Efficacy of Nasal Cannula Oxygen as a Preoxygenation Adjunct in Emergency Airway Management

Clare Hayes-Bradley, BSc, MBBS*; Anthony Lewis, MBBCh, PhD; Brian Burns, MBBCh, MSc; Matt Miller, MBChB

*Corresponding Author. E-mail: clarehayesbradley@yahoo.com, Twitter: @ClareHBradley.

Study objective: Although preoxygenation for emergency airway management is usually performed with nonrebreather face masks or bag-valve-mask devices, some clinicians also deliver supplemental high-flow oxygen by nasal cannula. We aim to measure the efficacy of supplemental nasal cannula oxygen delivery to conventional bag-valve-mask and nonrebreather face mask preoxygenation both with and without a simulated face mask leak.

Methods: We conducted a randomized crossover trial using healthy volunteers. We randomized subjects to preoxygenation with bag-valve-mask or nonrebreather face mask. In random sequence, subjects underwent 3-minute trials of preoxygenation with oxygen through mask alone at 15 L/min, oxygen through mask at 15 L/min with standardized leak, oxygen through mask at 15 L/min+oxygen through nasal cannula at 10 L/min, and oxygen through mask at 15 L/min+oxygen through nasal cannula at 10 L/min with standardized leak. The primary outcome was single-breath exhalation end-tidal oxygen (ETO_2). We compared ETO_2 between preoxygenation modalities, using nonparametric techniques.

Results: We enrolled 60 subjects (30 nonrebreather face mask and 30 bag-valve-mask). In scenarios without a mask leak, ETO_2 was similar between bag-valve-mask and bag-valve-mask+nasal cannula (mean 79% versus 75%; difference −3%; 95% confidence interval [CI] −8% to 1%). In bag-valve-mask scenarios with a mask leak, ETO_2 was higher for bag-valve-mask+nasal cannula than bag-valve-mask alone (mean 66% versus 41%; difference 25%; 95% CI 21% to 29%). ETO_2 was higher for nonrebreather face mask+nasal cannula than nonrebreather face mask (mean 67% versus 52%; difference 15%; 95% CI 12% to 18%). In nonrebreather face mask scenarios with a mask leak, ETO_2 was higher for nonrebreather face mask+nasal cannula than nonrebreather face mask (mean 65% versus 48%; difference 17%; 95% CI 13% to 20%).

Conclusion: Although not aiding bag-valve-mask preoxygenation with a good mask seal, supplemental nasal cannula oxygen improved preoxygenation efficacy in the presence of a bag-valve-mask mask leak. Supplemental nasal cannula oxygen improved nonrebreather face mask preoxygenation both with and without a mask leak. Supplemental nasal cannula oxygen may be helpful for preoxygenation before emergency airway management. [Ann Emerg Med. 2016;68:174-180.]

Please see page 175 for the Editor's Capsule Summary of this article.

0196-0644/$-see front matter

http://dx.doi.org/10.1016/j.annemergmed.2015.11.012

INTRODUCTION

Background

In emergency airway management and rapid sequence intubation, clinicians commonly perform preoxygenation before performing laryngoscopy and intubation. Preoxygenation denitrogenates the functional residual capacity of the lungs, creating an oxygen reservoir to allow periods of apnea during intubation.[1] Preoxygenation is essential to help prevent hypoxemia during emergency airway management.[2,3]

Common devices used for emergency airway preoxygenation include bag-valve-mask and the nonrebreather face mask, both of which vary by manufacturer in their delivered FiO_2.[4-8] In addition to bag-valve-mask or nonrebreather face mask, some clinicians provide supplemental high-flow oxygen through nasal cannula to increase the total oxygen flow. Bag-valve-mask or nonrebreather face mask seal may be difficult to maintain in emergency airway cases (for example, because of facial injuries or agitation), compromising preoxygenation, so

Editor's Capsule Summary

What is already known on this topic

Before emergency airway management, clinicians commonly perform preoxygenation with bag-valve-mask or nonrebreather mask.

What question this study addressed

Does supplemental high-flow nasal cannula oxygen improve preoxygenation?

What this study adds to our knowledge

In this randomized trial on 60 healthy volunteers, nasal cannula oxygen at 10 L/min improved end-tidal oxygen levels with nonrebreather mask, nonrebreather with a mask leak, and bag-valve-mask with a mask leak. Addition of nasal cannula did not improve end-tidal oxygen with well-sealed bag-valve-mask.

How this is relevant to clinical practice

Although requiring validation in clinical emergency department patients, supplemental nasal cannula oxygen may aid emergency airway management preoxygenation efforts.

some clinicians advocate the use of supplemental high-flow nasal cannula oxygen in the presence of a mask leak.[9-11]

Importance

Although supplemental nasal cannula oxygen for preoxygenation before emergency airway management theoretically increases oxygen delivery, to our knowledge there are no studies evaluating its efficacy. In addition, to our knowledge there are no studies evaluating the efficacy of supplemental nasal cannula oxygen for rapid sequence intubation preoxygenation in the presence of a bag-valve-mask or nonrebreather face mask leak.

Goals of This Investigation

In this study using healthy volunteers, we sought to assess the efficacy of supplemental nasal cannula oxygen in preoxygenation for simulated emergency airway management, with and without face mask leak.

MATERIALS AND METHODS

Study Design and Setting

We performed a randomized crossover study using healthy volunteers. All trials were conducted in the operating room or ICU of St George Hospital. The study was approved by the South Eastern Sydney Local Heath District Ethics Review Committee (HREC/15/POWH/54) and registered at the Australia and New Zealand Clinical Trials Registry.

Selection of Participants

Volunteers were requested from operating theater, emergency department (ED), or ICU staff at St George Hospital. Exclusion criteria were known respiratory or cardiac disease; current cardiac or respiratory medications, including inhalers; pregnancy; exposure to bleomycin or amiodarone; and facial hair or previous facial injury likely to affect mask seal. Male volunteers were asked to be clean-shaven on the day of testing. One participant was excluded before commencing because of previous exposure to amiodarone.

Interventions

After informed consent, each participant was randomized to either nonrebreather face mask or bag-valve-mask according to a random sequence generated with the statistical software R (version 3.1.2; R Foundation for Statistical Computing). Participants then underwent 4 trials of preoxygenation consisting of mask alone (bag-valve-mask or nonrebreather face mask), mask (bag-valve-mask or nonrebreather face mask) with simulated leak, mask+nasal cannula (bag-valve-mask+nasal cannula or nonrebreather face mask+nasal cannula), and mask+nasal cannula with simulated leak (Figure 1). The sequence of the 4 trials was randomized with a balanced Latin square design so that the order of trials of one participant was completed in the opposite order of another participant.

Bag-valve-mask preoxygenation was performed with a disposable self-inflating resuscitator (bag-valve-mask) with a 2-L reservoir bag (Mayo Healthcare, Mascot, NSW, Australia) and expiratory cap[12] connected to a heat moisture exchange filter and catheter mount. For the nonrebreather face mask, we used a standard adult nonrebreather mask with reservoir and safety vent (Mayo Healthcare).[13] Adult straight-prong nasal cannulae (Mayo Healthcare)[14] were used for all participants. For both bag-valve-mask and nonrebreather face mask, oxygen was delivered at 15 L/min. The adult nasal cannula oxygen flow rate was set at 10 L/min.

To create simulated mask leaks, we used 2 pieces of 4-cm-long nontapering portions of 16-French nasogastric tube (Medtronic, Minneapolis, MN). We inserted the pieces of nasogastric tube under both sides of the mask on the upper lip to create a standard disruption to the mask seal (Figure 2).