ELSEVIER

Resuscitation 65 (2005) 185–190

RESUSCITATION

www.elsevier.com/locate/resuscitation

# Two-rescuer CPR results in hyperventilation in the ventilating rescuer☆

A.R. Thierbach*, T. Piepho, M. Kunde, B.B. Wolcke, N. Golecki, B. Kleine-Weischede, C. Werner

*Clinic of Anaesthesiology, Johannes Gutenberg-University, Langenbeckstrasse 1, 55131 Mainz, Germany*

Received 13 September 2004; received in revised form 15 November 2004; accepted 23 November 2004

**Abstract**

The "Guidelines 2000 for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care – International Consensus on Science" recommend a tidal ventilation volume of 10 ml/kg body-weight without the use of supplemental oxygen during two-rescuer adult cardiopulmonary resuscitation (CPR). This relates to a ventilation volume of about 6.4 l/min. Additionally, the first aid provider ventilating the victim will breathe for him/herself during the external chest compression period adding another 3.2 l/min of ventilation. Finally, a deep breath is recommended before each ventilation to increase the end-expiratory oxygen concentration of the air exhaled.

To investigate the effects of these recommendations, 20 healthy volunteers were asked to perform two-rescuer CPR in a lung model connected to a BLS-manikin.

End-tidal carbon dioxide, oxygen saturation, and heart rate were recorded continuously. Capillary blood gas samples were collected and non-invasive blood pressure was recorded prior to the start of external chest compressions and immediately after the end of each measurment period. Furthermore, hyperventilation related symptoms reported by the volunteers were also recorded.

The data reveal a significant decrease in capillary and end-tidal carbon dioxide pressure in the volunteers ($P < 0.001$). Additionally, in 75% of test persons multiple hyperventilation associated symptoms occurred.

Ventilation during two-rescuer CPR performed according to the Guidelines 2000 may cause injury to the health of first aid providers. To minimize hyperventilation, both rescuers should exchange their positions at intervals of 3–5 min. These data challenge the recommendation to take a deep breath prior to each ventilation.


*Keywords:* ERC; Basic life support (BLS); Blood gases; Cardiopulmonary resuscitation (CPR); Carbon dioxide; End-tidal carbon dioxide; Respiration, artificial

## 1. Introduction

In August 2000 the "Guidelines 2000 for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care – International Consensus on Science" were published [1].

For patients suffering from a cardiopulmonary arrest, immediate cardiopulmonary resuscitation (CPR) is recommended to provide minimal perfusion and oxygenation of vital organs. If two rescuers are present, one individual should perform external chest compressions, while the other person provides "mouth-to-nose" or "mouth-to-mouth" ventilation.

Previous studies have investigated the effects of different compression–ventilation-ratios [2] as well as different tidal ventilation volumes. It has been shown that smaller tidal volumes decrease the occurrence of side effects during ventilation of unsecured airways, e.g. regurgitation and consecutive aspiration due to inflation of air into the stomach [3]. However, optimised oxygenation of the victim can only be achieved with supplemental oxygen ($O_2$) [4].

The Guidelines 2000 recommend the following for two rescuers performing CPR without the use of supplemental oxygen:

- a compression/ventilation ratio of 15–2,
- a compression rate of 100 $min^{-1}$,
- a tidal volume of 10 ml/kg bodyweight (approximately 700–1000 ml), and

☆ A Spanish and Portuguese translated version of the Abstract and Keywords of this article appears at 10.1016/j.resuscitation.2004.11.024.

* Corresponding author. Tel.: +49 6131 17 1; fax: +49 6131 365888.
*E-mail address:* thierbach@uni-mainz.de (A.R. Thierbach).

0300-9572/$ – see front matter © 2004 Published by Elsevier Ireland Ltd.
doi:10.1016/j.resuscitation.2004.11.024

- a deep inspiration before every breath, to increase the end-expiratory $O_2$ content in the air exhaled by the first aid provider [5].

Most statements and recommendations are based on results obtained by studies of the physiology and pathophysiology in the victim. One previous study concluded that artificial ventilation in patients suffering from isolated respiratory arrest leads to clinically relevant hyperventilation in first aid providers [6]. Investigations examining the effects of these new recommendations on first aid providers performing two-rescuer BLS have not been published to date.

The purpose of this study therefore was to examine the effects of ventilation during two-rescuer CPR on the rescuer ventilating the victim.

## 2. Materials and methods

The Ethics Committee of the Board of Physicians Rhineland-Palatinate, Germany had reviewed and approved the protocol of this study.

Participants with a history of hyperventilation syndrome, neurological disorders, and diseases resulting in an American Society of Anesthesiologists (ASA) classification III and above as well as pregnant women were excluded from the study. All 20 participants had undergone formal training in cardio-pulmonary resuscitation with emphasis on two-rescuer CPR prior to the study.

All participants gave their written, informed consent before entering the investigation and were instructed to stop ventilation if any severe hyperventilation associated symptoms should develop.

After increasing local perfusion with a mixture of nonivamid and nicoboxil (Finalgon®), a vasodilating jelly, an initial blood gas sample was taken from the earlobe of every participant to evaluate baseline capillary carbon dioxide ($pcapCO_2$) and oxygen ($pcapO_2$) pressures.

To exclude the influence of the second rescuer during two-rescuer CPR, both external chest compressions and ventilations were performed by the same volunteer during two different measurement periods.

During the first part of the data collection, all participants had to perform a sequence of 5 min of isolated external chest compression on a BLS manikin (Laerdal Rescusi Anne, Laerdal Medical Corporation, New York, USA). The 5 min interval was chosen based on the evidence of an initial steep decrease of end-tidal carbon dioxide pressure levels during the first 4 min of ventilation [6].

According to the 2000 guidelines, the compression rate was set to 100 $min^{-1}$. With the help of a metronome, this frequency was monitored continuously by at least one investigator. Following every sequence of 15 external chest compressions (9 s), a break of 5 s was allowed for two ventilations.

Upon completion of the compression sequence, a second blood gas sample was taken immediately from the earlobe of every participant.

Following a break of 20–30 min, all participants ventilated an artificial lung (Vent Aid Training Test LungTM, Michigan Instruments Inc., Grand Rapids, MI, USA) for a period of another 5 min.

Lung compliance and airway resistance were adjusted (according to the proposals by Dick and Ahnefeld [7]) to standards:

- compliance 0.5 l/kPa for each side of the lung,
- resistance 0.57 kPa/(l s).

After two ventilations (each with a tidal volume of 800 ml in 2 s) applied over a total period of 5 s, a break of 9 s followed.

A third blood gas sample was taken from the earlobe of every participant after the ventilation sequence.

During both the external chest compression and the ventilation periods end-tidal carbon dioxide pressure ($EtpCO_2$), oxygen saturation measured by pulse oximetry ($SaO_2$), and pulse rate were monitored continuously (Propaq encore, Protocol systems Inc., Beavertown, OR, USA) and recorded at minute intervals (Fig. 1).

The non-invasive blood pressure (NiBP) was measured prior to the onset of each measurement period and afterwards. All blood gas samples were analysed using a blood gas analyser (ABL 510, Radiometer-Copenhagen, Copenhagen, Denmark).

All hyperventilation-associated symptoms were recorded on standardised data collection sheets.

The statistical analysis of data obtained by this trial was based primarily on the clinical endpoints scale level: The

Fig. 1. Experimental setting.