Original Article

The Effectiveness of Oxygen-Powered Inhalation Devices in Prehospital Care

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Background: Oxygen-powered inhalation devices are intended to provide emergency ventilation support for patients in prehospital care by supplying an adequate volume of oxygen. However, there have yet been no studies conducted examining oxygen-powered inhalation devices in Thailand.

Objective: To compare the effectiveness of manual and oxygen-powered bag valve masks (BVMs).

Materials and Methods: This was a retrospective study consisting of 79 EMS patients over 18 years of age at Srinagarind Hospital with oxygen saturation lower than 92% and respiratory rate greater than 30 times/minute who underwent emergency BVM ventilation, either manually or using oxygen-powered inhalation devices, from January to December 2019.

Results: The mean age of the patients in the oxygen-powered inhalation BVM group was 56.3±9.7 years, and 71.8% (n = 28) were male. The mean respiratory rate (RR) in both groups was 42.2 per minute in minute 0. In the oxygen-powered inhalation BVM group this decreased to 30.2±3.2 after 2 minutes of ventilation. The mean oxygen saturation was 86.2% at minute 0 and increased to 97.0±2.6 after 2 minutes of ventilation.

Conclusion: Oxygen-powered inhalation devices reduce RR and increase mean oxygen saturation in EMS patients with dyspnea.

Keywords: Ventilators, Ambulances, Emergency medical services, Equipment and supplies

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The purpose of emergency medical services (EMS) is to treat emergency patients at the scene of an illness or injury. Because of this, personnel and equipment are often limited[1]. According to treatment guidelines, patients with low oxygen saturation should be given oxygen, using either a nasal cannula, a face mask, or continuous positive airway pressure (CPAP)[2]. A bag valve mask (BVM) with manual ventilation is an important tool oxygen delivery tool for EMS providers[3-6]. Hypercapnic respiratory failure, hypoxic respiratory failure, and apnea are indications for BVM manual ventilation in an EMS setting[7]. Barotrauma from hyperventilation is a possible serious complication that may result in lung injury. It can also cause hyperventilation[8]. Oxygen-powered inhalation devices, which are intended to provide emergency BVM ventilation support for EMS patients, deliver adequate volumes of oxygen to the patients' lungs. They also automatically adjust to changes in a patient's lung compliance, thus reducing the risk of barotrauma[9-12]. As there have yet been no studies conducted in Thailand regarding oxygen-powered inhalation devices in EMS, the objective of the present study was to compare effectiveness of manual and oxygen-powered BVMs.

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Materials and Methods

This was a retrospective descriptive study. The sample consisted of 79 EMS patients over 18 years of age at Srinagarind Hospital with oxygen saturation lower than 92% and respiratory rate greater than 30 times/minute who underwent emergency BVM ventilation, either manually or using oxygen-powered inhalation devices, from January to December 2019. Trauma patients and those with incomplete data were excluded. Ethics approval was provided by the Khon Kaen University Ethics Committee for Human Research (HE621540).

The sample size was calculated based on proportion of BVM ventilation. In order to achieve a significance level of 5% and power of test of 0.8, we determined that a sample size of 79 would be required. Statistical analysis was performed using SPSS for Windows version 16.0 (SPSS Inc., Chicago, IL, USA). Categorical data were presented as percentages, and continuous data were presented using mean and standard deviation. Univariable analysis was performed using a two-sample t-test for numerical data and a Pearson's correlation for data relationships between the two groups.

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The patients were classified into two groups based on the method by which BVM ventilation was administered: (1) the manual procedure group, consisting of patients who were provided oxygen using a 1,500 ml self-inflating bag with a reservoir made from plastic materials that re-expand after being manually collapsed, and (2) the oxygen-powered inhalation device group, consisting of patients who were provided oxygen using the Oxylator® FR-300 (CPR Medical Devices Inc., Canada; weight 0.18 kg; maximum inspiration flow rate 30 LPM; auto minute volume 10 to 12 LPM with auto-adjusting ventilation rate).

Results

The 79 subjects were divided into two groups and examined. Patient characteristics are shown in Table 1. The mean age of the patients in the oxygen-powered inhalation BVM group was 56.3±9.7 years, and 71.8% (n = 28) of them were male. The number of patients with diabetes mellitus, hypertension, and chronic kidney disease did not differ between the two groups.

The mean respiratory rate (RR) in both groups was 42.2 per minute at minute 0. In the oxygen-powered inhalation BVM group this decreased to 30.2±3.2 after 2 minutes of ventilation, which was significantly lower than in the manual BVM group (p<0.05), as shown in Figure 1.

In both groups, the mean oxygen saturation was 86.2% at minute 0. This increased to 97.0±2.6 in the oxygen-powered inhalation BVM after 2 minutes of ventilation, which was significantly higher than in the manual BVM group (p = 0.036), as shown in Figure 2.

Discussion

In many Western countries, oxygen-powered inhalation devices are used by first responders in prehospital care. The benefits of these devices are that they are easy to use and only require one person to operate. The present study found that the oxygen-powered inhalation devices (Oxylator® FR-300) significantly reduced RR and increased mean oxygen saturation after two minutes of use in EMS dyspnea patients, results that are consistent with those of a previous study[11]. This may be due to oxygen-powered inhalation devices having a more constant low flow rate and pressure limit oxygen supply than manual BVM devices[12]. The oxygen-powered inhalation devices can be used during cardiopulmonary resuscitation (CPR) to reduce interruptions in chest compressions or lung hyperventilation[13,14]. A previous study[12,13] found that measured RR, mean oxygen saturation, and end tidal carbon dioxide ($ETCO_2$) provided by oxygen-powered inhalation devices were comparable with those provided by manual BVM. However, that study collected data in an ambulance, which limited the effectiveness of the $ETCO_2$ detector.

The present study was limited in that it did not examine patients who had been injured or other non-cardiac arrest patients. It also did not examine body mass index (BMI), weight, or height, which may have affected oxygenation and ventilation.

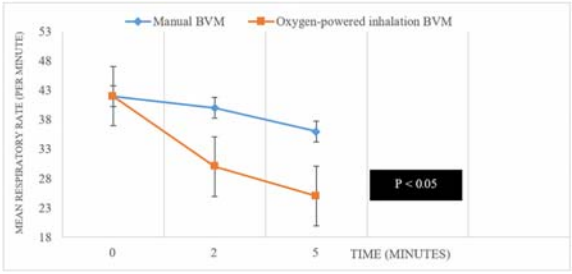

Figure 1. Comparison of mean respiratory rate.

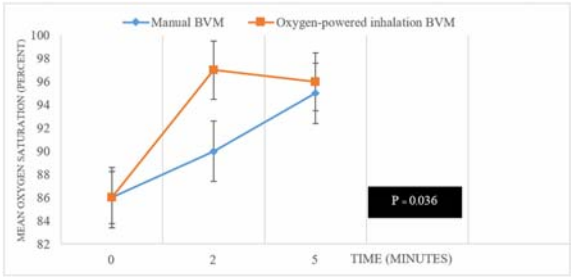

Figure 2. Comparison of mean oxygen saturation.

Table 1. Characteristics of the subjects

	Manual BVM n = 40, (%)	Oxygen-powered inhalation BVM n = 39, (%)	p-value
Sex: male	28 (70.0)	28 (71.8)	0.684
Age (years), mean ± SD	56.7±8.6	56.3±9.7	
Comorbidities			
Hypertension	22 (55.0)	18 (46.2)	0.632
Diabetes mellitus	20 (50.0)	18 (46.2)	0.585
Chronic kidney disease	14 (35.0)	10 (25.6)	0.610
Others	8 (20.0)	6 (15.4)	0.520

Conclusion

Oxygen-powered inhalation devices reduce RR and increase mean oxygen saturation in EMS patients with dyspnea.

What is already known on this topic?

Patients with low oxygen saturation can be given oxygen using various equipment configurations.

What this study adds?

Oxygen-powered inhalation devices can play an important role in airway management for EMS patients.

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Potential conflicts of interest

The authors declare no conflict of interest.

References

1. Apiratwarakul K, Ienghong K, Mitsungnern T, Kotruchin P, Phungoen P, Bhudhisawasdi V. Use of a motorlance to deliver emergency medical services; a prospective cross sectional study. Arch Acad Emerg Med 2019;7:e48.
2. Apiratwarakul K, Ienghong K, Ngaemsurach P, Gaysonsiri D, Rattanaseeha W. Effective of Continuous Positive Airway Pressure (CPAP) in emergency medical services. Srinagarind Med J 2016;31:162-6.
3. Strzelecki C, Shelton CL, Cunningham J, Dean C, Naz-Thomas S, Stocking K, et al. A randomised controlled trial of bag-valve-mask teaching techniques. Clin Teach 2020;17:41-6.
4. Sall FS, De Luca A, Pazart L, Pugin A, Capellier G, Khoury A. To intubate or not: ventilation is the question. A manikin-based observational study. BMJ Open Respir Res 2018;5:e000261.
5. Kroll M, Das J, Siegler J. Can altering grip technique and bag size optimize volume delivered with bag-valve-mask by emergency medical service providers? Prehosp Emerg Care 2019;23:210-4.
6. Carlson JN, Wang HE. Updates in emergency airway management. Curr Opin Crit Care 2018;24:525-30.
7. Bucher JT, Cooper JS. Bag mask ventilation (Bag Valve Mask, BVM). StatPearls [Internet]. Treasure Island, FL: StatPearls Publishing; 2020 [cited 2020 Mar 19]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK441924/.
8. Khoury A, Sall FS, De Luca A, Pugin A, Pili-Floury S, Pazart L, et al. Evaluation of bag-valve-mask ventilation in manikin studies: What are the current limitations? Biomed Res Int 2016;2016:4521767.
9. Noordergraaf GJ, Van Dun PJ, Schors MP, De Jong W, Noordergraaf A. Efficacy and safety in patients on a resuscitator, Oxylator EM-100, in comparison with a bag-valve device. Am J Emerg Med 2004;22:537-43.
10. Lindsey J. The oxylator: an innovative oxygen delivery device. JEMS 2004;29:100-2.
11. Osterwalder JJ, Schuhwerk W. Effectiveness of mask ventilation in a training mannikin. A comparison between the Oxylator EM100 and the bag-valve device. Resuscitation 1998;36:23-7.
12. Noordergraaf GJ, Van Dun PJ, Kramer BP, Schors MP, Hornman HP, De Jong W, et al. Airway management by first responders when using a bag-valve device and two oxygen-driven resuscitators in 104 patients. Eur J Anaesthesiol 2004;21:361-6.
13. Schaller SJ, Altmann S, Unsworth A, Schneider G, Bogner-Flatz V, Paul T, et al. Continuous chest compressions with a simultaneous triggered ventilator in the Munich Emergency Medical Services: a case series. Ger Med Sci 2019;17:Doc06.
14. Ewy GA. Cardiocerebral resuscitation should replace cardiopulmonary resuscitation for out-of-hospital cardiac arrest. Curr Opin Crit Care 2006;12:189-92.

ประสิทธิภาพเครื่องให้ออกซิเจนอัตโนมัติในการรักษาก่อนถึงโรงพยาบาล

กรกฎ อภิรัตน์วรากุล, กมลวรรณ เอี้ยงฮง, ดนุ เกษรศิริ, ฐปนวงศ์ มิตรสูงเนิน, มธุรส บูรณศักดา, วัชรพงศ์ พุทธิสวัสดิ์

ภูมิหลัง: เครื่องให้ออกซิเจนอัตโนมัติถือเป็นอุปกรณ์ในการช่วยหายใจแก่ผู้ป่วยในการรักษาก่อนถึงโรงพยาบาล อย่างไรก็ตามยังไม่มีการศึกษาถึงประสิทธิภาพที่ชัดเจนในระบบการแพทย์ฉุกเฉินของประเทศไทย

วัตถุประสงค์: เพื่อเปรียบเทียบประสิทธิภาพการช่วยหายใจผ่านหน้ากากระหว่างการใช้มือและเครื่องให้ออกซิเจนอัตโนมัติ

วัสดุและวิธีการ: การศึกษาแบบย้อนหลังในผู้ป่วยจำนวน 79 ราย ที่อายุมากกว่า 18 ปี ได้รับการรักษาผ่านระบบการแพทย์ฉุกเฉิน โรงพยาบาลศรีนครินทร์ มีค่าความอิ่มตัวของออกซิเจนปลายนิ้วน้อยกว่าร้อยละ 92 อัตราการหายใจมากกว่า 30 ครั้งต่อนาทีและได้รับการช่วยหายใจผ่านหน้ากากด้วยการใช้มือหรือเครื่องให้ออกซิเจนอัตโนมัติระหว่างเดือนมกราคม ถึงธันวาคม พ.ศ. 2562

ผลการศึกษา: อายุเฉลี่ยในกลุ่มที่ใช้เครื่องให้ออกซิเจนอัตโนมัติ 56.3±9.7 ปี ร้อยละ 71.8 เป็นชาย อัตราการหายใจเฉลี่ยทั้งสองกลุ่มคือ 42.2 ครั้งต่อนาทีเมื่อเริ่มทดสอบ ในกลุ่มที่ใช้เครื่องให้ออกซิเจนอัตโนมัติสามารถลดอัตราการหายใจเหลือ 30.2±3.2 ครั้งต่อนาทีหลังใช้เครื่องเป็นเวลา 2 นาทีและสามารถเพิ่มค่าความอิ่มตัวของออกซิเจนปลายนิ้วจากร้อยละ 86.2 เป็นร้อยละ 97.0±2 หลังใช้เครื่องเป็นเวลา 2 นาที

สรุป: เครื่องให้ออกซิเจนอัตโนมัติสามารถลดอัตราการหายใจและเพิ่มค่าความอิ่มตัวของออกซิเจนปลายนิ้วที่มีอาการเหนื่อยในระบบการแพทย์ฉุกเฉิน