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about

Basic Life Support Ventilation in Mountain Rescue
BASIC LIFE SUPPORT VENTILATION
IN MOUNTAIN RESCUE

Official recommendations of the
International Commission for Mountain Emergency Medicine (ICAR MEDCOM)

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Abstract

**Aims and methods:** Cardiopulmonary resuscitation in the mountains usually has to be performed under difficult and hostile circumstances and, sometimes for extended periods of time. Therefore, mountain rescuers should have the ability and the appropriate equipment to perform prolonged, efficient, and safe ventilation. Members of the International Commission for Mountain Emergency Medicine (ICAR MEDCOM) discussed the results of a literature review, focusing on the advantages and disadvantages of common ventilation techniques in Basic Life Support and their training methods with specific respect to use in mountain rescue, and recommendations were proposed. **Results and recommendations:** Bystanders fear the potential risk of infection and lack the willingness to perform mouth-to-mouth ventilation, though the risk of infection is low. Mouth-to-mouth ventilation remains the standard technique for bystander ventilation and, in the absence of a barrier device bystanders should not hesitate to ventilate a patient by this technique. For mountain rescue teams we encourage the use of a barrier device for artificial ventilation. Mouth-to-mask ventilation devices are most likely to fulfill the requirements of being safe, simple and efficient in the hands of a basically trained rescuer. The use of a mouth-to-mask ventilation device is recommended for out-of-hospital ventilation in the mountains and should be part of the mountain rescuer’s standard equipment. Bag-valve-mask ventilation is efficient, if performed by well-trained rescuers, but it leads to a low ventilation quality in the hands of a less experienced rescuer. It should be emphasized that regular training every six to twelve months is necessary to perform proper ventilation.

**Key words**
Basic Life Support, Mountain rescue, Resuscitation, Training, Ventilation.

Introduction

The quality of bystander Basic Life Support (BLS) significantly improves survival rate in patients with cardiac arrest (Wik, et al., 1994; Gallagher, et al., 1995). Ventilation, in addition to chest compression, plays an important role in BLS, especially if an Automated External Defibrillator or Advanced Life Support (ALS)-measures are not available within the first minutes of cardiac arrest (Idris, et al., 1994; Kern, et al., 1998). In contrast to urban and suburban areas, cardiopulmonary resuscitation in the mountains usually has to be performed under difficult, and hostile circumstances. In mountain rescue cardiopulmonary resuscitation sometimes has to be initiated by BLS-trained mountain rescuers in terrain that is difficult to access, and continued for a prolonged period until an ALS-team arrives, and intubates the patient. In contrast to the urban setting, mountain rescue scenarios involving deeply hypothermic, avalanche burial (Locher, et al., 1996; Brugger, et al., 2002; Paal, et al., 2006), or cold water immersion patients (Gilbert, et al., 2000) may require prolonged cardiopulmonary resuscitation. In these special circumstances, the prognosis remains good (Eich, et al., 2005; Lienhart, et al., 2005), but prolonged and efficient BLS is necessary to guarantee sufficient organ oxygenation until the patient is rewarmed (Mair, et al., 1994; Walpohn, et al., 1997). Some authors complain about a lack of rescuer willingness, or occasionally even rescuer refusal, to ventilate a patient by mouth-to-mouth technique. This hesitance is apparently due to fear of catching an infection (Ornato, et al., 1990; Locke, et al., 1995). Therefore, mountain rescuers should have both the ability and the appropriate equipment to perform efficient and safe ventilation. Ventilation devices for a basically trained mountain rescuer should be efficient, easy to use, small, light, durable, and cheap. The aim of this review is to evaluate ventilation techniques and training protocols in BLS with specific respect to their use in mountain rescue.

Methods and materials

A literature search in the Medline database was performed; articles published between January 1st 1980 and December 13th 2006, listed with the keywords “mouth to mouth ventilation”, “mouth to nose ventilation”, “mouth to mask ventilation”, “mouth to face shield ventilation”, “bag valve mask ventilation”, and “ventilation AND resuscitation AND training”
were retrieved. Moreover, the references of the retrieved articles were checked and further articles manually selected. Fifty-four articles were found relevant for the applicability in mountain rescue and therefore included in this non-systematic review. The results and deriving recommendations were discussed among the authors, and presented at the International Commission for Mountain Emergency Medicine (ICAR MEDCOM) meetings in Paklenica, Croatia; Cortina d’Ampezzo, Italy; and Gemmi Pass, Wallis, Switzerland, and prior to final approval.

**Results**

Advantages and disadvantages of the examined ventilation techniques are shown in table 1.

**Mouth-to-mouth ventilation**

Mouth-to-mouth ventilation does not need any additional equipment, and is considered the standard technique for bystander BLS (Becker, et al., 1997; Berg, 2000; Anonymous, 2005). However, bystanders fear the potential risk of infection (Wenzel, et al., 1997), and have a lack of willingness to perform mouth-to-mouth ventilation. Sporadic bacterial infections have been attributed to mouth-to-mouth ventilation; the bacteria involved include Mycobacterium Tuberculosis, Helicobacter Pylori (Figura, 1996), Neisseria Meningitidis, Neisseria Gonorrhoeae, Shigella Sonnei, Salmonella Infantis and, Streptococcus Pyogenes. Although transmission of viral diseases like Herpes Simplex (Mejicano, et al., 1998), and SARS (Christian, et al., 2004) has been described, the feared risk of transmission of blood borne viral infections like HIV and Hepatitis B or C has not been reported so far. Ventilation quality, defined in terms of a tidal volume within the stated range, is low after BLS-training; two studies reported 18% (Chamberlain, et al., 2002) and 20% (Smith, et al., 2004) of correct tidal volume. In a recent study 50% of the subjects exceeded the upper limit of the recommended tidal volume, and 79% inflated the stomach (Paal, et al., 2006). Significantly better results with 71% of correct tidal volume were reported with manikins giving verbal feedback (Wik, et al., 2002).

**Mouth-to-nose ventilation and mouth-to-mouth/nose ventilation**

A higher airway resistance in the nose results in lower tidal volume, stomach inflation and incidence of regurgitation with mouth-to-nose than with mouth-to-mouth ventilation (Ruben, et al., 1961; Ruben, 1964). Mouth-to-nose ventilation is recommended when it is impossible to ventilate the patient through the victim’s mouth (e.g. serious injury, trismus, no tight seal achievable) (Ruben, 1964). Some authors recommend mouth-to-mouth over mouth-to-nose ventilation as a first line technique in laymen without any barrier device (Safar, et al., 1959).

Mouth-to-mouth/nose ventilation may be advantageous in infants younger than six months, who are obligate nose breathers (Tonkin, et al., 1995; Wilson-Davis, et al., 1997).

**Mouth-to-mask ventilation**

Mouth-to-mask ventilation devices have a one-way valve that provides an adequate protection from bacterial contamination (Cydulka, et al., 1991); however, airway resistance through this one-way valve can be considerable with some devices (Hess, et al., 1993). Mouth-to-mask ventilation shows a lower peak airway pressure, and stomach inflation rate than mouth-to-mouth ventilation (Paal, et al., 2006). Some mouth-to-mask ventilation devices have an auxiliary oxygen inlet. By connecting an oxygen source, the oxygen fraction of the rescuer’s exhaled air can be increased, and the carbon dioxide fraction decreased (Thomas, et al., 1992; Wenzel, et al., 1994). This additional oxygen flow might improve outcome in cardiac arrest, since hypoxia and hypercapnia are independent risk factors in cardiopulmonary resuscitation (Idris, et al., 1995). Moreover, a comparative study between mouth-to-mouth, mouth-to-mask, and bag-valve-mask ventilation concluded, that mouth-to-mask ventilation with supplemental oxygen enrichment is the most efficient technique for non-invasive airway management (Johannigman, et al., 1991).
The dimensions of a mouth-to-mask ventilation device are 130x110x40 mm, the weight including the box is ~110 g. A mouth-to-mask ventilation device should be stored between -40° and 50°C, and its operative range is -10°C to 40°C (Laerdal, 2006).

**Bag-valve-mask-ventilation**

In two studies ventilation quality was lower with bag-valve-mask ventilation, using an adult bag-valve-mask, than with mouth-to-mask ventilation (Harrison, et al., 1982; Hess, et al., 1985); more than 50% of the subjects were not able to ventilate to the minimum required (Jesudian, et al., 1985). The volumes delivered with bag-valve-mask ventilation are poor, when performed by a single inexperienced rescuer, but improve when performed by two rescuers (Anonymous, 2005; Davidovic, et al., 2005). Another study, with well trained BLS- or ALS-providers, concluded that bag-valve-mask ventilation with a paediatric self-inflating 700 ml bag with 100% oxygen was the simplest and most successful strategy, even when provided by a single experienced rescuer (Dorges, et al., 2003). A new bag-valve-mask (SMART BAG, O-Two Medical Technologies Inc., Ontario, Canada) has been developed incorporating an inspiratory flow and peak airway pressure-limiting valve. This device significantly reduces mean airway pressure and stomach inflation compared with a standard bag-valve-mask while maintaining delivered lung tidal volumes (Wagner-Berger, et al., 2003; von Goedecke, et al., 2004). In another recent study a whistle was added as an audible indicator to the exhalation port of a self-inflating bag-valve-mask, resulting in higher tidal volumes compared with the standard bag-valve-mask (Lampotang, et al., 2006).

The dimensions of a bag-valve-mask ventilation device are 250x145x130 mm, the weight is ~625 g. A bag-valve-mask ventilation device should be stored between -40° and 60°C with air moisture 40 to 95%; its operative range is -18°C to 50°C with air moisture 15 to 95% (Laerdal, 2006).

**Mouth-to-face-shield ventilation**

Despite the integral filter six of eight face-shield devices did not provide an adequate protection from bacterial contamination (Cydulka, et al., 1991). In addition, delivered tidal volume with three different face shields was lower than the minimum required (Simmons, et al., 1995). Candidates performing mouth-to-face shield ventilation tended to hypoventilate a bench model, when compared to mouth-to-mouth, and mouth-to-mask ventilation (Paal, et al., 2006). Therefore, the use of mouth-to-face shield ventilation was discouraged by the 2000 CPR-guidelines (Anonymous, 2000).

The dimensions of a mouth-to-face shield ventilation device are 93x70x2 mm, the weight is ~5 g. A mouth-to-face shield ventilation device should be stored between -40° and 50°C, and its operative range is -10°C to 40°C (Laerdal, 2006).

**Ventilation training**

BLS ventilation is a complex psychomotor skill (Wenzel, et al., 1997; Eisenburger, et al., 1999). Ventilation skills deteriorate over a year, with the same rapid loss of skills in lay persons as in medical personnel who are not routinely involved in resuscitation (Kaye, et al., 1986). This lack of skill retention could be the result of low initial skill acquisition (Kaye, et al., 1998). Furthermore, Kaye et al. showed that a group of candidates all failed when evaluated by an independent instructor using a fully computerized system. Another instructor had, nonetheless, considered these same candidates competent when evaluated by subjective criteria (Kaye, et al., 1991). Wenzel et al. showed that the retention of ventilation skills was unpredictable with only 5% of the candidates being able to reproduce their ventilation performance six months after training (Wenzel, et al., 1997). Ventilation skills were better acquired and retained for periods of six and twelve months, when a manikin gave verbal feedback in the initial assessment, as well as in the reassessment (Wik, et al., 2002, 2005).
Recommendations

Mouth-to-mouth ventilation remains the standard technique for bystander ventilation. We emphasize that in the absence of barrier devices, bystanders should not hesitate, if necessary, to ventilate a patient without delay, since the risk of infection is low. However, we encourage the use of a barrier device, such as mouth-to-mask or bag-valve-mask ventilation, to perform BLS ventilation in mountain rescue.

Mouth-to-mask ventilation, in comparison with mouth-to-mouth ventilation, may decrease peak airway pressure and the rate of stomach inflation, thereby limiting the adverse effects of excessive ventilation of an unprotected airway (Paal, et al., 2006). Handling is simple and mask dislocation is unlikely once it is in place (Fig. 1). A better fit leads to a better ventilation quality and less air leakage. Finally, the rescuer will be less exhausted (Thierbach, et al., 2003; Thierbach, et al., 2005); this could be valuable in prolonged BLS. Mouth-to-mask ventilation seems to be safe, simple and efficient in the hands of a basic-trained rescuer. Therefore, ICAR MEDCOM recommends the use of a mouth-to-mask ventilation device for out-of-hospital ventilation in mountain rescue. It should be a regular part of the mountain rescuer’s equipment.

Bag-valve-mask ventilation is efficient and safe in the hands of a well-trained rescuer. However, it is a demanding skill and, in the hands of less experienced rescuers, it leads to a low tidal volume from air leaking from beneath the mask. Its efficiency might be improved further if performed by two persons, one sealing the mask with both hands on the patient’s face, the so called double C-clamp, and the second ventilating the patient (Cummins, et al., 1986; Wayne, et al., 2001).

It should be emphasized, that regular training every six to twelve months is necessary to perform proper ventilation (Eisenburger, et al., 1999). Ways of improving teaching methods could have a marked effect on the quality of ventilation. Such methods include teaching in small groups, allocating more time to practice the skills (Kaye, et al., 1991), staged teaching (i.e. learning BLS in sequential steps, such as chest compressions first, and ventilation afterwards) (Chamberlain, et al., 2002; Smith, et al., 2004), or feedback aided training (Wik, et al., 2002, 2005).

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References


Table 1. Advantages and disadvantages of Basic Life Support ventilation techniques. § (Wenzel, et al., 1997); § (Paal, et al., 2006); § (Ruben, 1964); § (Safar, et al., 1959); § (Cydulka, et al., 1991); § (Cummins, et al., 1986;Wayne, et al., 2001); * (Anonymous, 2005;Davidovic, et al., 2005).

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<thead>
<tr>
<th>Ventilation technique</th>
<th>Advantages</th>
<th>Disadvantages</th>
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<tr>
<td>Mouth-to-mouth</td>
<td>No ventilation device needed</td>
<td>Risk of infection</td>
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<td>Rarely performed by bystanders§</td>
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<td>High tidal volume and stomach ventilation rate§</td>
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<tr>
<td>Mouth-to-nose</td>
<td>No ventilation device needed</td>
<td>Risk of infection</td>
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<td>Low stomach inflation rate§</td>
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<td>Low tidal volume*</td>
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<td>Mouth-to-mask</td>
<td>No risk of infection %</td>
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<td>More correct tidal volume than mouth-to-mouth§</td>
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<td>Bag-valve-mask</td>
<td>No risk of infection</td>
<td>Low correct tidal volume in the hands of inexperienced rescuers*</td>
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<td>High correct tidal volume in the hands of experienced rescuers§</td>
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<tr>
<td>Mouth-to-face shield</td>
<td>Risk of infection %</td>
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<td></td>
<td>Low tidal volume*</td>
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Legend

Figure 1. The two-rescuer BLS-technique with one rescuer performing the mouth-to-mask ventilation from behind the patient’s head is shown. Apply chin lift and, if there is no cervical trauma, tilt the head backwards. Fix the mouth-to-mask ventilation device with a double C-clamp, squeeze the mask on the patient’s face and lift the jaw towards the mask. Perform ventilations, each with one second for inspiration. Control adequate lung ventilation by evident rise and fall of the patient’s chest. Perform ventilations according to CPR-guidelines (Anonymous, 2005).