The world as it is

Basic life support in a diving bell and deck decompression chamber

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Abstract

(Acott CJ. Basic life support in a diving bell and deck decompression chamber. *Diving and Hyperbaric Medicine*. 2008; 38: 159-62.)
Basic life support (BLS) in a diving bell (DB) or deck decompression chamber (DDC) is difficult due to the confined space and limited equipment. Retrieval of the unconscious diver into the DB requires the use of a pulley system. Once inside the bell, space limitations dictate that any resuscitative efforts are attempted with the victim (diver) either suspended in the upright position by the pulley system or lying against the DB's curved side in a semi-supine position. BLS at best achieves a carotid artery systolic blood pressure of 40 mmHg or 30% of cardiac output in the supine position and, therefore, would be ineffective for a diver suspended on a pulley due to inadequate cerebral perfusion. Compression-only cardiopulmonary resuscitation (CPR) may be the only option with the victim lying against the bell's side due to an inability to perform rescue breathing. However, compression ventilation CPR is possible in a DDC provided space limitations do not deny the rescuers access to the patient. The use of an automatic external defibrillator in a hyperbaric chamber has not been studied and therefore cannot be recommended in a DB or DDC. The laryngeal mask airway has been recommended by the Diving Medical Advisory Committee, but an accompanying study suggests that a new device, the i-gel™ without an inflatable cuff, may be a more suitable airway option for the future.

Introduction

Basic life support (BLS) in a diving bell (DB) or deck decompression chamber (DDC) is difficult due to the confined space, limited equipment and poor lighting. To date the only study addressing this issue was published by Myers and Bradley in 1981 and reflected the protocols of the time.[1] In 2006, Acott addressed emergency airway management using currently available extraglottic airway devices; however, the latest BLS guidelines were not discussed.[2]

Retrieval of an injured or unconscious diver to a DB is a complicated process that will ensure a considerable delay before any resuscitative efforts can be established. This process involves recognition that the diver is in trouble (known sequence of threatening events, oral communication is lost, a failure by the outside diver to answer signals via the umbilical or an indication from the diver's bell gauge that the diver is not breathing) and the commencement of the recovery phase. Recovery is multifaceted and involves the bellman recovering the diver's umbilical, uncoiling his own umbilical, switching to on-board gas supply, preparing the inside hoist, placing his helmet and fins on, exiting the bell after flooding it, locating the diver, attaching him to the hoist and then re-entering the bell and pulling the diver in. Once the injured diver is inside the bell the bellman must evacuate the bell, remove his and the injured diver's helmet and some of the victim's gear so that he is able to place the victim in a semi-supine position against the side of the bell or suspend him in the upright position by the pulley

Figure 1
A diver on anterior hoist inside the bell with the bellman almost obscured behind him. Once the hatch is closed, the diver lies semi-supine against the bell wall; the difficulties of access for resuscitation are obvious (photo from Acott 2007)

system.[3] BLS inside a DB is, therefore, extremely hard if not impossible to do (Figure 1).

Basic life support guidelines

Since 2000, the management of a sudden cardiac arrest (SCA) has changed. These changes were based on extensive evaluation of the current resuscitation evidence by the International Liaison Committee on Resuscitation (ILCOR).[4–8] Changes to the BLS guidelines have attempted to simplify and eliminate time-wasting procedures and were summarised in this journal recently.[9]

- Any attempt at resuscitation is better than none.
- External cardiac massage (ECM) should be started as soon as possible followed by early defibrillation via an automatic external defibrillator (AED).
- Interruptions to external cardiac compressions should be minimized (kept to < 10 seconds).
- The compression rate is 100 compressions per minute (although there is no human evidence identified for an optimal compression-ventilation ratio for CPR in patients of any age).
- The compression to ventilation ratio be 30:2 irrespective of the number of rescuers (this maintains international consistency, simplified teaching and increases the chance of skill retention).

Other changes that are relevant to BLS in a DB are that:

- the carotid pulse is no longer palpated because the 'no signs of life' equals being unconscious, unresponsive, not breathing normally and not moving
- the finger sweep to clear the airway only be performed if required
- compressions and ventilation should be continued up until the first defibrillation attempt
- chest compressions are important if defibrillation can't be delivered within five minutes of collapse.

Current data indicate that prompt bystander cardiopulmonary resuscitation (CPR) is the main determinant of a successful outcome.[6,9] The proportion of patients who survive a pre-hospital event varies greatly (quoted rates are between 20 and 50%) but the earlier bystander external cardiac compression (ECM) is commenced with the addition of early defibrillation the greater the chance of survival. Survival decreases by 7–10% for every minute without ECM. The importance of early bystander CPR was clearly shown by a retrospective study of 115 patients who suffered a pre-hospital cardiac arrest and were managed only by ambulance personnel. Those patients surviving to an emergency department showed a median response interval of seven minutes, whilst no patient survived to hospital where the response interval was greater than 14 minutes.[10] Because of the above and other data, it is important that all divers are trained in BLS.

ECM must be performed with the victim supine on a flat, hard surface and achieve a depth of about one-third of the chest diameter (studies have shown this can also be achieved with the rescuer's leg or foot).[6,11] Several case studies have also shown it can be performed successfully with the patient prone on a hard surface.[11] Efficient ECM can achieve 20 to 30 per cent of the cardiac output in the supine position with a carotid artery systolic pressure of 40 mmHg.[6,9,12] These data suggest that CPR attempted with the victim upright hanging from a pulley (as recommended by the Comex company[13]) would be ineffective in maintaining cerebral perfusion and therefore should not be attempted.

The precordial thump

Because there are inherent difficulties in performing BLS in a DB or DDC the use of a precordial thump may be thought to be effective. However, there have been no prospective studies to recommend this, and while there are three case studies showing that it has converted a ventricular tachycardia/ventricular fibrillation (VT/VF) arrest to a perfusing rhythm, other studies have shown it to convert VT to fast VT , VF, asystole or complete heart block. Both the Australian Resuscitation Council (ARC) and the European Resuscitation Council (ERC) recommend that the precordial thump should be used only in a witnessed, monitored VF or VT cardiac arrest within the first 15 seconds and only if a defibrillator is not readily available. The American Heart Association (AHA) has no recommendations for or against its use except that it is not included in BLS training.[4,7–9,11] The precordial thump is, therefore, not recommended for use in a DB or DDC.

Compression-only CPR

Compression-only CPR is an option when the rescuers are unwilling or unable to do rescue breathing (mouth to mouth) and should be continuous at a rate of approximately 100 compressions per minute. Some animal studies and extrapolation from clinical evidence suggest that rescue breathing (RB) is not essential within the first five minutes of adult CPR for a VF sudden cardiac arrest (this type of arrest is generally regarded as non-asphyxial). This may be applicable to BLS in a DB because the diver would have been breathing a gas mixture containing approximately 50 kPa of oxygen. If the airway is open, passive chest recoil following compressions may provide some air exchange. Historically the older methods of CPR (Silvester, Shafer and Holger Nielson) provided some ventilation despite the lack of rescue breathing. Observational studies of adult cardiac arrest show that survival rates are better with compression only than with no CPR but were not as good as normal compression-ventilation CPR.[4,6–9] Access to the victim's airway is limited once lying against the wall of the DB and so compression-only CPR may be the only option if the victim has suffered a cardiac event. Compression-ventilation CPR may be effective if performed inside a DDC because the patient would be supine and on a hard surface; however, the position of the resuscitator(s) relative to the patient is dependent on the size and shape of the chamber and access to the victim's airway may be limited.

Basic life support in a diving bell

There is no current recommendation from the Diving Medical Advisory Committee (DMAC) for an AED to be present at a diving platform or included in the diver's medical kit for a DB or DDC, although the use of a laryngeal mask has been recommended.[14] Space limitations, plus a lack of testing in a hyperbaric environment often prevent an AED from being carried in a DB or DDC. The insertion of an intravenous cannula and the administration of vasopressors or antiarrthymics are also clearly not an option due to the inability to identify the victim's cardiac rhythm. However, as stated by the ARC, ERC and AHA the foundation of good advanced cardiac life support is good BLS and not pharmacological intervention.[4,7,8]

The recommended use of a cervical collar to stabilise the head also needs to be reassessed.[14] If applied incorrectly cervical immobilisation can cause airway obstruction in unconscious victims and a rise in intracranial pressure.[15] Application will also waste time before ECM can commence. The use of a cervical collar should only be considered when there is clear evidence for a neck injury, which is infrequent in diving accidents managed underwater.

A new extraglottic airway device (EAD), the i-gel™, was tested by Acott, and considered likely to be suitable for use in a DB or DDC.[16] The i-gel was more effective in achieving an airway from different positions of the operator, and was preferred by diver medical technicians when compared to the classic laryngeal mask airway for emergency airway management. However, the current ILCOR 2005 guidelines provide information on different methods and devices and it is too early to recommend the incorporation of the i-gel into a proposed new BLS algorithm for a DB or DDC except as one of various alternatives. Keeping the airway patent is of the utmost importance in BLS, and not the device used.

Recommendations

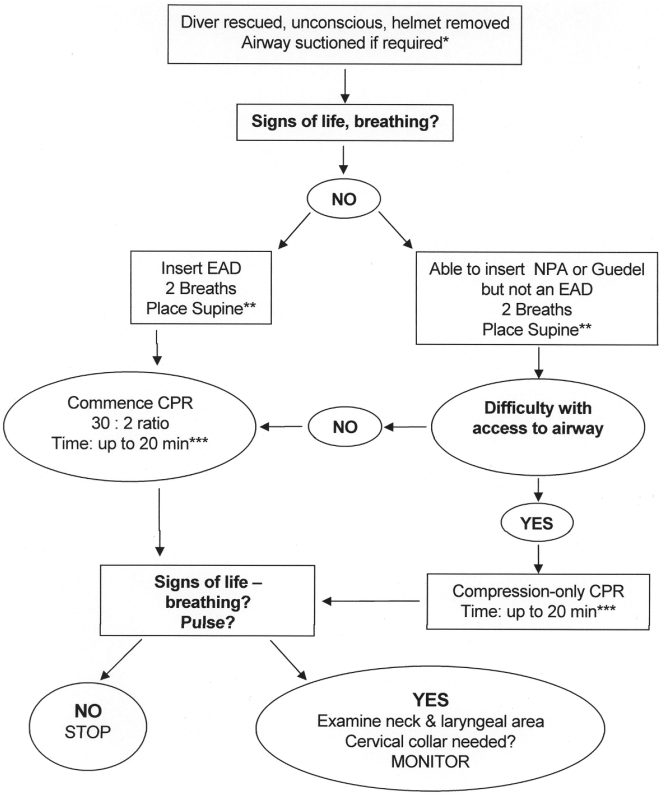
The time must be noted when the bellman has recognised that the diver is in trouble. Timing is important because the chances of survival decrease 7–10% per minute. Once the diver is brought into the DB he should be checked for signs of life after his helmet has been removed and his airway cleared/suctioned if required. If there are no signs of life the bellman can try to insert an EAD. If the bellman is unable to insert the EAD, then a nasopharyngeal or Guedel airway can be used. Two rescue breaths (RBs) should be given via the EAD prior to laying the diver against the side of the DB and commencing ECM. If the bellman still has access to the EAD and is able to give rescue breathing, then the recommended ratio of two breaths and 30 compressions should be used. If not, then compression-only CPR should be used at a rate of 100 compressions per minute. If there are no signs of recovery, it is currently unclear after what time interval CPR should be abandoned (the ILCOR 2005 document suggests BLS should be continued till defibrillation or 20 minutes of asystole). However, this length of time is complicated by a number of factors underwater, for instance by how long it took for resuscitation to be commenced from the time it was noted that the diver was unresponsive and requiring rescue.[10]

Two proposed algorithms, one for when signs of life are absent and one for when they are present, for the resuscitation of a diver in a bell are shown in Figures 2 and 3.

Reassessment of CPR skills

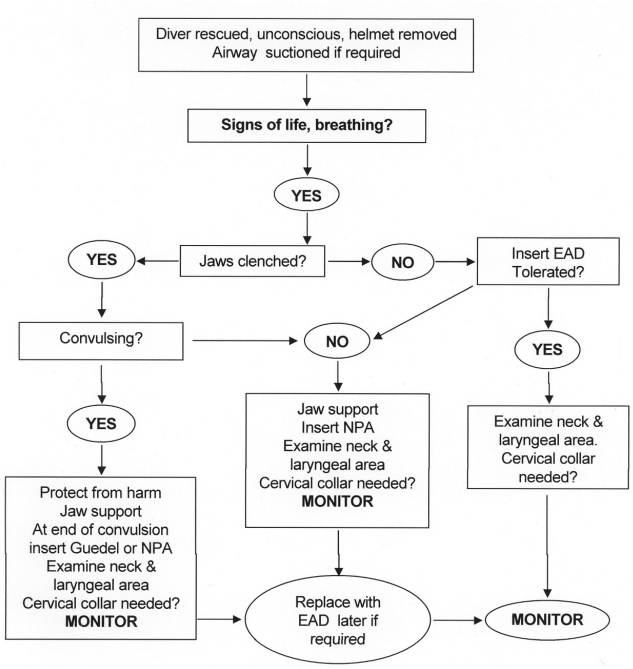
CPR skills have been shown to decline rapidly following initial achievement of competency. The ARC recommends that CPR skills are reassessed annually. The assessment should focus on the provision of adequate CPR and not on the technicalities.[4] These recommendations have implications for DMT training.

Figure 2
Summary of resuscitation in a diving bell for a diver without signs of life



* DMAC recommends the use of a suction device in a DB or DDC.
** Do not attempt to resuscitate with the diver suspended from the pulley in upright position. Patient is placed against the DB wall (which will be semi-supine) or supine in a DDC.
*** This time is determined by the retrieval time to get the diver into the bell.

Figure 3
Summary of resuscitation in a diving bell for an unconscious diver with signs of life
(NPA – nasopharyngeal airway)



Summary

ECM should be commenced as soon as the diver is brought into the bell. If RB cannot be performed then compression-only CPR should be used. Timing of events is crucial in determining how long resuscitative efforts are continued.

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References

1 Myers RAM, Bradley ME. An evaluation of cardiopulmonary resuscitation techniques for use in a diving bell. In: Bachrach AJ, Matzen MM, editors. *Proceedings of the 7th Symposium on Underwater Physiology*. Bethseda, MA: Undersea and Hyperbaric Medical Society; 1981.

2 Acott CJ. Extraglottic airway devices for use in diving medicine – a review of the literature. Part 2: airway management in a diving bell and deck decompression chamber. *Diving and Hyperbaric Medicine*. 2007; 37: 16-24.

3 Forsyth AW. *An evaluation of unconscious diver recovery into a hyperbaric environment*. Master of Science Degree in occupational safety thesis. Robens Centre for Occupational Health and Safety EHIMS, University of Surrey; 2000. <www.resus.org.au/public/basic_life_support.pdf> (accessed February 2008)

4 ILCOR consensus on science and treatment recommendations. *Resuscitation.* 2006; 67: 157-341.

5 2005 American Heart Association Guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Part 3: overview of CPR. *Circulation*. 2005; 112 (Suppl): IV 12-18.

6 European Resuscitation Committee. <www.erc.edu/index.php/bls_aed_overview/eu/> (accessed February 2008)

7 American Heart Association. <www.americanheart.org/downloadable/heart/1132621842912Winter2005.pdf >(accessed February 2008)

8 Part 7.2: management of cardiac arrest. *Circulation*. 2005; 112 (Suppl): IV 58-66.

9 Acott CJ. Comments on the revised ARC Guidelines. *Diving and Hyperbaric Medicine*. 2006; 36: 229-30.

10 Jennings P, Pasco J. Survival from out-of-hospital cardiac arrest in the Geelong region of Victoria, Australia. *Emerg Med Aust*. 2001; 13: 319-25.

11 International consensus on cardiovascular resuscitation and emergency cardiovascular care science with treatment recommendations Part 2: Adult Basic Life Support. *Resuscitation*. 2005; 67: 187-201.

12 Robertson C, Holmerg S. Compression techniques and blood flow during cardiopulmonary resuscitation. *Resuscitation*. 1992; 13: 123-32.

13 *La decompression et ses risques*. Livre Medical Comex: Fascicule II. Marseille: Comex Diving Limited; 1978.

14 Diving Medical Advisory Committee. <www.dmac-diving.org/guidance/DMAC15.pdf> (accessed February 2008)

15 Soar J, Deakin CD, Nolan JP, Abbas G, Alfonzo A, et al. European Resuscitation Council Guidelines for Resuscitation. Section 7. Cardiac arrest in special circumstances. *Resuscitation*. 2005; 67 (S1): 135-70.

16 Acott CJ. Extraglottic airway devices for use in diving medicine – part 3: the i-gel™. *Diving and Hyperbaric Medicine*. 2008; 38: 124-7.

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