British Journal of Anaesthesia 1997; **79**: 151–158

Basic life support

A. J. HANDLEY

This review introduces the new guidelines for basic life support for use in the UK, approved by the Resuscitation Council (UK), and based on the work of the International Liaison Committee on Resuscitation. Some of the background reasoning behind the development of these guidelines is discussed.

Basic life support

The term basic life support (BLS) refers to maintaining an airway and supporting breathing and the circulation. It comprises the following elements: initial assessment, airway maintenance, expired air ventilation (rescue breathing; mouth-to-mouth ventilation) and chest compression. When all are combined the term cardiopulmonary resuscitation (CPR) is used. BLS implies that no equipment is used; when a simple airway or face mask for mouth-to-mask resuscitation is used, this is defined as "basic life support with airway adjunct".

The purpose of BLS is to maintain adequate ventilation and circulation until a means can be obtained to reverse the underlying cause of the arrest. It is therefore a "holding operation", although on occasion, particularly when the primary pathology is respiratory failure, it may itself reverse the cause and allow full recovery.

History

The earliest reference to mouth-to-mouth ventilation is considered to be in the Bible, when God created Adam,[10] and when the prophet Elisha revived an apparently dead child.[11] An early medical report of success was reported by Tossach in 1744.[61] After this report, however, there was no further progress with the technique, and attention was turned towards manual methods such as those described by Silvester,[67] Schafer[64] and Holger Nielsen.[33] It is possible that the prudery of the Victorian era prevented acceptance of any method which involved lip contact, but it was not until the 1950s that mouth-to-mouth ventilation was rediscovered and became accepted universally as the method of choice. The inefficiency of the manual methods has led to them being abandoned.[59]

Closed chest cardiac massage was first described in 1878 by Boehm[61] and used successfully in a few cases of cardiac arrest over the next 10 years. After that, however, open chest massage became the standard management for cardiac arrest until 1960, when the classic article on closed chest massage by Kouwenhoven, Jude and Knickerbocker was published.[44] As this coincided with the rebirth of mouth-to-mouth ventilation, 1960 could be considered the year in which modern cardiopulmonary resuscitation was born.

Does BLS work?

Approximately 70% of all cases of cardiac arrest occur out of hospital, often in the victim's home.[27] Early intervention by a bystander—calling for the emergency services and initiating CPR—can materially improve eventual outcome.[18] The sooner that BLS can be instituted the better is the outcome.[21] The concept of the "chain of survival" (see fig. 1) emphasizes that optimum results can be achieved only with the four elements of: early access, early CPR, early defibrillation and early advanced cardiac life support.[19] Most cases of survival from cardiac arrest occur when the victim is in ventricular fibrillation, and the effect of CPR is to prevent this rhythm from degenerating into asystole,[74] the prognosis for which is poor.[77] The provision of a defibrillator at the earliest possible opportunity is of prime importance. The longer the delay before this can be achieved, the more important is the provision of CPR.[12] The opposite is also the case; where the emergency back-up is so well advanced that a defibrillator can be provided on scene within 3–4 min, initial CPR is of little benefit.[71]

For a witnessed, out-of-hospital cardiac arrest when the victim is in ventricular fibrillation, a survival rate to leaving hospital of approximately 30% should be possible.[23] Recent reports show that this can be achieved in Europe.[25]

If cardiac arrest occurs in hospital, the outcome depends on the underlying condition of the patient[41]: approximately 15% may be expected to

(*Br. J. Anaesth*. 1997; **79**: 151–158).

Key words

Complications, cardiac arrest. Heart, resuscitation. Basic life support.

ANTHONY J. HANDLEY, MD, FRCP, Department of Medicine, Colchester General Hospital, Turner Road, Colchester, Essex CO4 5JL.

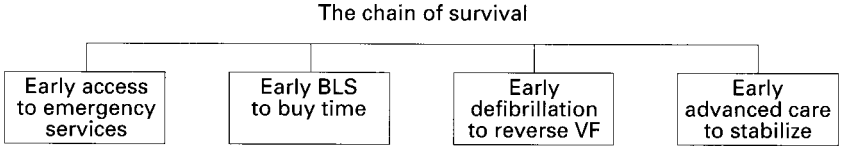

Figure 1 The concept of "chain of survival". The concept emphasizes that optimum results can be achieved only with the four elements of: early access, early CPR, early defibrillation and early advanced cardiac life support. BLS = Basic life support, VF = ventricular fibrillation.

leave hospital alive.[73] For these patients, CPR may play a much lesser role compared with defibrillation and advanced life support.[41]

BLS guidelines

Since 1975 the American Heart Association has periodically issued standards and guidelines for the performance of resuscitation including BLS.[24 68 69 70] These guidelines have been followed by many organizations throughout the world, but there have also been numerous variations. In 1992 the European Resuscitation Council issued guidelines particularly appropriate to the emergency care facilities available within Europe.[5] The Resuscitation Council (UK) adopted these guidelines which then became the standard for this country.[26]

In 1993 the Basic Life Support Group of the International Liaison Committee on Resuscitation (ILCOR) was formed to review existing BLS guidelines from around the world, and to produce a document, or "advisory statement", that could be used as a resource by organizations wishing to develop their own guidelines. The group consists of representatives from resuscitation councils throughout the world, including the American Heart Association, Australian Resuscitation Council, European Resuscitation Council, Heart and Stroke Foundation of Canada, and Resuscitation Council of Southern Africa. An "advisory statement" on BLS (and on advanced life support and paediatric life support) has now been produced.[37] This advisory statement has been adopted, with minor modifications, by the Resuscitation Council (UK) and is presented below.

Even though the value of early, bystander CPR is universally recognized and public CPR programmes have been in existence for approximately 30 yr, most communities still fail to train a sufficiently high proportion of the public to perform basic life support.[27] Paradoxically, in some high-risk populations, the likelihood of bystander CPR being performed is particularly poor.[8 23]

The special challenge when producing guidelines for BLS is to make them equally applicable for use by members of the general public and by health care professionals.

The BLS group of ILCOR set itself four objectives—the advisory statements had to: (a) embrace modern scientific opinion; (b) be as simple as possible to aid skill retention; (c) be the best advice available whatever the cause or nature of the cardiopulmonary arrest; (d) be acceptable to all countries and organizations.

Inevitably, objectives (c) and (d) required compromise decisions. Some variations had to be incorporated to allow for the different causes of collapse, particularly the difference between primary respiratory and primary cardiac arrest. It was also accepted that differences in the level of national and local emergency medical services would dictate the optimum point in the resuscitation attempt when the lone rescuer should leave the victim to go to obtain help.

What should be taught?

What the public is taught must be based on the most up-to-date available scientific evidence. BLS skills have to be taught, learnt and remembered, yet are often only used for the first time months or years later. It is well recognized that skill decay is rapid, even among professionals.[9 15 54] This may be caused partly by poor standards of teaching,[42] but partly also by the highly complex nature of the psychomotor skills involved. Within 4 months of being trained, 50% of first aiders were unable to perform adequate CPR on a manikin[35]; 6 months after a public course in BLS, only approximately 7% of those attending were deemed able to perform safe and effective CPR.[51]

The psychomotor skills required for BLS are particularly susceptible to rapid decay. Almost 50 separate skills are needed to perform the current sequence of CPR, which is partly the reason why learning and retention are difficult.[30] Clearly it would be possible to simplify BLS techniques for the lay person to no more than "pump and blow". In contrast, far more complicated procedures than those currently published could be developed by the addition of more comprehensive assessment of the victim, and different emphasis of management depending on the aetiology of the respiratory or cardiac arrest. It is not known how "simple" training could be made in order to aid skill retention, while still maintaining clinical effectiveness.

There is uncertainty within the literature regarding how "good" CPR has to be in order to save a life.[45] Do victims who receive perfectly performed compressions and rescue breathing (so called "good CPR") fare better than victims who receive less effective CPR? A definitive answer is still awaited, but the clear conclusion from many studies is that the lowest survival rates occur when there is no attempt at CPR.[12] Any CPR is better than no CPR. Therefore, a simple, basic approach that can be taught effectively to the largest number of people should help to increase the pool of individuals willing to attempt BLS.

The following *sequence of actions* is aimed primarily

at the single lay rescuer dealing with an adult victim. Health care providers and emergency personnel are likely to possess extended resuscitation skills, and the situations in which they may be called upon to use these skills often require more complicated BLS guidelines. The underlying principles, however, remain the same.

These guidelines are intended for the resuscitation of adults, but the principles can be applied effectively to infants and children. Guidelines specific to infants and children are discussed elsewhere in this issue of the journal. In the following descriptions, the masculine includes the feminine.

Sequence of actions (fig. 2)

1. *Ensure safety of rescuer and victim.*
2. *Check the victim and see if he responds.*
- Gently shake his shoulders and ask loudly: "Are you all right?"

3A. *If he responds by answering or moving.*
- Leave him in the position in which you find him (provided he is not in further danger), check his condition and get help if needed.
- Reassess him regularly

3B. *If he does not respond.*
- Shout for help.
- Open his airway by tilting his head and lifting his chin: if possible with the victim in the position in which you find him, place your hand on his forehead and gently tilt his head back keeping your thumb and index finger free to close his nose if rescue breathing is required; at the same time, with your fingertip(s) under the point of the victim's chin, lift the chin to open the airway; if you have any difficulty, turn the victim onto his back and then open the airway as described. Avoid head tilt if trauma to the neck is suspected.

4. *Keeping the airway open, look, listen and feel for breathing (more than an occasional gasp).*

Look for chest movements; listen at the victim's mouth for breath sounds; feel for air on your cheek.
- Look, listen and feel for *up to 10 s* before deciding that breathing is absent.

5A. *If he is breathing (other than an occasional gasp).*
- Turn him into the recovery position.
- Check for continued breathing.

5B. *If he is not breathing.*
- Send someone for help or, if you are on your own, leave the victim and go for help (see below); return and start rescue breathing as below.
- Turn the victim onto his back if he is not already in this position.
- Remove any visible obstruction from the victim's mouth, including dislodged dentures, but leave well fitting dentures in place.
- Give two *effective* rescue breaths, each of which makes the chest rise and fall: ensure head tilt and chin lift; pinch the soft part of his nose closed with the index finger and thumb of your hand on his forehead; open his mouth a little, but maintain chin lift; take a breath and place your lips around his mouth, making sure that you have a good seal; blow steadily into his mouth for approximately 1.5–2 s watching for his chest to rise; maintaining head tilt and chin lift, take your mouth away from the victim and watch for his chest to fall as air comes out.
- Take another breath and repeat the sequence as above to give two effective rescue breaths in all.
- If you have difficulty achieving an effective breath: re-check the victim's mouth and remove any obstruction; re-check that there is adequate head tilt and chin lift; make up to five attempts in all to achieve two effective breaths; even if unsuccessful, move on to assessment of circulation.

6. *Assess the victim for signs of a circulation.*
- Look for any movement, including swallowing or breathing (more than an occasional gasp).
- Check the carotid pulse.
- Take no more than 10 s to do this.

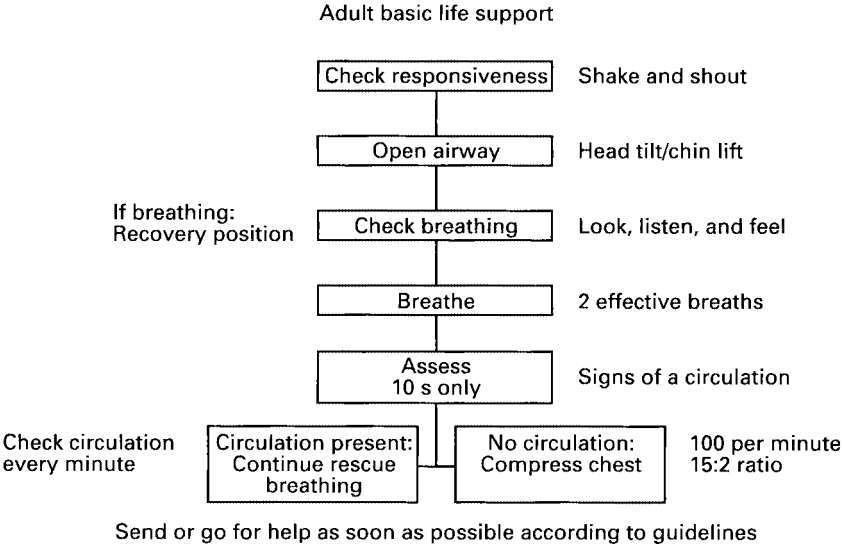

Figure 2 Algorithm for adult basic life support. The sequence of actions is aimed primarily at the single lay rescuer dealing with an adult victim.

7A. *If you are confident that you can detect signs of a circulation within 10 s.*

- Continue rescue breathing, if necessary, until the victim starts breathing on his own.
- Approximately every minute re-check for signs of a circulation; take no more than 10 s each time.
- If the victim starts to breathe on his own but remains unconscious, turn him into the recovery position. Check his condition and be ready to turn him onto his back and re-start rescue breathing if he stops breathing.

7B. *If there are no signs of a circulation, or you are at all unsure.*

- Start chest compression: locate the lower half of the sternum and place the heel of one hand there, with the other hand on top of the first; interlock the fingers of both hands and lift them to ensure that pressure is not applied over the victim's ribs. Do not apply any pressure over the upper abdomen or bottom tip of the sternum; position yourself vertically above the victim's chest and, with your arms straight, press down on the sternum to depress it between 4–5 cm (1.5–2 in); release the pressure, then repeat at a rate of approximately 100 times a minute (a little less than two compressions a second). Compression and release should take an equal amount of time.
- Combine rescue breathing and compression: after 15 compressions tilt the head, lift the chin and give two effective breaths; return your hands immediately to the correct position on the sternum and give another 15 compressions, continuing compressions and breaths in a ratio of 15:2.

8. *Continue resuscitation until:*

The victim shows signs of life, qualified help arrives or you become exhausted.

Readers will note a number of changes between this sequence of actions and the BLS guidelines adopted by the Resuscitation Council (UK) in 1992.[39] Many of the changes are minor and represent consensus agreement. However, there are a number of topics where an explanation of how the final decisions were reached is of value.

Volume and rate of ventilation

Rescue breathing has been a well accepted technique of airway management in BLS since the early 1960s.[60] The volume of air required for each inflation has been quoted as 800–1200 ml, with each breath taking 1–1.5 s.[24]

Artificial ventilation without airway protection (such as tracheal intubation) carries a high risk of gastric inflation, regurgitation and pulmonary aspiration.[6] The risk of gastric inflation depends on: (a) proximal airway pressure, which is determined by tidal volume and inflation rate; (b) alignment of the head and neck, and degree of patency of the airway; and (c) opening pressure of the lower oesophageal sphincter (approximately 20 cm H_2O).[57]

It has been shown recently that a tidal volume of 400–500 ml is sufficient to provide adequate ventilation in adult BLS because carbon dioxide delivery during cardiac arrest is very low.[7 34] Although this value is lower than that recommended previously, it is consistent with the accepted teaching that tidal volume should be that which causes the chest to rise as in normal spontaneous breathing.

During combined rescue breathing and chest compression, the rate of ventilation is dependent on both the ventilation volume and compression rate. An inflation time of 1.5–2 s diminishes the risk of exceeding the oesophageal opening pressure and results in an inflation/exhalation cycle of approximately 3 s. A chest compression rate of approximately 100 per minute is recommended (see below). It therefore takes 9 s to perform 15 cardiac compressions. Allowing 6 s for the two rescue breaths, single rescuer CPR should result in about 8 breaths and 60 chest compressions per minute.[6]

Circulatory assessment

The single most important sign of cardiac arrest in an unconscious, non-breathing adult has always been the absence of a carotid pulse. Current teaching is that pulselessness should lead to the initiation of chest compression. The time allowed to feel for the pulse differs between resuscitation councils[5 24 43] but none recommends more than 10 s for a normothermic victim, as time is critical when starting CPR.

Should the "carotid pulse check" still be taught as the sole criterion for the initiation of chest compression? Is the carotid pulse check in fact difficult, particularly for lay persons?

Recent studies have strongly suggested that the time needed to diagnose with confidence the presence or absence of a carotid pulse is far greater than the 5–10 s normally recommended, with times in excess of 30 s being needed to achieve a diagnostic accuracy of 95%.[2 28 29 47] Even with prolonged palpation, 45% of carotid pulses may be pronounced absent when in fact present.[20] It should also be borne in mind that most of the studies were undertaken using normotensive volunteers, a situation far different from finding a collapsed, cyanosed victim in the street who is likely to be hypotensive, vasoconstricted or worse.

Many ambulance services offer CPR instruction over the telephone to callers reporting victims who have collapsed. The criteria for advising CPR are normally a combination of unresponsiveness and lack of breathing.[48] It is not usual practice for the dispatcher to ask for a carotid pulse check before advising chest compression, mainly because of the perceived difficulty in describing the technique over the telephone.

As a result of these considerations the BLS group of ILCOR has recommended that the carotid pulse check should be "de-emphasized" and that other criteria should be used to determine the need for chest compression in an unresponsive, apnoeic adult patient. It was decided to use the expression: "Look for signs of a circulation", to include looking for movement and checking the carotid pulse. The rescuer should limit the time taken for this check to no more than 10 s. Therefore, absence of any obvious signs of life, not necessarily absence of the carotid pulse, should be sufficient indication to initiate chest compression.

It should be emphasized that this departure from current teaching is aimed, at least for now, only at the lay rescuer; checking for a pulse remains an important part of advanced life support and the algorithm for use of automatic external defibrillators.

Rate of chest compression

The original term "cardiac massage" and its successor "external cardiac compression" reflect the initial theory as to how chest compressions achieve an artificial circulation—namely, by squeezing the heart. This "heart pump theory"[44] was criticized in the mid-1970s, first because echocardiography demonstrated that the cardiac valves become incompetent during resuscitation[55 76] and, second, because coughing alone was shown to produce a life-sustaining circulation.[17] The alternative "thoracic pump" theory[58] proposes that chest compression, by increasing intrathoracic pressure, propels blood out of the thorax; forward flow occurs because veins at the thoracic inlet collapse while the arteries remain patent.

An extension of the controversy raised by these conflicting theories is the argument as to whether or not the rate of chest compression during resuscitation should be fast or slow. In practice, compression rates of 40–120 per minute have successfully resuscitated patients in cardiac arrest; changes in national and international recommendations reflect mainly changes in consensus opinion. It is important, however, to recognize that even when performed optimally, chest compressions do not achieve more than 30% of the normal cerebral perfusion.[61]

Because a more rapid rate of chest compression is required in infants and children, and because simplification of the guidelines is seen as an important objective, a universal compression rate of 100 per minute (expressed for the lay person as: "a little slower than two a second") seems an admirable compromise.

What is important, however, is that the compression and relaxation phases should each occupy about half the compression: relaxation cycle in order to maximize blood flow.[75] In practice, this is difficult to achieve.[38]

Call first—call fast

The first link in the "chain of survival"[19] is to gain access to the emergency medical services. Advice as to the optimum time during a resuscitation attempt at which to leave the victim to go for help depends on several factors: whether the rescuer is alone; whether the victim has a primary respiratory or primary cardiac arrest; the distance to the nearest point of aid (for example a telephone); and the facilities offered by the emergency services.

The importance of early defibrillation in the treatment of sudden cardiac death is now accepted, and major initiatives are moving forward to deliver a defibrillator and the first shock at the earliest possible moment.[22] The 1992 AHA guidelines[24] emphasized that the rescuer should, if no other help is available, leave an adult victim immediately after establishing unresponsiveness in order to call an ambulance or emergency medical service ("phone first"). The ERC guidelines[5] advise that a shout for assistance should be made as soon as the victim is found to be unconscious, but that the loan rescuer should not leave to go for help until cardiac arrest is diagnosed by means of a pulse check ("phone fast"). Both the AHA and ERC guidelines seek to ensure that a defibrillator reaches the victim at the earliest appropriate opportunity. Both agree that if the victim is a child, the rescuer should provide rescue support (ventilatory or circulatory or both) for about 1 min before leaving the victim and calling the rescue team.[50]

In children the aetiology of cardiopulmonary arrest is different from that of the adult.[40] Respiratory arrest is far more common than cardiac arrest which, if it occurs, is usually secondary to respiratory arrest. The outcome of attempts at resuscitation from cardiac arrest in children is dismal at best, with a high chance of poor neurological status afterwards.[65] Survival after cardiopulmonary arrest in children is dependent mainly on the immediate provision of effective rescue breathing,[31] hence the recommendation of 1 min rescue support before leaving and phoning for help.

Although the current (and proposed) guidelines define a child as up to the age of an adult (presumed 18 yr), there is evidence that the increased frequency of primary respiratory arrest persists until approximately 30 yr of age.[1 49] A difficulty that would be encountered using this age as the cut-off between going for help at once or undertaking initial basic life support, would be finding a way of describing (particularly to the lay person) how to determine the age of the collapsed adult victim. As so often is the case, a "best compromise" wins the day.

In the USA a "call first" policy exists, with full emergency service dispatch taking place if a victim is reported to be unresponsive. The ambulance service in the UK is moving towards the US model of priority-based dispatch, and when an emergency call is received, the caller is now usually asked whether the victim is conscious or unconscious, breathing or not breathing. Unlike the US system, however, a top priority dispatch takes place only if the victim is unconscious and not breathing. As already discussed, the presence or absence of a pulse is not a factor in determining priority further. Because of the different policies of the two countries, the Resuscitation Council (UK) advises that the time for the lone rescuer to leave the victim to go for help should normally be immediately after establishing absence of breathing.

There is a further argument against giving two breaths before a rescuer leaves the victim. It has been shown that in some communities there is a reluctance to perform rescue breathing, or a delay in starting ventilation, on a stranger because of concern over disease transmission, particularly the fear of contracting HIV.[14 53] By advising that a call to the ambulance service should be made as soon as the absence of breathing has been established, help can be found with the minimum of delay.

For of all these reasons, the Resuscitation Council (UK) has endorsed the following advice:

When to get help

It is vital for rescuers to get help as quickly as possible.

- When more than one rescuer is available, one should start resuscitation while another rescuer goes for help.
- A lone rescuer has to decide whether to start resuscitation or to go for help first. In these circumstances, if the likely cause of unconsciousness is trauma (injury), drowning *or* if the victim is an infant or a child, the rescuer should perform resuscitation for *approximately 1 min* before going for help.

If the victim is an *adult*, and the cause of unconsciousness is *NOT* trauma or drowning, the rescuer should assume that the victim has a heart problem and go for help immediately after establishing unresponsiveness and the absence of breathing.

Recovery position

The airway of an unconscious victim who is breathing spontaneously is at risk of obstruction by the tongue and from inhalation of mucus and vomit. Placing the victim on the side helps to prevent these problems, and allows fluid to drain easily from the mouth. This lateral, coma, side or recovery position, has been advocated in anaesthesia for more than 100 yr[13] and is still standard practice today. It is surprising, therefore, that its introduction into first aid practice was only within the past 50 yr.[63] Perhaps even more surprising is that in 1992 there was no mention of a recovery position in the AHA guidelines.[24]

Some compromise is needed when positioning the victim; a true lateral posture tends to be unstable, involves excessive lateral flexion of the cervical spine and results in less free drainage from the mouth. A near-prone position, on the other hand, can result in under ventilation because of splinting of the diaphragm and reduction in pulmonary and thoracic compliance.[62]

Potential injury to the victim has also to be considered.[3] There have been several recent reports of interference with upper limb blood flow in association with the recovery position advocated by the European Resuscitation Council.[32 36] This involves the lowermost arm being brought into a ventral position with the uppermost arm crossing it and producing a pressure effect on the blood vessels and, possibly, the nerve supply. Placing the lowermost arm in a dorsal position may not necessarily be the answer, as this involves movement that could, at least theoretically, injury the shoulder joint. However, it is the compromise chosen by the Resuscitation Council (UK) for its 1997 guidelines.

There is inadequate published evidence for definite conclusions but the recognition of the potential for harm and benefit from placing the victim on the side must be remembered.

Many different versions of the recovery position exist, each with its own advocates. The BLS group of ILCOR concluded that it was unable to recommend one specific position, but instead agreed on six principles that should be followed when managing the unconscious, spontaneously breathing victim:

1. The victim should be in as near a true lateral position as possible with the head dependent to allow free drainage of fluid.
2. The position should be stable.
3. Any pressure on the chest that impairs breathing should be avoided.
4. It should be possible to turn the victim onto the side and return to the back easily and safely, having particular regard to the possibility of cervical spine injury.
5. Good observation of, and access to, the airway should be possible.
6. The position itself should not give rise to any injury to the victim.

The future

If one adheres strictly to the definition of basic life support as the maintenance of an airway and support of breathing and circulation without the use of equipment, there is limited scope for improving the current techniques.

Based on the "thoracic pump" theory of chest compression, the greater the intrathoracic pressure produced, the better should be the forward flow of blood. Experimentally this has been achieved by simultaneous compression and ventilation, but intubation with a cuffed tracheal tube is needed to protect the airway from refluxing gastric contents, and to avoid gastric insufflation.[16] Increasing intra-abdominal pressure by the use of an abdominal "vest" also results in an improvement in blood flow during cardiac arrest, but again requires the use of equipment.[66]

Within the strict definition of basic life support, improvement in aortic arterial pressure has been achieved during cardiac arrest without any extraneous equipment by simultaneous chest and abdominal compression,[4] and by increasing the rate of chest compression to 120 per minute.[72] There has also been a tentative suggestion that a return to open chest CPR might be of benefit in some cases.[56]

It is important, however, to bear in mind that there is no published evidence that any of these techniques produce a significant improvement in the outcome of cardiac arrest in the human victim.

The use of a device (Ambu CardioPump) to produce "active compression–decompression" CPR is currently creating a lot of interest, and a flurry of articles in the resuscitation literature. The principle of this device is based on a case described in 1990 of a human resuscitated with the help of a "plumber's helper", better known in the UK as a plunger used for unblocking sink and WC outflows.[46] A rubber suction cup is used alternately to compress then re-expand the chest, thus improving venous return. The reports are encouraging, but proof of increased survival after cardiac arrest is still awaited.[52] If this is forthcoming, the device may represent an important advance in basic life support, albeit with the use of an adjunct.

For the time being, the way to improve survival, particularly in out-of-hospital cardiac arrest, lies with increased public education in the basic

techniques of rescue breathing and chest compression, linked closely to greater awareness of the need to call early for the emergency services and the provision of first responder defibrillation.

References

1. Appleton GO, Cummins RO, Larson MP, Graves JR. CPR and the single rescuer: At what age should you "call first" rather than "call fast"? *Annals of Emergency Medicine* 1995; **25**: 492–494.
2. Bahr J, Klingler H, Panzer W, Rode H, Kettler D. Skills of lay people in checking the carotid pulse. *Resuscitation* (in press).
3. Baker JHE. The first aid management of spinal cord injury. *Seminars in Orthopaedics* 1989; **4**: 2–14.
4. Barranco F, Lesmes A, Irles JA, Blasco J, Leal J, Rodriguez J, Leon C. Cardiopulmonary resuscitation with simultaneous chest and abdominal compression: comparative study in humans. *Resuscitation* 1990; **20**: 67–77.
5. Basic Life Support Working Party of the European Resuscitation Council. Guidelines for basic life support. *Resuscitation* 1992; **24**: 103–110.
6. Baskett P, Bossaert L, Carli P, Chamberlain D, Dick W, Nolan JP, Parr MJA, Scheidegger D, Zideman D. Guidelines for the basic management of the airway and ventilation during resuscitation. A statement by the Airway and Ventilation Management Working Group of the European Resuscitation Council. *Resuscitation* 1996; **31**: 187–200.
7. Baskett P, Nolan J, Parr M. Tidal volumes which are perceived to be adequate for resuscitation. *Resuscitation* 1996; **31**: 231–234.
8. Becker LB, Han BH, Meyer PM, Wright FA, Rhodes KV, Smith DW, Barrett J, CPR Chicago. Racial differences in the incidence of cardiac arrest and subsequent survival. *New England Journal of Medicine* 1993; **329**: 600–606.
9. Bell JH, Harrison DA, Carr B. Resuscitation skills of trainee anaesthetists. *Anaesthesia* 1995; **50**: 692–694.
10. Bible: Genesis, **2**: 7 (King James Version).
11. Bible: II Kings, **4**: 34–35 (King James Version).
12. Bossaert L, Van Hoeyweghen R, the Cerebral Resuscitation Study Group. Bystander cardiopulmonary resuscitation: CPR in out-of-hospital arrest. *Resuscitation* 1989; **17** (Suppl. I): S99–109.
13. Bowles RL. *On Stertor, Apoplexy, and the Management of the Apoplectic State*. London: Bailliere, Tindall and Cox, 1891.
14. Brenner DE, Kauffman J. Reluctance of internists and medical nurses to perform mouth-to-mouth resuscitation. *Archives of Internal Medicine* 1993; **153**: 1763–1769.
15. Broomfield R. A quasi-experimental research to investigate the retention of basic cardiopulmonary resuscitation skills and knowledge by qualified nurses following a course in professional development. *Advances in Nursing* 1996; **23**: 1016–1023.
16. Chandra N, Rudikoff M, Weisfeldt ML. Simultaneous chest compression and ventilation at high airway pressure during cardiopulmonary resuscitation. *Lancet* 1980; **1**: 175–178.
17. Criley JM, Blaufuss AJ, Kissel GL. Cough-induced cardiac compression: self-administered form of cardiopulmonary resuscitation. *Journal of the American Medical Association* 1976; **236**: 1246–1250.
18. Cummins RO, Eisenberg MS. Prehospital cardiopulmonary resuscitation. Is it effective? *Journal of the American Medical Association* 1985; **253**: 2408–2412.
19. Cummins RO, Ornato JP, Thies WH, Pepe PE. Improving survival from sudden cardiac arrest: The "chain of survival" concept. A statement for health professionals from the Advanced Cardiac Life Support Subcommittee and the Emergency Cardiac Care Committee, American Heart Association. *Circulation* 1991; **83**: 1832–1847.
20. Eberle B, Dick WF, Schneider T, Wisser G, Doetsch S, Tzanova I. Checking the carotid pulse check: diagnostic accuracy of first responders in patients with or without a pulse. *Resuscitation* 1996; **33**: 107–116.
21. Eisenberg MS, Bergner L, Hallstrom A. Cardiac resuscitation in the community. Importance of rapid provision and implications for program planning. *Journal of the American Medical Association* 1979; **241**: 1905–1907.
22. Eisenberg MS, Copass MK, Hallstrom AP, Blake B, Bergner L, Short FA, Cobb LA. Treatment of out-of-hospital cardiac arrests with rapid defibrillation by emergency medical technicians. *New England Journal of Medicine* 1980; **302**: 1379–1383.
23. Eisenberg MS, Horwood BT, Cummins RO, Reynolds-Haertle R, Herne TR. Cardiac arrest and resuscitation: A tale of 29 cities. *Annals of Emergency Medicine* 1990; **19**: 179–186.
24. Emergency Cardiac Care Committee and Subcommittees, American Heart Association. Guidelines for cardiopulmonary resuscitation and emergency cardiac care. *Journal of the American Medical Association* 1992; **268**: 2171–2295.
25. Fischer M, Fischer NJ, Schuttler J. One-year survival after out-of-hospital cardiac arrest in Bonn city: outcome report according to the 'Urstein style'. *Resuscitation* 1997; **33**: 233–243.
26. Fisher JM, Handley AJ. Basic life support. In: Colquhoun MC, Handley AJ, Evans TR, eds. *ABC of Resuscitation*. London: BMJ, 1995; 1–5.
27. Fitzpatrick B, Watt GCM, Tunstall-Pedoe H. Potential impact of emergency intervention on sudden deaths from coronary heart disease in Glasgow. *British Heart Journal* 1992; **67**: 250–254.
28. Flesche CW, Brewer S, Mandel LP, Brevik H, Tarnow J. The ability of health professionals to check the carotid pulse. *Circulation* 1994; **90** (Suppl. I): I-288.
29. Flesche CW, Tucker TP, Lorenz C, Nerudo B, Tarnow J. The carotid pulse check as a diagnostic tool to assess pulselessness during adult basic life support. *Euroanaesthesia '95* (abstract).
30. Flint LS, Billi JE, Kelly K, Mandel L, Newell L, Stapleton ER. Education in adult basic life support training programs. *Annals of Emergency Medicine* 1993; **22**: 468–474.
31. Friesen RM, Duncan P, Tweed W, Bristow G. Appraisal of paediatric cardiopulmonary resuscitation. *Canadian Medical Association Journal* 1982; **126**: 1055–1058.
32. Fulstow R, Smith GB. The new recovery position. A cautionary tale. *Resuscitation* 1993; **26**: 89–91.
33. Garland TO. *Artificial Respiration*. London: Faber, 1956.
34. Garnett AR, Ornato JP, Gonzalez ER, Johnson EB. End tidal carbon dioxide monitoring during cardiopulmonary resuscitation. *Journal of the American Medical Association* 1987; **252**: 512–515.
35. Glendon AI, McKenna SP, Hunt K, Blaylock SS. Variables affecting cardiopulmonary resuscitation skill decay. *Journal of Occupational Psychology* 1988; **61**: 243–255.
36. Handley AJ. Recovery position. *Resuscitation* 1993; **26**: 93–95.
37. Handley AJ, Becker LB, Allen M, van Drenth A, Kramer EB, Montgomery WH. Single rescuer adult basic life support: An advisory statement from the Basis Life Support Working Group of the International Liaison Committee on Resuscitation (ILCOR). *Resuscitation* 1997; **34**: 101–108.
38. Handley AJ, Handley JA. The relationship between rate of chest compression and compression: relaxation ratio. *Resuscitation* 1995; **30**: 237–241.
39. Handley AJ, Swain A, eds. *Advanced Life Support Manual*, 2nd Edn. London: Resuscitation Council (UK), 1996; 16.
40. Hazinski MF. Is pediatric resuscitation unique? Relative merits of early CPR and ventilation versus early defibrillation for young victims of cardiac arrest. *Annals of Emergency Medicine* 1995; **25**: 540–543.
41. Kaye W, Mancini ME. Improving outcome from cardiac arrest in the hospital with a reorganized and strengthened chain of survival: an American view. *Resuscitation* 1996; **31**: 181–186.
42. Kaye W, Rallis S, Mancini ME, Linhares KC, Angell ML, Donovan DS, Zajano NC, Finger JA. The problem of poor retention of cardiopulmonary resuscitation skills may lie with the instructors, not the learner or curriculum. *Resuscitation* 1991; **21**: 67–87.
43. Kloeck WGJ. New recommendations for basic support in adults, children and infants. *Trauma and Emergency Medicine* 1993; **10**: 738–748.
44. Kouwenhoven WB, Jude JR, Knickerbocker GG. Closed-chest cardiac massage. *Journal of the American Medical Association* 1960; **173**: 1064–1067.

45. Lombardi G, Gallager J, Gennis P. Outcome of out-of-hospital cardiac arrest in New York City. *Journal of the American Medical Association* 1994; **271**: 678–683.
46. Lurie KG, Lindo C, Chin J. CPR: the P stands for plumber's helper. *Journal of the American Medical Association* 1990; **264**: 1661.
47. Mather C, O'Kelly S. The palpation of pulses. *Anaesthesia* 1996; **51**: 189–191.
48. Medical Priority Consultants Inc. Pre-arrival instructions from the Advanced Medical Priority Dispatch System, version 10.2.
49. Mogayzel C, Quan L, Graves JR, Tiedeman D, Fahrenbruch C, Herndon P. Out-of-hospital ventricular fibrillation in children and adolescents: Causes and outcome. *Annals of Emergency Medicine* 1995; **25**: 484–491.
50. Montgomery W, Brown DD, Hazinski MF, Clawse J, Newell LD, Flint LS. Citizen response to cardiopulmonary emergencies. *Annals of Emergency Medicine* 1993; **22**: 428–434.
51. Morgan CL, Donnelly PD, Lester CA, Assar DH. Effectiveness of the BBC's 999 training roadshows on cardiopulmonary resuscitation: video performance of cohort of unforewarned participants at home six months afterwards. *British Medical Journal* 1996; **313**: 912–916.
52. Ornato JP. Efficacy vs. effectiveness: The case of active compression–decompression (ACD) CPR. *Resuscitation* 1997; **34**: 3–5.
53. Ornato JP, Hallagan L, McMahan SB, Peeples EH, Rostafuiski AG. Attitudes of BCLS instructors about mouth-to-mouth resuscitation. *Annals of Emergency Medicine* 1990; **19**: 151–156.
54. Quiney NF, Gardner J, Brampton W. Resuscitation skills amongst anaesthetists. *Resuscitation* 1995; **29**: 215–218.
55. Rich S, Wix HL, Shapiro EP. Clinical assessment of heart chamber size and valve motion during cardiopulmonary resuscitation by two-dimensional echocardiography. *American Heart Journal* 1981; **102**: 368–373.
56. Robertson C. The value of open chest CPR for non-traumatic cardiac arrest. *Resuscitation* 1991; **22**: 203–208.
57. Ruben H, Knudsen EJ, Carugati G. Gastric inflation in relation to airway pressure. *Acta Anaesthesiologica Scandinavica* 1961; **5**: 107–114.
58. Rudikoff MT, Maughan WL, Effron M, Freund P, Weisfeldt ML. Mechanisms of blood flow during cardio-pulmonary resuscitation. *Circulation* 1980; **61**: 345–352.
59. Safar P. Failure of manual respiration. *Journal of Applied Physiology* 1959; **14**: 84–88.
60. Safar P. History of cardiopulmonary–cerebral resuscitation. In: Kaye W, Bircher NG, eds. *Cardiopulmonary Resuscitation. Clinics in Critical Care Medicine*. New York: Churchill Livingstone, 1989; 1–53.
61. Safar P, Bircher NG. *Cardiopulmonary Cerebral Resuscitation*, 3rd Edn. London: Saunders, 1988.
62. Safar P, Escarrage LA. Compliance in apneic anesthetized adults. *Anaesthesiology* 1959; **20**: 283–289.
63. St John Ambulance Association. *First Aid to the Injured*, 39th Edn. London: St John Ambulance Association, 1937.
64. Schafer EA. Description of a simple and efficient method of performing artificial respiration in the human subject. *Medico-Chirurgical Transactions* 1904; **87**: 609–623.
65. Schindler MB, Bohn D, Cox PN, McCrindle BW, Jarvis A, Edmonds J, Barker G. Outcome of out-of-hospital cardiac or respiratory arrest in children. *New England Journal of Medicine* 1996; **335**: 1473–1479.
66. Shaffner DH, Schleien CL, Koehler RC, Eberle B, Traystman RJ. Effect of vest cardiopulmonary resuscitation on cerebral and coronary perfusion in an infant porcine model. *Critical Care Medicine* 1994; **22**: 1817–1826.
67. Silvester HR. A new method of resuscitating stillborn children and of restoring persons apparently dead or drowned. *British Medical Journal* 1858; **2**: 576–579.
68. Standards and guidelines for cardiopulmonary resuscitation (CPR) and emergency cardiac care (ECC). *Journal of the American Medical Association* 1980; **244**: 453–509.
69. Standards and guidelines for cardiopulmonary resuscitation (CPR) and emergency cardiac care (ECC). *Journal of the American Medical Association* 1986; **255**: 2905–2984.
70. Standards for cardiopulmonary resuscitation (CPR) and emergency cardiac care (ECC). *Journal of the American Medical Association* 1974; **227** (Suppl.): 833–868.
71. Stueven H, Troiano P, Thompson B, Mateer JR, Kastenson EH, Tonsteldt D, Hargarten K, Kowalski R, Aprahamian C, Darin J. Bystander/first responder CPR: Ten years experience in a paramedic system. *Annals of Emergency Medicine* 1986; **15**: 707–710.
72. Swenson RD, Weaver WD, Niskanen RA, Martin J, Dahlberg S. Hemodynamics in humans during conventional and experimental methods of cardiopulmonary resuscitation. *Circulation* 1988; **78**: 630–639.
73. Tunstall-Pedoe H, Bailey L, Chamberlain DA, Marsden AK, Ward ME, Zideman DA. Survey of 3765 cardiopulmonary resuscitations in British hospitals (the BRESUS study); methods and overall results. *British Medical Journal* 1992; **304**: 1346–1351.
74. Weaver WD, Cobb LA, Dennis D, Ray R, Hallstrom AP, Copass MK. Amplitude of ventricular fibrillation waveform and outcome after cardiac arrest. *Annals of Internal Medicine* 1985; **102**: 53–55.
75. Weisfeldt ML, Halperin HR. Cardiopulmonary resuscitation: beyond cardiac massage. *Circulation* 1986; **74**: 443–448.
76. Werner JA, Greene HL, Janko CL, Cobb LA. Visualization of cardiac valve motion in man during external chest compression using two-dimensional echocardiography. *Circulation* 1981; **63**: 1417–1421.
77. Weston CFM, Stephens MR. An audit of cardiac arrest management by extended trained ambulance crew. *Resuscitation* 1992; **23**: 207–216.