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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 fulfil the requirements of being safe, simple and efficient in the hands of a basic-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;Walpoth, 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 vicitim'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

Anonymous. (2005). Part 4: Adult Basic Life Support. Circulation 112:IV19-IV34.

Becker L. B., Berg R. A., Pepe P. E., Idris A. H., Aufderheide T. P., Barnes T. A., Stratton S. J. and Chandra N. C. (1997). A reappraisal of mouth-to-mouth ventilation during bystander-initiated cardiopulmonary resuscitation. A statement for healthcare professionals from the Ventilation Working Group of the Basic Life Support and Pediatric Life Support Subcommittees, American Heart Association. Circulation 96:2102-2112.

Berg R. A. (2000). Role of mouth-to-mouth rescue breathing in bystander cardiopulmonary resuscitation for asphyxial cardiac arrest. Crit Care Med 28:N193-195.

Brugger H. and Durrer B. (2002). On-site treatment of avalanche victims ICAR-MEDCOM-recommendation. High Alt Med Biol 3:421-425.

Chamberlain D., Smith A., Woollard M., Colquhoun M., Handley A. J., Leaves S. and Kern K. B. (2002). Trials of teaching methods in basic life support (3): comparison of simulated CPR performance after first training and at 6 months, with a note on the value of re-training. Resuscitation 53:179-187.

Christian M. D., Loutfy M., McDonald L. C., Martinez K. F., Ofner M., Wong T., Wallington T., Gold W. L., Mederski B., Green K. and Low D. E. (2004). Possible SARS coronavirus transmission during cardiopulmonary resuscitation. Emerg Infect Dis 10:287-293.

Cummins R. O., Austin D., Graves J. R., Litwin P. E. and Pierce J. (1986). Ventilation skills of emergency medical technicians: A teaching challenge for emergency medicine. Ann Emerg Med 15:1187-1192.

Cydulka R. K., Connor P. J., Myers T. F., Pavza G. and Parker M. (1991). Prevention of oral bacterial flora transmission by using mouth-to-mask ventilation during CPR. J Emerg Med 9:317-321.

Davidovic L., LaCovey D. and Pitetti R. D. (2005). Comparison of 1- versus 2-person bag-valve-mask techniques for manikin ventilation of infants and children. Ann Emerg Med 46:37-42.

Dorges V., Wenzel V., Knacke P. and Gerlach K. (2003). Comparison of different airway management strategies to ventilate apneic, nonpreoxygenated patients. Crit Care Med 31:800-804.

Eich C., Brauer A. and Kettler D. (2005). Recovery of a hypothermic drowned child after resuscitation with cardiopulmonary bypass followed by prolonged extracorporeal membrane oxygenation. Resuscitation 67:145-148.

Eisenburger P. and Safar P. (1999). Life supporting first aid training of the public--review and recommendations. Resuscitation 41:3-18.

Figura N. (1996). Mouth-to-mouth resuscitation and Helicobacter pylori infection. Lancet 347:1342.

Gallagher E. J., Lombardi G. and Gennis P. (1995). Effectiveness of bystander cardiopulmonary resuscitation and survival following out-of-hospital cardiac arrest. JAMA 274:1922-1925.

Gilbert M., Busund R., Skagseth A., Nilsen P. A. and J.P. S. (2000). Resuscitation from accidental hypothermia of 13.7°C with circulatory arrest. Lancet 355:375-376.

Harrison R. R., Maull K. I., Keenan R. L. and Boyan C. P. (1982). Mouth-to-mask ventilation: a superior method of rescue breathing. Ann Emerg Med 11:74-76.

Hess D. and Baran C. (1985). Ventilatory volumes using mouth-to-mouth, mouth-to-mask, and bag-valve-mask techniques. Am J Emerg Med 3:292-296.

Hess D., Simmons M., Slikkers F. and Dickerson R. (1993). Resistance to flow through the valves of mouth-to-mask ventilation devices. Respir Care 38:183-188.

Idris A. H., Becker L. B., Fuerst R. S., Wenzel V., Rush W. J., Melker R. J. and Orban D. J. (1994). Effect of ventilation on resuscitation in an animal model of cardiac arrest. Circulation 90:3063-3069.

Idris A. H., Wenzel V., Becker L. B., Banner M. J. and Orban D. J. (1995). Does hypoxia or hypercarbia independently affect resuscitation from cardiac arrest? Chest 108:522-528.

Jesudian M. C., Harrison R. R., Keenan R. L. and Maull K. I. (1985). Bag-valve-mask ventilation; two rescuers are better than one: preliminary report. Crit Care Med 13:122-123.

Johannigman J. A., Branson R. D., Davis K., Jr. and Hurst J. M. (1991). Techniques of emergency ventilation: a model to evaluate tidal volume, airway pressure, and gastric insufflation. J Trauma 31:93-98.
Kaye W. and Mancini M. E. (1986). Retention of cardiopulmonary resuscitation skills by physicians, registered nurses, and the general public. Crit Care Med 14:620-622.
Kaye W. and Mancini M. E. (1998). Teaching adult resuscitation in the United States--time for a rethink. Resuscitation 37:177-187.
Kaye W., Rallis S. F., Mancini M. E., Linhares K. C., Angell M. L., Donovan D. S., Zajano N. C. and Finger J. A. (1991). The problem of poor retention of cardiopulmonary resuscitation skills may lie with the instructor, not the learner or the curriculum. Resuscitation 21:67-87.
Kern K. B., Hilwig R. W., Berg R. A. and Ewy G. A. (1998). Efficacy of chest compression-only BLS CPR in the presence of an occluded airway. Resuscitation 39:179-188.
Laerdal. 2006. Personal Communication. In: Laerdal, Stavanger, Norway.
Lampotang S., Lizdas D. E., Gravenstein N. and Robicsek S. (2006). An audible indication of exhalation increases delivered tidal volume during bag valve mask ventilation of a patient simulator. Anesth Analg 102:168-171.
Lienhart H. G., John W. and Wenzel V. (2005). Cardiopulmonary resuscitation of a near-drowned child with a combination of epinephrine and vasopressin. Pediatr Crit Care Med 6:486-488.
Locher T. and Walpoth B. H. (1996). [Differential diagnosis of circulatory failure in hypothermic avalanche victims: retrospective analysis of 32 avalanche accidents]. Schweiz Med Wochenschr 85:1275-1282.
Locke C. J., Berg R. A., Sanders A. B., Davis M. F., Milander M. M., Kern K. B. and Ewy G. A. (1995). Bystander cardiopulmonary resuscitation. Concerns about mouth-to-mouth contact. Arch Intern Med 155:938-943.
Mair P., Kornberger E., Furtwaengler W., Balogh D. and Antretter H. (1994). Prognostic markers in patients with severe accidental hypothermia and cardiocirculatory arrest. Resuscitation 27:47-54.
Mejicano G. C. and Maki D. G. (1998). Infections acquired during cardiopulmonary resuscitation: estimating the risk and defining strategies for prevention. Ann Intern Med 129:813-828.
Ornato J. P., Hallagan L. F., McMahan S. B., Peeples E. H. and Rostafinski A. G. (1990). Attitudes of BCLS instructors about mouth-to-mouth resuscitation during the AIDS epidemic. Ann Emerg Med 19:151-156.
Paal P., Beikircher W. and Brugger H. (2006). [Avalanche emergencies : Review of the current situation.]. Anaesthesist 55:314-324.
Paal P., Falk M., Sumann G., Demetz F., Beikircher W., Gruber E., Ellerton J. and Brugger H. (2006). Comparison of mouth-to-mouth, mouth-to-mask and mouth-to-face-shield ventilation by lay persons. Resuscitation 70:117-123.
Ruben H. (1964). The Immediate Treatment of Respiratory Failure. Br J Anaesth 36:542-549.
Ruben H. M., Elam J. O., Ruben A. M. and Greene D. G. (1961). Investigation of upper airway problems in resuscitation. 1. Studies of pharyngeal x-rays and performance by laymen. Anesthesiology 22:271-279.
Safar P. and Redding J. (1959). The "tight jaw" in resuscitation. Anesthesiology 20:701-702.
Simmons M., Deao D., Moon L., Peters K. and Cavanaugh S. (1995). Bench evaluation: three face-shield CPR barrier devices. Respir Care 40:618-623.
Smith A., Colquhoun M., Woollard M., Handley A. J., Kern K. B. and Chamberlain D. (2004). Trials of teaching methods in basic life support (4): comparison of simulated CPR performance at unannounced home testing after conventional or staged training. Resuscitation 61:41-47.
Thierbach A. R., Piepho T., Kunde M., Wolcke B. B., Golecki N., Kleine-Weischede B. and Werner C. (2005). Two-rescuer CPR results in hyperventilation in the ventilating rescuer. Resuscitation 65:185-190.
Thierbach A. R., Wolcke B. B., Krummenauer F., Kunde M., Janig C. and Dick W. F. (2003). Artificial ventilation for basic life support leads to hyperventilation in first aid providers. Resuscitation 57:269-277.
Thomas A. N., Hyatt J., Chen J. L. and Barker S. J. (1992). The Laerdal pocket mask: effects of increasing supplementary oxygen flow. Anaesthesia 47:967-971.

Tonkin S. L., Davis S. L. and Gunn T. R. (1995). Nasal route for infant resuscitation by mothers. Lancet 345:1353-1354.
von Goedecke A., Wagner-Berger H. G., Stadlbauer K. H., Krismer A. C., Jakubaszko J., Bratschke C., Wenzel V. and Keller C. (2004). Effects of decreasing peak flow rate on stomach inflation during bag-valve-mask ventilation. Resuscitation 63:131-136.
Wagner-Berger H. G., Wenzel V., Voelckel W. G., Rheinberger K., Stadlbauer K. H., Muller T., Augenstein S., von Goedecke A., Lindner K. H. and Keller C. (2003). A pilot study to evaluate the SMART BAG: a new pressure-responsive, gas-flow limiting bag-valve-mask device. Anesth Analg 97:1686-1689.
Walpoth B. H., Walpoth-Aslan B. N., Mattle H. P., Radanov B. P., Schroth G., Schaeffler L., Fischer A. P., von Segesser L. and Althaus U. (1997). Outcome of survivors of accidental deep hypothermia and circulatory arrest treated with extracorporeal blood warming. N Engl J Med 337:1500-1505.
Wayne M. A., Delbridge T. R., Ornato J. P., Swor R. A. and Blackwell T. (2001). Concepts and application of prehospital ventilation. Prehosp Emerg Care 5:73-78.
Wenzel V., Idris A. H., Banner M. J., Fuerst R. S. and Tucker K. J. (1994). The composition of gas given by mouth-to-mouth ventilation during CPR. Chest 106:1806-1810.
Wenzel V., Lehmkuhl P., Kubilis P. S., Idris A. H. and Pichlmayr I. (1997). Poor correlation of mouth-to-mouth ventilation skills after basic life support training and 6 months later. Resuscitation 35:129-134.
Wenzel V., Lindner K. H. and Prengel A. W. (1997). Beatmung wahrend der kardiopulmonalen Reanimation (CPR). Eine Literaturstudie und Analyse von Beatmungsstrategien. Anaesthesist 46:133-141.
Wik L., Myklebust H., Auestad B. H. and Steen P. A. (2002). Retention of basic life support skills 6 months after training with an automated voice advisory manikin system without instructor involvement. Resuscitation 52:273-279.
Wik L., Myklebust H., Auestad B. H. and Steen P. A. (2005). Twelve-month retention of CPR skills with automatic correcting verbal feedback. Resuscitation 66:27-30.
Wik L., Steen P. A. and Bircher N. G. (1994). Quality of bystander cardiopulmonary resuscitation influences outcome after prehospital cardiac arrest. Resuscitation 28:195-203.
Wilson-Davis S. L., Tonkin S. L. and Gunn T. R. (1997). Air entry in infant resuscitation: oral or nasal routes? J Appl Physiol 82:152-155.

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).

Ventilation technique	Advantages	Disadvantages
Mouth-to-mouth	No ventilation device needed	Risk of infection Rarely performed by bystanders[§] High tidal volume and stomach ventilation rate[$]
Mouth-to-nose	No ventilation device needed Low stomach inflation rate[#]	Risk of infection Low tidal volume[+]
Mouth-to-mask	No risk of infection[%] More correct tidal volume than mouth-to-mouth[$] Low stomach inflation rate[$]	
Bag-valve-mask	No risk of infection High correct tidal volume in the hands of experienced rescuers[&]	Low correct tidal volume in the hands of inexperienced rescuers*
Mouth-to-face shield		Risk of infection[%] Low tidal volume*

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).

Figure 1