American Journal of Emergency Medicine xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

American Journal of Emergency Medicine

journal homepage: www.elsevier.com/locate/ajem

Head elevation and lateral head rotation effect on facemask ventilation efficiency: Randomized crossover trials

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ARTICLE INFO

Article history:
Received 4 February 2017
Received in revised form 3 May 2017
Accepted 8 May 2017
Available online xxxx

Keywords:
Head elevation
Lateral head rotation
Facemask ventilation volume
Randomized clinical trial

ABSTRACT

Purpose: We performed two prospective randomized crossover trials to evaluate the effect of head elevation or lateral head rotation to facemask ventilation volume.
Methods: In the first trial, facemask ventilation was performed with a 12-cm high pillow (HP) and 4-cm low pillow (LP) in 20 female patients who were scheduled to undergo general anesthesia. In the second trial, facemask ventilation was performed with and without lateral head rotation in another 20 female patients. Ventilation volume was measured in a pressure-controlled ventilation (PCV) manner at 10, 15, and 20 cmH_2O inspiratory pressures.
Results: In the first trial evaluating head elevation effect, facemask ventilation volume was significantly higher with a HP than with a LP at 15 and 20 cmH_2O inspiratory pressure (15 cmH_2O: HP $_{median}$540 [$_{IQR}$480–605] mL, LP 460 [400–520] mL, $P = 0.006$, 20 cmH_2O: HP 705 [650–800] mL, LP 560 [520–677] mL, $P < 0.001$). In the second trial, lateral head rotation did not significantly increase facemask ventilation volume at all inspiratory pressure.
Conclusion: Head elevation increased facemask ventilation volume in normal airway patients, while lateral head rotation did not.

1. Introduction

Facemask ventilation is the essential technique for airway management during resuscitation. Emergency physicians frequently encounter difficult facemask ventilation due to airway obstruction [1]. Though nasal or oral airway is an effective device for upper airway obstruction release, difficult facemask ventilation still occurs in non-negligible number of patients [2-4].

Emergency physicians empirically perform head elevation or lateral head rotation to facilitate facemask ventilation. Previous reports have investigated the efficacy of head positioning on upper airway patency [5,6]. However, no quantitative evaluation has been performed on the effects of head elevation/lateral rotation on facemask ventilation volume. As such evaluation in emergency situation may be unethical, we decided to perform these evaluation in the operation room.

We hypothesized that head elevation and lateral head rotation may facilitate facemask ventilation by increasing ventilation volume. To test this hypothesis, we performed two independent crossover clinical trials to assess facemask ventilation volume using mechanical ventilation in a pressure-controlled ventilation (PCV) manner.

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2. Methods

The institutional ethical review board of Osaka Medical College approved the study protocol. We registered this study in the University hospital Medical Information Network Clinical Trials Registry (Registration number: UMIN000021507, UMIN000023019).

In the first trial, conducted in March and April 2016, we assessed 22 female patients for eligibility (Fig. 1). No patient refused to participate and two were excluded for not fulfilling the eligibility criteria because their body mass index was over 35. After obtaining written informed consent, 20 female patients aged 20 to 75 years undergoing general anesthesia in the supine position were recruited. We excluded male patients to unify the clinical trial condition based on a previous study, which reported that male sex was a risk factor for facemask ventilation [4]. The following patients were also excluded from the present study: (1) those with anticipated difficult facemask ventilation such as morbid obesity (body mass index over 35), apparent short neck, and sleep apnea syndrome, and (2) those with high risk of aspirating stomach contents.

Facemask ventilation was performed in a PCV manner with both 12-cm high pillow (HP) and 4-cm low pillow (LP) in the supine position in all patients. Pillows were cut-out cushions (4 cm height) typically used during induction of anesthesia. For the HP trial, cushions were tripled-over, resulting in an approximate height of 12 cm [7]. The vertical

http://dx.doi.org/10.1016/j.ajem.2017.05.004
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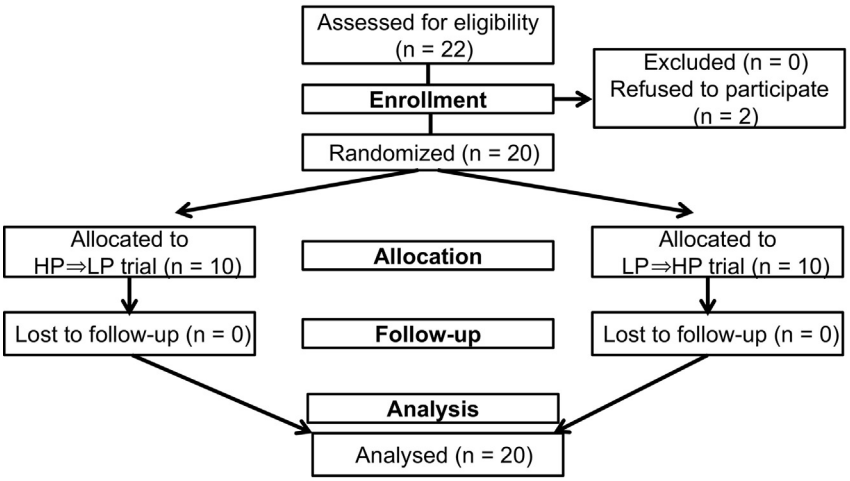

Fig. 1. CONSORT flowchart in the first trial.

gaze was maintained in both HP and LP trial. The order of HP and LP trials was randomly assigned by the envelope method [8].

In the second trial, conducted in July and August 2016, 23 female patients were assessed for eligibility (Fig. 2). None refused to participate and three were excluded for not fulfilling the eligibility criteria (two were morbid obesity and one gastro-esophageal reflex disease). After obtaining written informed consent, 20 female patients aged 20 to 75 years undergoing general anesthesia in the supine position were recruited. Facemask ventilation was performed in all patients both with and without lateral head rotation. Lateral head rotation was achieved by 30 degree clockwise measured by protractor. We decided this angle from the viewpoint of patient safety and our routine practice.

In both trials, we did not administer any premedication to patients. Anesthesia was induced with remifentanil 0.3–0.5 μg kg^{-1} min^{-1} and propofol 1.5–2 mg kg^{-1}. Rocuronium 0.9 mg kg^{-1} was administered as neuromuscular blockade to eliminate the incidence of laryngospasm [9]. Anesthesiologists determined the doses of propofol and remifentanil does on the basis of the patient's condition. After loss of consciousness, anesthesiologists with >5 years of clinical experiences performed facemask ventilation with two hand maneuvers using 3–5% sevoflurane in oxygen with the double hand technique which perform E-C clamp with both hands for yielding sealing pressure [10]. Cases with <20 cmH_2O leak pressure or insufficient ventilation were excluded from the viewpoint of patient safety.

Facemask ventilation volume was measured by the ventilator attached to the anesthesia machine (Fabius GS®, Dräger, Germany) in the PCV mode with an inspiratory pressure of 10, 15, or 20 cmH_2O at 8 breaths per minute and a 1:2 inspiratory to expiratory ratio. The measurement started after confirming the zero count of train-of-four using TOF watch® (NIHON KOHDEN, Tokyo, Japan) [11]. Facemask ventilation volume was the average volume measured during 1 min. Measurement was performed at PCV in order (10, 15, 20), and the order of interventions was randomly assigned using the envelope method at each pressure.

We performed statistical analysis using JMP® 11 (SAS Institute Inc., Cary, NC, USA). Facemask ventilation volume, the primary outcome, was assessed using the Wilcoxon matched-pairs signed rank test and compared between groups. Data are expressed as either number of patients, mean (standard deviation (SD)), or median [interquartile range (IQR)]. A *P-value* < 0.05 was considered statistically significant.

For sample size calculation in the first trial, facemask ventilation volume at PCV 15 cmH_2O was about 500 ± 200 mL with a normal height pillow, and 800 ± 200 mL with a HP. We considered this 300 mL difference clinically significant, as it was approximately 60% of the facemask ventilation volume with a normal height pillow. To detect this difference with 80% power and 5% significance level, 16 patients were required. To adjust for potential missing data, we planned to recruit 20 patients to each group. For sample size calculation in the second trial,

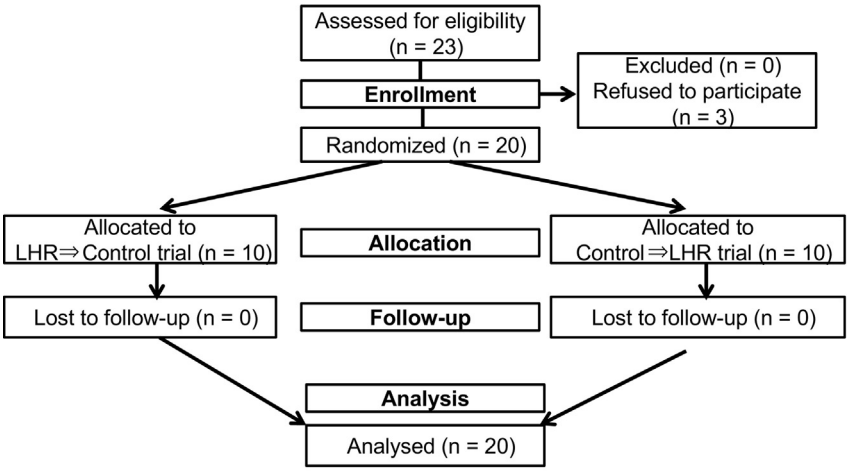

Fig. 2. CONSORT flowchart in the second trial.

Please cite this article as: Matsunami S, et al, Head elevation and lateral head rotation effect on facemask ventilation efficiency: Randomized crossover trials, American Journal of Emergency Medicine (2017), http://dx.doi.org/10.1016/j.ajem.2017.05.004