Nasal mask ventilation is better than face mask ventilation in edentulous patients

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Abstract

Background and Aims: Face mask ventilation of the edentulous patient is often difficult as ineffective seating of the standard mask to the face prevents attainment of an adequate air seal. The efficacy of nasal ventilation in edentulous patients has been cited in case reports but has never been investigated.
Material and Methods: Consecutive edentulous adult patients scheduled for surgery under general anesthesia with endotracheal intubation, during a 17-month period, were prospectively evaluated. After induction of anesthesia and administration of neuromuscular blocker, lungs were ventilated with a standard anatomical face mask of appropriate size, using a volume controlled anesthesia ventilator with tidal volume set at 10 ml/kg. In case of inadequate ventilation, the mask position was adjusted to achieve best-fit. Inspired and expired tidal volumes were measured. Thereafter, the face mask was replaced by a nasal mask and after achieving best-fit, the inspired and expired tidal volumes were recorded. The difference in expired tidal volumes and airway pressures at best-fit with the use of the two masks and number of patients with inadequate ventilation with use of the masks were statistically analyzed.
Results: A total of 79 edentulous patients were recruited for the study. The difference in expiratory tidal volumes with the use of the two masks at best-fit was statistically significant ($P = 0.0017$). Despite the best-fit mask placement, adequacy of ventilation could not be achieved in 24.1% patients during face mask ventilation, and 12.7% patients during nasal mask ventilation and the difference was statistically significant.
Conclusion: Nasal mask ventilation is more efficient than standard face mask ventilation in edentulous patients.

Key words: Difficult mask ventilation, edentulous, face mask leak, nasal mask ventilation

Introduction

Anticipation of the difficult airway is vital for safe and efficient of airway management. Difficult airway generally includes difficult laryngoscopy, difficult intubation, and difficult mask ventilation (DMV). Mask ventilation provides the anesthesia care provider with a rescue technique after unsuccessful attempts at intubation.[1] The value of DMV seems to have taken a back seat to the more glamorous problem of difficult intubation.[2] DMV may result in inability to achieve adequate ventilation with potential serious adverse outcomes.[3]

Face mask ventilation of the edentulous patient is often difficult as ineffective seating of the standard mask to the face prevents attainment of an adequate air seal.[4] In edentulous patients, air leaks due to reduced contact between the mask and the cheeks.[5] It is common practice for one person to hold the mask with both hands over the patient's face while a second person ventilates the lungs by squeezing the bag.

Liang *et al.* recently demonstrated the efficacy of nasal ventilation in reducing airway obstruction vis-à-vis oral-nasal ventilation.[1] Nasal positive-pressure ventilation has been suggested as an effective mode of ventilation in edentulous patients;[6] however to our knowledge, it has never been investigated. Nasal positive

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pressure ventilation may be used in edentulous patients as the mask contact is only on the maxillary plane.[1] We hypothesized that, in edentulous patients requiring general anesthesia, the nasal mask placement would be more effective in reducing air leaks than the standard face mask placement.

Material and Methods

The study was performed at a tertiary care hospital after approval of the Institutional Ethics Committee of Command Hospital (CC), Lucknow. Informed consent was obtained from all patients. All consecutive edentulous adult patients scheduled for surgery under general anesthesia with endotracheal intubation, during a 17-month period, were prospectively evaluated for inclusion in this study. A pilot study was conducted on five patients to determine the minimum number of patients required for the main study, as no similar study on edentulous patients was available in contemporary literature. Based on the pilot study, a minimum number of 62 patients were required for 80% power ($\alpha = 0.05$, $\beta = 0.2$) and 83 patients for 90% power ($\alpha = 0.05$, $\beta = 0.1$). The time period was decided based on predicted recruitment of 5-6 edentulous patients per month. The exclusion criteria were contraindication to mask ventilation (emergency cases requiring a rapid sequence induction, planned awake intubation), prognathia or retrognathia, history of snoring, sleep apnea, obesity, and patients with beards.

Dentures of all edentulous patients were removed before they were taken to the operating room, as per standard practice of the institution. All patients were routinely monitored using electrocardiography, noninvasive blood pressure measurement and peripheral oxygen saturation (SpO_2) before induction of general anesthesia. After preoxygenation, anesthesia was induced with a sequence of fentanyl, 2 mcg/kg, intravenous and a sleep dose of thiopentone, 3-5 mg/kg, injected intravenous over 60 s. After loss of consciousness and preliminary verification of ability to maintain airway, vecuronium, 0.8-1 mg/kg, was administered to achieve neuromuscular blockade. Lungs were ventilated with positive-pressure ventilation holding a single use anatomical face mask (EcoMask II, Intersurgical, Berkshire, UK), with the left hand, using the ventilator circle system, and compressing the reservoir bag manually for 1 min. A face mask of appropriate size (small adult, medium adult or large adult) was chosen to achieve the best-fit for each patient. After 2 min, on partial onset of neuromuscular blockade, an ascending bellow anesthesia machine ventilator (AV-S Ventilator, Penlon Limited, Abingdon, UK) replaced the manual reservoir bag as the ventilation drive. The fresh gas flow was preset at 6-8 l/min of oxygen with 2% sevoflurane, and the ventilator set on volume-controlled mode with a tidal volume of 10 ml/kg (delivered volume), respiratory rate 12 breaths/min and I:E ratio 1:2.

Standard face mask ventilation was performed by placing the thumb and index finger on the body of the mask, whereas the other fingers moved the mandible toward the upper teeth and maintained the head in extended position (primary positioning). Delivered and Expired tidal volumes were measured with two spirometry sensors (Integrated in AV-S Ventilator, Penlon Limited, Abingdon, UK), placed in the delivery and expired ends of the anesthesia breathing system. In case of inadequate ventilation for five consecutive breaths (defined as a difference of >25% between the set delivered and the expired tidal volume/fall in bellows of the ventilator/ inadequate capnograph trace/inadequate visual rising of the chest wall), the mask position was adjusted by repositioning the inferior end of the mask above the mandible, with the head in extension position (best-fit positioning). The cephalad end of the mask remained on the bridge of the nose for both positions. The readings of the expired tidal volumes and adequacy of capnograph trace were noted in the 3rd min after stabilization in the best-fit position. The SpO_2, peak airway pressure, and fall in the bellows, in case any, were recorded. In case of inability to achieve adequate ventilation, despite above positioning, the mask was held with both hands as a rescue measure. In case this too failed, a Guedel's airway was introduced and help of a second person taken to achieve the face mask seal.

After 3 min, the face mask was changed to an infant size transparent anatomical face mask (EcoMask II, Intersurgical, Berkshire, UK) so placed that it covered only the nose. The inferior end of the mask was seated on the upper lip. In case the mask was small for the nose, it was changed to a pediatric size mask with the inferior part of the mask seated on the upper lip. The mask was held with the left hand by placing the thumb and index finger on the body of the mask, whereas the middle, ring, and little fingers moved the mandible toward the maxilla. The mouth closed as a result of the upward pressure of the three fingers [Figure 1]. The head was placed in the neutral position and not extended. In case of inadequate ventilation for five consecutive breaths (as defined above), the mask position was adjusted by repositioning the inferior end of the mask above the upper lip and ensuring that the mouth was closed, while maintaining the head in neutral position (best-fit positioning). No change in the delivered volume or ventilator settings was made. After achieving best-fit positioning and allowing a minute to pass, the readings of the expired tidal volumes and adequacy of capnograph trace were noted. The ventilation strategy flowchart followed in the study is shown in Table 1. The SpO_2, peak airway pressure, and fall in the bellows, in case any, were recorded. In case of inability to

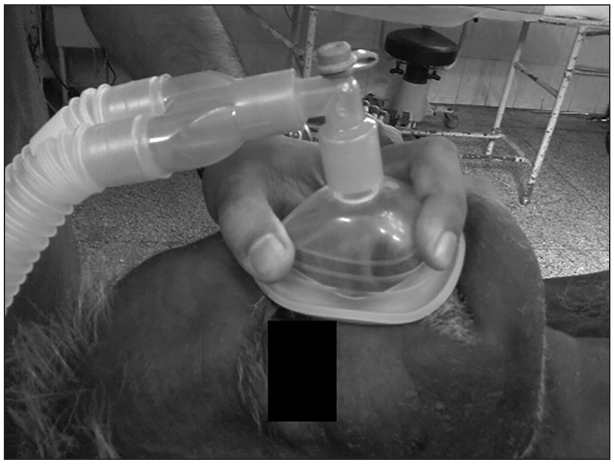

Figure 1: Patient with nasal mask placement. The mask is held with the left hand by placing the thumb and index finger on the body of the mask, while the middle, ring, and little fingers move the mandible toward the maxilla to ensure closure of the mouth

achieve adequate ventilation, despite above positioning, other airway adjuncts were used as rescue airway. The holding of the mask was done in all cases by a resident with at least 2 years experience in anesthesiology, under supervision of the principal investigator, and the tidal volume recordings were noted by a junior resident blinded to the study.

Upon completion of the study, the subject's airway was secured in a normal manner by tracheal placement of an endotracheal tube or using an airway adjunct in case of failure to intubate the trachea. Anesthesia was maintained in a routine manner as per the requirements of the case.

Statistical analysis

One-tailed paired Student's *t*-test was used to compare expired tidal volumes and maximum airway pressure at best-fit in the standard face mask and nasal mask placements. The results are expressed as mean ± standard deviation (SD). McNemar test was used to compare the number of patients in whom inadequate mask fit was not achieved despite best-fit mask placement using the two techniques. All analysis was performed using Minitab Statistical software version 11 (Minitab Inc., State College, PA, USA). $P < 0.05$ was considered statistically significant. One-tailed significance testing was done because our hypothesis stated that the nasal mask ventilation placement would be more effective in reducing air leaks than the standard face mask placement in edentulous patients.

Results

Seventy-nine edentulous patients were recruited for the study during January 2010 to May 2011. The patient characteristics are shown in Table 2. Twenty-two patients underwent oncosurgical, 18 gastrointestinal endoscopic, 13 cardiac-surgical, 9 gynecological, 9 urological, and 8 reconstructive surgical procedures. Five patients had limited flexion/extension of the neck, and 2 had a history of neck radiation therapy.

Table 1: The ventilation protocol flowchart followed in the study

Standard face mask ventilation after induction
↓
Preliminary check of ability to maintain airway
↓
Administration of neuromuscular blocking agent
↓
Manual supportive ventilation for 2 min
↓
Mechanical ventilation on volume control mode using standard face mask after 2 min
↓
Mechanical ventilation on volume control mode after changing over to a nasal mask after 3 min

Table 2: Patient demographics

Age (years)	64.9±8.8 (48-83)
Sex (M/F)	45/29
Weight (kg)	59.4±9.3 (40-78)
Height (cm)	163.7±10.7 (136-180)
Body Mass Index (kg/m²)	22.1±2.2 (17.4-27.0)
American Society of Anesthesiologists class	Class 1=7, Class 2=46, Class 3=26
Mallampati score	Class 1=31, Class 2=35, Class 3=13

Values given as Mean ± SD (Range)

The differences in airway dynamic parameters and inadequacy of ventilation after best-fit positioning with the use of face mask and with the use of nasal mask are shown in Table 3. The results are expressed as mean ± SD. The difference in expiratory tidal volumes with the use of the two masks at best-fit was statistically significant ($P = 0.0017$). Despite the best-fit mask placement, adequate ventilation could not achieved in 19 (24.1%) patients during face mask ventilation and 10 (12.7%) patients during nasal mask ventilation ($P < 0.05$, McNemar's test with Yate's correction). Delivery of <50% of the set tidal volume was achieved in 7 patients (8.9%) with standard face mask and in 2 patients (2.5%) with nasal mask. Rescue airway was needed in these patients.

Despite the best-fit positioning and use of airway adjuncts, lungs of three patients were impossible to ventilate with the standard face mask; however they could be ventilated with a nasal mask, though with inadequate tidal volume. The ventilator bellows could not be kept filled in these patients and repeated use of oxygen flush was needed. No patient, however, experienced SpO_2 below 95% during the study period.

Table 3: Delivered/expired tidal volume and peak airway pressure recorded with use of face mask and nasal mask ventilation

Parameter	Face mask ventilation (n = 79)	Nasal mask ventilation (n = 79)	P
Delivered tidal volume ± SD (mL)	594±93.4	594±93.4	
Expired tidal volume ± SD (mL) at best-fit	498.7±150.7	532.3±118.3	0.0017
Percent difference in delivered and expired tidal volumes at best-fit ± SD (%)	83.1±19.8	89.8±14.4	0.0018
Peak airway pressure at best-fit ± SD (cm H_2O)	9.2±3.9	11.8±3.4	<0.001
Number of patients with inadequate ventilation after best-fit	19	10	
Number of patients with >50% difference in delivered and expired tidal volumes after best-fit	7	2	

SD = Standard deviation

Four patients had difficult tracheal intubation, requiring the use of airway adjuncts. Two of these patients had associated impossible face mask ventilation. Higher airway pressures were achieved with the use of nasal mask. The difference in airway pressures with the use of the two masks was statistically significant.

Discussion

Difficult mask ventilation has been defined as the inability of an unassisted anesthesiologist to prevent or reverse signs of inadequate ventilation during positive pressure mask ventilation.[7] Body mass index >26 kg/m^2, age >55 years, male gender, higher Mallampati airway grading, history of habitual snoring, macroglossia, lack of teeth, lower thyromental distance, neck radiation changes, and presence of beard have been defined as risk factors for DMV[5,7,8] with the presence of two of them indicating high likelihood of DMV.[8] DMV has an incidence of 1.5-7.8% in the general population[7-9] and 16% in edentulous patients.[10] It results in inadequate ventilation characterized by no/reduced perceptible chest movement, oxygen desaturation by pulse oximetry, perception of severe gas flow leak around the mask and an inadequate end tidal carbon dioxide.[8,11,12]

The edentulous patient has less friction between the upper and lower jaw to maintain joint stability, contributing to air leakage around the face mask.[8] Various mechanisms and approaches to overcome this air leak in edentulous patients have been proposed. Nonremoval of dentures at induction of anesthesia helps maintain proper facial support, thus permitting better face mask fit.[8] However, the dentures may accidently be aspirated or swallowed.[10] Our institutional protocol requires removal of the dentures before the patient is sent to the operation theater. Other approaches suggested to achieve a good seal are placement of the caudal end of the mask between the inferior lip and the alveolar ridge; and lower lip face mask placement with two hands grip.[10,13]

In a sedated person in supine position, the soft palate and tongue fall backward due to gravity, and obstruct the pharyngeal airway. Neuromuscular blockade worsens this obstruction. The triple airway maneuver is performed to maintain patency of the upper airway and permit face mask ventilation. Liang *et al.* in their landmark study demonstrated that nasal mask ventilation could be performed maintaining the head in neutral position, without resorting to the triple airway maneuver.[1] They hypothesized that the obstruction of the oropharynx by the tongue facilitates nasal ventilation by reducing the oral leak. In a recent study, the same group of investigators has demonstrated that mouth-to-nose breathing is more effective than mouth-to-mouth breathing in anesthetized, apneic adult subjects without chemical paralysis.[14] We also maintained the head in neutral position to minimize the oral leak without displacing the tongue. We demonstrated higher airway pressures with better air delivery and reduction of leaks with the use of nasal mask in neutral position.

Mask ventilation is often ineffective in edentulous patients, and in some cases almost impossible, because of the lack of facial support. The placement of the inferior end of nasal mask over the upper lip results in the contact of the mask with tissues with maxillary support, which are not deficient in edentulous patients. Mask ventilation is also affected by a number of other variables such as amount of facial adipose tissue, contour of the facial skeleton, and bone resorption in edentulous patients. The lips are approximated by the upward force applied by the fingers, preventing leakage of the breathing gases from the oral cavity.

We found a statistically significant rise in the expired tidal volume and peak airway pressure on changing over to nasal mask ventilation. We also managed to reduce the number of patients with inadequate mask ventilation by around 50% by using nasal mask ventilation.

During our study volume controlled mechanical ventilation was used to achieve a constant, predetermined tidal volume delivery so that loss due to leak could be quantified. We considered the fall in ventilator bellows and a >25% difference between the delivered and the expired tidal volume as indicators of inadequate ventilation. Others have quantified inadequate ventilation as a difference of at least 33% between inspired and expired tidal volumes. The value was selected arbitrarily as per their clinical experience that air leaks of lower magnitude are not usually clinically relevant.[10]

We encountered a higher incidence of inadequate ventilation delivery in edentulous patients with use of face mask, than that reported earlier by Langeron *et al.*,[8] possibly because we used two-hand face mask grip as a rescue method while they used it as a primary method of mask holding. We also used a stricter, quantifiable and a more objective criterion to define inadequate ventilation. Racine *et al.* were able to reduce the incidence of DMV to 16% with lower lip placement of the face mask.[10] However, with the use of nasal mask, we were able to reduce it further. While using face mask, we encountered impossible mask ventilation in 3 patients, but only one was impossible to ventilate when nasal mask was used. We were able to deliver reasonable ventilation in all cases and no patient had oxyhemoglobin desaturation.

The limitations of our study were the inability to achieve adequate blinding of the observer, and that the order of treatments was not randomized. The recordings were made more than 2 min after initiation of mechanical ventilation as per the recommendations of the manufacturer, to stabilize the spirometer sensor function. By this time, the neuromuscular blockade onset should have ensured a near constant upper airway anatomy.

In summary, we found nasal mask ventilation in the neutral position to be more efficient than standard face mask ventilation in edentulous patients. The air leak was lower due to a better contact between the facial tissue and the mask. It is recommended that nasal mask ventilation should be the primary mode of ventilation in edentulous patients.

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Conflict of interest

There are no conflicts of interest.

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