the science of resuscitation since the last ILCOR review in 2000. The following is a summary of the evidence-based recommendations for the performance of basic life support:

- Rescuers begin CPR if the victim is unconscious, not moving, and not breathing (ignoring occasional gasps).
- For mouth-to-mouth ventilation or for bag-valve-mask ventilation with room air or oxygen, the rescuer should deliver each breath in 1 s and should see visible chest rise.
- Increased emphasis on the process of CPR: push hard at a rate of 100 compressions per min, allow full chest recoil, and minimise interruptions in chest compressions.
- For the single rescuer of an infant (except newborns), child, or adult victim, use a single compression—ventilation ratio of 30:2 to simplify teaching, promote skills retention, increase the number of compressions given, and decrease interruptions in compressions. During two-rescuer CPR of the infant or child, healthcare providers should use a 15:2 compression—ventilation ratio.
- During CPR for a patient with an advanced airway (i.e. tracheal tube, Combitube, laryngeal mask airway [LMA]) in place, deliver ventilations at a rate of 8—10 per min for infants (excepting neonates), children and adults, without pausing during chest compressions to deliver the ventilations.

Epidemiology and recognition of cardiac arrest

Many people die prematurely from sudden cardiac arrest (SCA), often associated with coronary heart disease. The following section summarises the burden, risk factors, and potential interventions to reduce the risk.

Epidemiology

Incidence
W137, W138A

Consensus on science. Approximately 400,000—460,000 people in the United States (LOE 5)[1] and 700,000 people in Europe (LOE 7)[2] experience SCA each year; resuscitation is attempted in approximately two thirds of these victims.[3] Case series and cohort studies showed wide variation in the incidence of cardiac arrest, depending on the method

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of assessment:

1.5 per 1000 person-years based on death certificates (LOE 5),[4]
0.5 per 1000 person-years based on activation of emergency medical services (EMS) systems (LOE 5).[5,6]

In recent years the incidence of ventricular fibrillation (VF) at first rhythm analysis has declined significantly.[7–9]

Prognosis
W138B

Consensus on science. Since the previous international evidence evaluation process (the International Guidelines 2000 Conference on CPR and ECC),[10] there have been three systematic reviews of survival-to-hospital discharge from out-of-hospital cardiac arrest (LOE 5).[5,11,12] Of all victims of cardiac arrest treated by EMS providers, 5—10% survive; of those with VF, 15% survive to hospital discharge. In data from a national registry, survival to discharge from in-hospital cardiac arrest was 17% (LOE 5).[13] The aetiology and presentation of in-hospital arrest differ from that of out-of-hospital arrests.

Risk of cardiac arrest is influenced by several factors, including demographic, genetic, behavioural, dietary, clinical, anatomical, and treatment characteristics (LOE 4—7).[4,14–19]

Recognition

Early recognition is a key step in the early treatment of cardiac arrest. It is important to determine the most accurate method of diagnosing cardiac arrest.

Signs of cardiac arrest
W142A, W142B

Consensus on science. Checking the carotid pulse is an inaccurate method of confirming the presence or absence of circulation (LOE 3)[20]; however, there is no evidence that checking for movement, breathing, or coughing (i.e. ''signs of circulation'') is diagnostically superior (LOE 3).[21,22] Agonal gasps are common in the early stages of cardiac arrest (LOE 5).[23] Bystanders often report to dispatchers that victims of cardiac arrest are ''breathing'' when they demonstrate agonal gasps; this can result in the withholding of CPR from victims who might benefit from it (LOE 5).[24]

Treatment recommendation. Rescuers should start CPR if the victim is unconscious (unresponsive), not moving, and not breathing. Even if the victim takes occasional gasps, rescuers should suspect that cardiac arrest has occurred and should start CPR.

Airway and ventilation

The best method of obtaining an open airway and the optimum frequency and volume of artificial ventilation were reviewed.

Airway

Opening the airway
W149

Consensus on science. Five prospective clinical studies evaluating clinical (LOE 3)[25,26] or radiological (LOE 3)[27–29] measures of airway patency and one case series (LOE 5)[30] showed that the head tilt—chin lift manoeuvre is feasible, safe, and effective. No studies have evaluated the routine use of the finger sweep manoeuvre to clear an airway in the absence of obvious airway obstruction.

Treatment recommendation. Rescuers should open the airway using the head tilt—chin lift manoeuvre. Rescuers should use the finger sweep in the unconscious patient with a suspected airway obstruction only if solid material is visible in the oropharynx.

Devices for airway positioning
W1, W49A, W49B

Consensus on science. There is no published evidence on the effectiveness of devices for airway positioning. Collars that are used to stabilise the cervical spine can make airway management difficult and increase intracranial pressure (LOE 4[31–33]; LOE 5[34]).

Foreign-body airway obstruction
W151A, W151B

Like CPR, relief of foreign-body airway obstruction (FBAO) is an urgent procedure that should be taught to laypersons. Evidence for the safest, most effective, and simplest methods was sought.

Consensus on science. It is unclear which method of removal of FBAO should be used first. For conscious victims, case reports showed success in relieving FBAO with back blows (LOE 5),[35–37] abdominal thrusts (LOE 5),[36–44] and chest thrusts (LOE 5).[36] Frequently, more than one technique was needed to achieve relief of the obstruction.[36,45–50] Life-threatening complications have been associated with the use of abdominal thrusts (LOE 5).[48,51–72]

For unconscious victims, case reports showed success in relieving FBAO with chest thrusts (LOE 5)[49] and abdominal thrusts (LOE 5).[73] One randomised trial of manoeuvres to clear the airway in cadavers (LOE 7)[74] and two prospective studies in anaesthetised volunteers (LOE 7)[75,76] showed that higher airway pressures can be generated by using the chest thrust rather than the abdominal thrust.

Case series (LOE 5)[36,37,45] reported the finger sweep as effective for relieving FBAO in unconscious adults and children aged >1 year. Four case reports documented harm to the victim's mouth (LOE 7)[77,78] or biting of the rescuer's finger (LOE 7).[29,30]

Treatment recommendation. Chest thrusts, back blows, or abdominal thrusts are effective for relieving FBAO in conscious adults and children >1 year of age, although injuries have been reported with the abdominal thrust. There is insufficient evidence to determine which should be used first. These techniques should be applied in rapid sequence until the obstruction is relieved; more than one technique may be needed. Unconscious victims should receive CPR. The finger sweep can be used in the unconscious patient with an obstructed airway if solid material is visible in the airway. There is insufficient evidence for a treatment recommendation for an obese or pregnant patient with FBAO.

Ventilation

Mouth-to-nose ventilation

W157A, W157B

Consensus on science. A case series suggested that mouth-to-nose ventilation of adults is feasible, safe, and effective (LOE 5).[79]

Treatment recommendation. Mouth-to-nose ventilation is an acceptable alternative to mouth-to-mouth ventilation.

Mouth-to-tracheal stoma ventilation

W158A, 158B

Consensus on science. There was no published evidence of the safety or effectiveness of mouth-to-stoma ventilation. A single crossover study of patients with laryngectomies showed that a paediatric face mask provided a better seal around the stoma than a standard ventilation mask (LOE 4).[80]

Treatment recommendation. It is reasonable to perform mouth-to-stoma breathing or to use a well-sealing, round pediatric face mask.

Tidal volumes and ventilation rates

W53, W156A

Consensus on science. There was insufficient evidence to determine how many initial breaths should be given. Manikin studies (LOE 6)[81–83] and one human study (LOE 7)[84] showed that when there is no advanced airway (such as a tracheal tube, Combitube, or LMA) in place, a tidal volume of 1 L produced significantly more gastric inflation than a tidal volume of 500 mL. Studies of anaesthetised patients with no advanced airway in place showed that ventilation with 455 mL of room air was associated with an acceptable but significantly reduced oxygen saturation when compared with 719 mL (LOE 7).[85] There was no difference in oxygen saturation with volumes of 624 and 719 mL (LOE 7).[85] A study of cardiac arrest patients compared tidal volumes of 500 mL versus 1000 mL delivered to patients with advanced airways during mechanical ventilation with 100% oxygen at a rate of 12 min^{-1} (LOE 2).[86] Smaller tidal volumes were associated with higher arterial PCO_2 and worse acidosis but no differences in PaO_2.

Reports containing both a small case series (LOE 5) and an animal study (LOE 6)[87,88] 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 min^{-1} and inspiration times >1 s were associated with no survival (LOE 5).[87,88] Extrapolation from an animal model of severe shock suggests that a ventilation rate of six ventilations per minute is associated with adequate oxygenation and better haemodynamics than $\geq$12 ventilations min^{-1} (LOE 6).[89] In summary, larger tidal volumes and ventilation rates can be associated with complications, whereas the detrimental effects observed with smaller tidal volumes appear to be acceptable.

Treatment recommendation. For mouth-to-mouth ventilation with exhaled air or bag-valve-mask ventilation with room air or oxygen, it is reasonable to give each breath within a 1-s inspiratory time to achieve chest rise. After an advanced airway (e.g. tracheal tube, Combitube, LMA) 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 8—10 ventilations min^{-1} without pausing during chest compressions to deliver ventilations. Use the same initial tidal volume and rate in patients regardless of the cause of the cardiac arrest.

Mechanical ventilators and automatic transport ventilators
W55,W152A

Consensus on science. Three manikin studies of simulated cardiac arrest showed a significant decrease in gastric inflation with manually triggered, flow-restricted, oxygen-powered resuscitators when compared with ventilation by bag-valve-mask (LOE 6).[90—92] One study showed that firefighters who ventilated anaesthetised patients with no advanced airway in place produced less gastric inflation and lower peak airway pressure with manually triggered, flow-limited, oxygen-powered resuscitators than with a bag-valve-mask (LOE 5).[93] A prospective cohort study of intubated patients, most in cardiac arrest, in an out-of-hospital setting showed no significant difference in arterial blood gas values between those ventilated with an automatic transport ventilator and those ventilated manually (LOE 4).[94] Two laboratory studies showed that automatic transport ventilators can provide safe and effective management of mask ventilation during CPR of adult patients (LOE 6).[95,96]

Treatment recommendation. There are insufficient data to recommend for or against the use of a manually triggered, flow-restricted resuscitator or an automatic transport ventilator during bag-valve-mask ventilation and resuscitation of adults in cardiac arrest.

Chest compressions

Several components of chest compressions can alter effectiveness: hand position, position of the rescuer, position of the victim, depth and rate of compression, decompression, and duty cycle (see definition below). Evidence for these techniques was reviewed in an attempt to define the optimal method.

Chest compression technique

Hand position
W167A,W167C

Consensus on science. There was insufficient evidence for or against a specific hand position for chest compressions during CPR in adults. In children who require CPR, compression of the lower one third of the sternum may generate a higher blood pressure than compressions in the middle of the chest (LOE 4).[97]

Manikin studies in healthcare professionals showed improved quality of chest compressions when the dominant hand was in contact with the sternum (LOE 6).[98] There were shorter pauses between ventilations and compressions if the hands were simply positioned ''in the center of the chest'' (LOE 6).[99]

Treatment recommendation. It is reasonable for laypeople and healthcare professionals to be taught to position the heel of their dominant hand in the centre of the chest of an adult victim, with the non-dominant hand on top.

Chest compression rate, depth, decompression, and duty cycle
W167A,W167B,W167C

Consensus on science

Rate. The number of compressions delivered per minute is determined by the compression rate, the compression—ventilation ratio, the time required to provide mouth-to-mouth or bag-valve-mask ventilation, and the strength (or fatigue) of the rescuer. Observational studies showed that responders give fewer compressions than currently recommended (LOE 5).[100—103] Some studies in animal models of cardiac arrest showed that high-frequency CPR (120—150 compressions min^{-1}) improved haemodynamics without increasing trauma when compared with standard CPR (LOE 6),[104—107] whereas others showed no effect (LOE 6).[108] Some studies in animals showed more effect from other variables, such as duty cycle (see below).[109] In humans, high-frequency CPR (120 compressions min^{-1}) improved haemodynamics over standard CPR (LOE 4).[110] In mechanical CPR in humans, however, high-frequency CPR (up to 140 compressions min^{-1}) showed no improvement in haemodynamics when compared with 60 compressions min^{-1} (LOE 5).[111,112]

Depth. In both out-of-hospital[102] and in-hospital[100] studies, insufficient depth of compression was observed during CPR when compared with currently recommended depths (LOE 5).[100,102] Studies in animal models of adult cardiac arrest showed that deeper compressions (i.e. 3—4 in.) are correlated with improved ROSC and 24-h neurological outcome when compared with standard-depth compressions (LOE 6).[107,113,114] A manikin study of rescuer CPR showed that compressions became shallow within one minute, but providers became aware of fatigue only after 5 min (LOE 6).[115]

Decompression. One observational study in humans (LOE 5)[88] and one manikin study (LOE 6) [116] showed that incomplete chest recoil was common during CPR. In one animal study incomplete chest recoil was associated with significantly increased intrathoracic pressure, decreased venous return, and decreased coronary and cerebral perfusion during CPR (LOE 6).[117] In a manikin study, lifting the hand slightly but completely off the chest during decompression allowed full chest recoil (LOE 6).[116]

Duty cycle. The term *duty cycle* refers to the time spent compressing the chest as a proportion of the time between the start of one cycle of compression and the start of the next. Coronary blood flow is determined partly by the duty cycle (reduced coronary perfusion with a duty cycle >50%) and partly by how fully the chest is relaxed at the end of each compression (LOE 6).[118] One animal study that compared duty cycles of 20% with 50% during cardiac arrest chest compressions showed no statistical difference in neurological outcome at 24 h (LOE 6).[107]

A mathematical model of Thumper CPR showed significant improvements in pulmonary, coronary, and carotid flow with a 50% duty cycle when compared with compression—relaxation cycles in which compressions constitute a greater percentage of the cycle (LOE 6).[119] At duty cycles ranging between 20 and 50%, coronary and cerebral perfusion in animal models increased with chest compression rates of up to 130—150 compressions min^{-1} (LOE 6).[104,105,109] In a manikin study, duty cycle was independent of the compression rate when rescuers increased progressively from 40 to 100 compressions min^{-1} (LOE 6).[120] A duty cycle of 50% is mechanically easier to achieve with practice than cycles in which compressions constitute a smaller percentage of cycle time (LOE 7).[121]

Treatment recommendation. It is reasonable for lay rescuers and healthcare providers to perform chest compressions for adults at a rate of at least 100 compressions min^{-1} and to compress the sternum by at least 4—5 cm. Rescuers should allow complete recoil of the chest after each compression. When feasible, rescuers should frequently alternate ''compressor'' duties, 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%.

Firm surface for chest compressions
W167A

Consensus on science. When manikins were placed on a bed supported by a pressure-relieving mattress, chest compressions were less effective than those performed when the manikins were placed on the floor. Emergency deflation of the mattress did not improve the efficacy of chest compressions (LOE 6).[122,123] These studies did not involve standard mattresses or backboards and did not consider the logistics of moving a victim from a bed to the floor.

Treatment recommendation. Cardiac arrest victims should be placed supine on a firm surface (i.e. backboard or floor) during chest compressions to optimise the effectiveness of compressions.

CPR process versus outcome
W182A, W182B, W194

Consensus on science. CPR compression rate and depth provided by lay responders (LOE 5),[124] physician trainees (LOE 5),[100] and EMS personnel (LOE 5)[102] were insufficient when compared with currently recommended methods. Ventilation rates and durations higher or longer than recommended when CPR is performed impaired haemodynamics and reduced survival rates (LOE 6).[88] It is likely that poor performance of CPR impairs haemodynamics and possibly survival rates.

Treatment recommendation. It is reasonable for instructors, trainees, providers, and EMS agencies to monitor and improve the process of CPR to ensure adherence to recommended compression and ventilation rates and depths.

Alternative compression techniques

CPR in the prone position
W166D

Consensus on science. Six case series that included 22 intubated hospitalised patients documented survival to discharge in 10 patients who received CPR in a prone position (LOE 5).[125—130]

Treatment recommendation. CPR with the patient in a prone position is a reasonable alternative for intubated hospitalised patients who cannot be placed in the supine position.

Leg-foot chest compressions
W166C

Consensus on science. Three studies in manikins showed no difference in chest compressions, depth, or rate when leg-foot compressions were used instead of standard chest compressions (LOE 6).[131–133] Two studies[132,133] reported that rescuers felt fatigue and leg soreness when using leg-foot chest compressions. One study[132] reported incomplete chest recoil when leg-foot chest compressions were used.

'Cough' CPR
W166A

Consensus on science. Case series (LOE 5)[134–136] show that repeated coughing every one to three seconds during episodes of rapid VF in supine, monitored, trained patients in the cardiac catheterisation laboratory can maintain a mean arterial pressure > 100 mmHg and maintain consciousness for up to 90 s. No data support the usefulness of cough CPR in any other setting, and there is no specific evidence for or against use of cough CPR by laypersons in unsupervised settings.

Compression—ventilation sequence

Any recommendation for a specific CPR compression—ventilation ratio represents a compromise between the need to generate blood flow and the need to supply oxygen to the lungs. At the same time any such ratio must be taught to would-be rescuers, so that skills acquisition and retention are also important factors.

Effect of ventilations on compressions

Interruption of compressions
W147A, W147B

Consensus on science. In animal studies interruption of chest compressions is associated with reduced ROSC and survival as well as increased postresuscitation myocardial dysfunction (LOE 6).[137–139]

Observational studies (LOE 5)[100,102] and secondary analyses of two randomised trials (LOE 5)[140,141] have shown that interruption of chest compressions is common. In a retrospective analysis of the VF waveform, interruption of CPR was associated with a decreased probability of conversion of VF to another rhythm (LOE 5).[141]

Treatment recommendation. Rescuers should minimise interruptions of chest compressions.

Compression—ventilation ratio during CPR
W154

Consensus on science. An observational study showed that experienced paramedics performed ventilation at excessive rates on intubated patients during treatment for out-of-hospital cardiac arrest (LOE 5).[88] An in-hospital study also showed delivery of excessive-rate ventilation to patients with and without advanced airways in place.[100] Two animal studies showed that hyperventilation is associated with excessive intrathoracic pressure and decreased coronary and cerebral perfusion pressures and survival rates (LOE 6).[87,88]

Observational studies in humans showed that responders gave fewer compressions than currently recommended (LOE 5).[100–102]

Multiple animal studies of VF arrests showed that continuous chest compressions with minimal or no interruptions is associated with better haemodynamics and survival than standard CPR (LOE 6).[137,139,142–144]

Results of varying compression—ventilation ratios in intubated animal models and even theoretical calculations have yielded mixed results. In one animal model of cardiac arrest, use of a compression—ventilation ratio of 100:2 was associated with significantly improved neurological function at 24 h when compared with a ratio of 15:2 or continuous-compression CPR, but there was no significant difference in perfusion pressures or survival rates (LOE 6).[145] In an animal model of cardiac arrest, use of a compression—ventilation ratio of 50:2 achieved a significantly greater number of chest compressions than using either 15:2 or 50:5 (LOE 6).[146] Carotid blood flow was significantly greater at a ratio of 50:2 compared with 50:5 and not significantly different from that achieved with a ratio of 15:2. Arterial oxygenation and oxygen delivery to the brain were significantly higher with a ratio of 15:2 when compared with a ratio of either 50:5 or 50:2. In an animal model of cardiac arrest, a compression—ventilation ratio of 30:2 was associated with significantly shorter time to ROSC and greater systemic and cerebral oxygenation than with continuous chest compressions (LOE 6).[147] A theoretical analysis suggests that a compression—ventilation ratio of 30:2 would provide the best blood flow and oxygen delivery (LOE 7).[148]

An animal model of asphyxial arrest showed that compression-only CPR is associated with significantly greater pulmonary oedema than both compression and ventilation, with or without oxygenation (LOE 6).[149]

Treatment recommendation. There is insufficient evidence that any specific compression—ventilation ratio is associated with improved outcome in patients with cardiac arrest. To increase the number of compressions given, minimise interruptions of chest compressions, and simplify instruction for teaching and skills retention, a single compression—ventilation ratio of 30:2 for the lone rescuer of an infant, child, or adult victim is recommended. Initial steps of resuscitation may include (1) opening the airway while verifying the need for resuscitation, (2) giving 2—5 breaths when initiating resuscitation, and (3) then providing compressions and ventilations using a compression—ventilation ratio of 30:2.

Chest compression-only CPR
W52, W164A, W164B

Consensus on science. No prospective studies have assessed the strategy of implementing chest compression—only CPR. A randomised trial of telephone instruction in CPR given to untrained lay responders in an EMS system with a short (mean: four minutes) response interval suggests that a strategy of teaching chest compressions alone is associated with similar survival rates when compared with a strategy of teaching chest compressions and ventilations (LOE 7).[150]

Animal studies of nonasphyxial arrest demonstrate that chest compression—only CPR may be as efficacious as compression—ventilation CPR in the initial few minutes of resuscitation (LOE 6).[142,150] In another model of nonasphyxial arrest, however, a compression—ventilation ratio of 30:2 maintained arterial oxygen content at two thirds of normal, but compression-only CPR was associated with desaturation within two minutes (LOE 6).[147] In observational studies of adults with cardiac arrest treated by lay responders trained in standard CPR, survival was better with compression-only CPR than with no CPR but not as good as with both compressions and ventilations (LOE 3;[151] LOE 4[124]).

Treatment recommendation. Rescuers should be encouraged to do compression-only CPR if they are unwilling to do airway and breathing manoeuvres or if they are not trained in CPR or are uncertain how to do CPR. Researchers are encouraged to evaluate the efficacy of compression-only CPR.

Postresuscitation positioning

Recovery position
W155, W146A, W146B

Consensus on science. No studies were identified that evaluated any recovery position in an unconscious victim with normal breathing. A small cohort study (LOE 5)[152] and a randomised trial (LOE 7)[153] in normal volunteers showed that compression of vessels and nerves occurs infrequently in the dependent limb when the victim's lower arm is placed in front of the body; however, the ease of turning the victim into this position may outweigh the risk (LOE 5).[154,155]

Treatment recommendation. It is reasonable to position an unconscious adult with normal breathing on the side with the lower arm in front of the body.

Special circumstances

Cervical spine injury

For victims of suspected spinal injury, additional time may be needed for careful assessment of breathing and circulation, and it may be necessary to move the victim if he or she is found face-down. In-line spinal stabilisation is an effective method of reducing risk of further spinal damage.

Airway opening
W150A, W150B

Consensus on science. The incidence of cervical spine injury after blunt trauma was 2.4% (LOE 5)[156] but increased in patients with craniofacial injuries (LOE 4),[157] a Glasgow Coma Scale score of <8 (LOE 4),[158] or both (LOE 4).[159] A large cohort study (LOE 4)[160] showed that the following features are highly sensitive (94% to 97%) predictors of spinal injury when applied by professional rescuers: mechanism of injury, altered mental status, neurological deficit, evidence of intoxication, spinal pain or tenderness, and distracting injuries (i.e. injuries that distract the victim from awareness of cervical pain). Failure to stabilise an injured spine was associated with an increased risk of secondary neurological injury (LOE 4).[161,162] A case—control study of injured patients with and without stabilisation showed that the risk of secondary injury may be lower than previously thought (LOE 4).[163]

All airway manoeuvres cause spinal movement (LOE 5).[164] Studies in human cadavers showed that both chin lift (with or without head tilt) and jaw thrust were associated with similar, substantial movement of the cervical vertebrae (LOE 6;[164—166] LOE 7[167,168]). Use of manual in-line stabilisation (MILS)[168] or spinal collars (LOE 6)[164] did not prevent spinal movement. Other studies have shown that application of MILS during airway manoeuvres reduces spinal movement to physiological levels

(LOE 5,6).[169,170] Airway manoeuvres can be undertaken more safely with MILS than with collars (LOE 3, 5).[171–173] But a small study of anaesthetised paralysed volunteers showed that use of the jaw thrust with the head maintained in neutral alignment did not improve radiological airway patency (LOE 3).[28] No studies evaluated CPR on a victim with suspected spinal injuries.

Treatment recommendation. Maintaining an airway and adequate ventilation is the overriding priority in managing a patient with a suspected spinal injury. In a victim with a suspected spinal injury and an obstructed airway, the head tilt—chin lift or jaw thrust (with head tilt) techniques are feasible and may be effective for clearing the airway. Both techniques are associated with cervical spinal movement. Use of MILS to minimise head movement is reasonable if a sufficient number of rescuers with adequate training are available.

Face-down victim
W143A, W143B

Consensus on science. Head position was an important factor in airway patency (LOE 5),[174] and it was more difficult to check for breathing with the victim in a face-down position. Checking for breathing by lay and professional rescuers was not always accurate when done within the recommended 10 s (LOE 7).[21,22] A longer time to check for breathing will delay CPR and may impair outcome.

Treatment recommendation. It is reasonable to roll a face-down, unresponsive victim carefully into the supine position to check for breathing.

Drowning

Drowning is a common cause of death worldwide. The special needs of the drowning victim were reviewed.

CPR for drowning victim in water
W160A, W160B

Consensus on science. Expired-air resuscitation in the water may be effective when undertaken by a trained rescuer (LOE 5;[175,176] LOE 6[177]). Chest compressions are difficult to perform in water and could potentially cause harm to both the rescuer and victim.

Treatment recommendation. In-water expired-air resuscitation may be considered by trained rescuers, preferably with a flotation device, but chest compressions should not be attempted in the water.

Removing drowning victim from water
W161

Consensus on science. Human studies showed that drowning victims without clinical signs of injury or obvious neurological deficit, a history of diving, use of a waterslide, trauma, or alcohol intoxication are unlikely to have a cervical spine injury (LOE 4;[178,179] LOE 5[180–184]).

Treatment recommendation. Drowning victims should be removed from the water and resuscitated by the fastest means available. Only victims with risk factors or clinical signs of injury or focal neurological signs should be treated as a victim with a potential spinal cord injury, with immobilisation of the cervical and thoracic spine.

EMS system

Dispatcher instruction in CPR
W165

Consensus on science. Observational studies (LOE 4)[185,186] and a randomised trial (LOE 2)[187] of telephone instruction in CPR by dispatchers to untrained lay responders in an EMS system with a short (mean 4 minutes) response interval showed that dispatcher instruction in CPR increases the likelihood of performance of bystander CPR but may or may not increase the rate of survival from cardiac arrest.

Treatment recommendation. Providing telephone instruction in CPR is reasonable.

Improving EMS response interval
W148A

Consensus on science. Cohort studies (LOE 3)[188–191] and a systematic review (LOE 1)[12] of cohort studies of patients with out-of-hospital cardiac arrest show that reducing the interval from EMS call to arrival increases survival to hospital discharge. Response time may be reduced by using professional first responders such as fire or police personnel or other methods.

Treatment recommendation. Administrators responsible for EMS and other systems that respond to patients with cardiac arrest should evaluate their process of delivering care and make resources available to shorten response time intervals when improvements are feasible.

Risks to victim and rescuer

Risks to trainees
W141B, W141C, W196

Consensus on science. Few adverse events from training in CPR have been reported by instructors and trainees even though millions of people are trained annually throughout the world. Case series reported the following infrequent adverse occurrences in trainees (LOE 5): infections, including herpes simplex virus (HSV);[192] *Neisseria meningitides*;[193] hepatitis B virus (HBV);[194] stomatitis;[195] tracheitis;[196] and others, including chest pain or near-syncope attributed to hyperventilation[197] and fatal myocardial infarction.[198] There was no evidence that a prior medical assessment of ''at-risk'' trainees reduces any perceived risk (LOE 7).[199]

Commonly used chemical disinfectants effectively removed bacteriologic and viral contamination of the training manikin (LOE 6).[200,201] Another study showed that 70% ethanol with or without 0.5% chlorhexidine did not completely eradicate herpes simplex contamination after several hours (LOE 6).[192]

Treatment recommendation. Training manikins should be cleaned between trainee ventilation sessions. It is acceptable to clean them with commercially available antiseptic, 30% isopropyl alcohol, 70% alcohol solution, or 0.5% sodium hypochlorite, allowing at least 1 minute of drying time between trainee ventilation sessions.

Risks to responders
W141A, W159A, W159B, W184A, W184B

Consensus on science. Few adverse events resulting from providing CPR have been reported, even though CPR is performed frequently throughout the world. There were only isolated reports of persons acquiring infections after providing CPR, e.g. tuberculosis[202] and severe acute respiratory distress syndrome (SARS).[203] Transmission of HIV during provision of CPR has never been reported. Responders exposed to infections while performing CPR might reduce their risk of becoming infected by taking appropriate prophylactic steps (LOE 7).[193] Responders occasionally experienced psychological distress.[204–208]

No human studies have addressed the safety, effectiveness, or feasibility of using barrier devices during CPR. Laboratory studies showed that nonwoven fibre filters or barrier devices with one-way valves prevented oral bacterial flora transmission from victim to rescuer during mouth-to-mouth ventilation (LOE 6).[209,210] Giving mouth-to-mouth ventilation to victims of organophosphate or cyanide intoxication was associated with adverse effects for responders (LOE 5).[211,212] One study showed that a high volume of air transmitting a highly virulent agent (i.e. SARS coronavirus) can overwhelm the protection offered by gowns, 2 sets of gloves, goggles, a full face shield, and a non—fit-tested N95 disposable respirator (LOE 5).[203]

Treatment recommendation. Providers should take appropriate safety precautions when feasible and when resources are available to do so, especially if a victim is known to have a serious infection (e.g. HIV, tuberculosis, HBV, or SARS).

Risks for the victim
W140A

Consensus on science. The incidence of rib fractures among survivors of cardiac arrest who received standard CPR is unknown. Rib fractures and other injuries are commonly observed among those who die following cardiac arrest and provision of standard CPR (LOE 4).[213] One study (LOE 4)[214] showed an increased incidence of sternal fractures in an active compression—decompression (ACD)-CPR group when compared with standard CPR alone. The incidence of rib fractures after mechanically performed CPR appeared to be similar to that occurring after performance of standard CPR (LOE 6).[215] There is no published evidence of the incidence of adverse effects when chest compressions are performed on someone who does not require resuscitation.

Treatment recommendation. Rib fractures and other injuries are common but acceptable consequences of CPR given the alternative of death from cardiac arrest. After resuscitation all patients should be reassessed and re-evaluated for resuscitation-related injuries.

If available, the use of a barrier device during mouth-to-mouth ventilation is reasonable. Adequate protective equipment and administrative, environmental, and quality control measures are necessary during resuscitation attempts in the event of an outbreak of a highly transmittable microbe such as the SARS coronavirus.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.resuscitation.2005.09.016.

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