Flush Rate Oxygen for Emergency Airway Preoxygenation

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Study objective: Recent data suggest that emergency airway preoxygenation with a bag-valve-mask (BVM) device (held with a tight mask seal but without squeezing the bag) is superior to a nonrebreather (NRB) mask at standard oxygen flow rates. We seek to determine whether preoxygenation with an NRB mask with flush rate oxygen (>40 L/min by fully opening a standard oxygen flowmeter) is noninferior to BVM device with standard-flow oxygen (15 L/min). We also seek to compare the efficacy of preoxygenation with NRB mask at flush rate oxygen with both NRB mask with oxygen at 15 L/min and simple mask at flush rate oxygen.

Methods: We performed a crossover trial using healthy volunteers. In random sequence, subjects underwent 3-minute trials of preoxygenation with nonrebreather mask with oxygen at 15 L/min (NRB-15), nonrebreather mask with flush rate oxygen (NRB-Flush), BVM device with oxygen at 15 L/min (BVM-15), and simple mask with flush rate oxygen. The primary outcome measure was the FeO_2 in a single exhaled breath. We compared the FeO_2 of NRB-Flush to other study groups, using a prespecified noninferiority margin of 10%.

Results: We enrolled 26 subjects. Mean FeO_2 values for NRB-15, NRB-Flush, BVM-15, and simple mask with flush rate oxygen were 54% (95% confidence interval [CI] 50% to 57%), 86% (95% CI 84% to 88%), 77% (95% CI 74% to 81%), and 72% (95% CI 69% to 76%), respectively. FeO_2 for NRB-Flush was noninferior to BVM-15 (difference 8%; 95% CI 5% to 11%). FeO_2 for NRB-Flush was higher than both NRB-15 (FeO_2 difference 32%; 95% CI 29% to 35%) and simple mask with flush rate oxygen (FeO_2 difference 13%; 95% CI 10% to 17%).

Conclusion: Preoxygenation with NRB-Flush was noninferior to BVM-15. NRB with flush rate oxygen may be a reasonable preoxygenation method for spontaneously breathing patients undergoing emergency airway management. [Ann Emerg Med. 2017;69:1-6.]

Please see page 2 for the Editor's Capsule Summary of this article.

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INTRODUCTION

Background

Oxygen desaturation is an important and unwanted adverse event of emergency airway management.[1] Clinicians often perform preoxygenation to reduce the risk of hypoxemia during airway management. Although preoxygenation is widely practiced, the optimal method for it remains unclear. Common devices used for preoxygenation in the emergency department (ED) for spontaneously breathing patients include the bag-valve-mask (BVM) device, the simple face mask, and the nonrebreather (NRB) mask.

In the spontaneously breathing patient, effective preoxygenation with a BVM device requires a 1-way valve at the exhalation port and a tight mask seal against the face. Many standard BVM devices do not have built-in 1-way valves, resulting in a fraction of delivered oxygen similar to room air.[2] Also, many critically ill ED patients requiring intubation are dyspneic or agitated and unable to tolerate the required tight mask seal.[3] An NRB mask with oxygen flow at 15 L/min similarly delivers a relatively low fraction of inspired oxygen inadequate for preoxygenation.[4,5]

Older studies suggest that a face mask with high flow rate oxygen (48 L/min) can effectively denitrogenate the lungs.[6,7] High "flush rate" oxygen flow can be achieved with most standard medical oxygen flowmeters by turning the adjustor knob past the highest gradation on the flowmeter until it cannot be rotated farther.

Editor's Capsule Summary

What is already known on this topic

Before emergency airway management, clinicians commonly perform preoxygenation using bag-valve-mask (BVM) device or nonrebreather (NRB) mask.

What question this study addressed

Is preoxygenation by NRB mask with flush rate oxygen as good as BVM device at 15 L/min?

What this study adds to our knowledge

In this randomized trial on 26 healthy volunteers, the FeO_2 for flush rate NRB mask was noninferior to BVM device at 15 L/min.

How this is relevant to clinical practice

Although requiring validation in clinical emergency department patients, flush rate oxygen by NRB mask may aid emergency airway management preoxygenation efforts.

Importance

If an NRB mask at a high flow rate could perform similarly to a BVM device in spontaneously breathing patients, then effective preoxygenation could be achieved without the need for a BVM device with a 1-way valve and the burden of maintaining a tight mask seal during preoxygenation.

Goals of This Investigation

In this study of healthy volunteers, we sought to determine whether preoxygenation with an NRB mask with flush rate oxygen is noninferior to BVM device with oxygen at 15 L/min. We also sought to compare the preoxygenation efficacy of an NRB mask with flush rate oxygen to an NRB mask with oxygen at 15 L/min and a simple mask with flush rate oxygen.

MATERIALS AND METHODS

Study Design and Setting

We performed a crossover study using healthy volunteers to mirror 2 recent studies.[4,5] All trials were conducted in the Hennepin County Medical Center Emergency Department. The local institutional review board approved this study; all subjects provided informed consent.

Selection of Participants

ED staff were asked to volunteer for this investigation. Exclusion criteria included symptomatic respiratory disease at participation, smoking history greater than 5 pack-years, pregnancy, or younger than 18 years. We included subjects with a history of well-controlled chronic respiratory disease (eg, asthma), as well as subjects with facial hair.

Interventions

After informed consent, each subject underwent 4 trials of preoxygenation in random sequence: NRB mask with oxygen at 15 L/min (NRB-15), NRB mask with flush rate oxygen (NRB-Flush), BVM with oxygen at 15 L/min, and simple mask with flush rate oxygen. Subjects lay supine on a bed with the head elevated to 30 degrees. Baseline FeO_2 values were obtained before the first preoxygenation trial. For each preoxygenation trial, the subject performed tidal breathing for 3 minutes. The sequence of the 4 trials was randomized with a balanced Latin square design so that the order of trials of 1 participant was completed in the opposite order of that of another participant.

We used standard adult respiratory equipment in the trial (NRB mask: model 1059, Hudson RCI, Research Triangle Park, NC; simple mask: model 1041, Hudson RCI; BVM: 1st Response Manual Resuscitator, model V8503, Smiths Medical, St. Paul, MN) (Figure 1). The NRB and face masks were placed on the face; the metal clip was compressed against the bridge of the nose and the elastic headband was tightened. The reservoir bag for the NRB mask was inflated with oxygen before use. The BVM device contained an 850-mL reservoir. We added a 1-way disk-type valve to the exhalation port (model 533-MS-PMVEA; MedSource International, Chaska, MN). The reservoir on the BVM device was flushed with high-flow oxygen for 15 seconds to ensure it contained 100% oxygen before it was applied to the participant's face. The subject held the face mask tightly against his or her face and could adjust the mask if a leak was perceived by the subject or detected by a study investigator.

A standard oxygen flowmeter with gradations 0 to 15 L/min was used for all trials (model 8MFA; Precision Medical, Northampton, PA; maximum marked flush rate 40 to 60 L/min) (Figure 2). The flush rate was achieved by rotating the flowmeter dial counterclockwise until it could not be turned farther. The pressure delivered to the oxygen ports in our ED is between 50 and 55 lb/in^2. An independent engineer unaffiliated with the study analyzed the flush rate flow through the flowmeter and affirmed oxygen flow rate of 50 L/min at 50 lb/in^2, and 54 L/min at 55 lb/in^2. Therefore, the flush rate used in this study likely provided a flow of 50 to 54 L/min. We did not use a more precise measure of flow because we wanted to use standard ED equipment available to all emergency physicians.

Methods of Measurement and Outcome Measures

The outcome measure was the FeO_2, measured at the end of each preoxygenation trial. FeO_2 was measured with