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The incidence and risk factors of difficult mask ventilation

Tulay Sahin Yildiz, Mine Solak, and Kamil Toker

Department of Anesthesiology, School of Medicine, University of Kocaeli, Kocaeli, Turkey

Abstract
Purpose. The ability to ventilate and oxygenate a patient using a bag-mask breathing system may be lifesaving in the case of failure of the initial intubation attempt. In this study, we aimed to determine the incidence of difficult mask ventilation (DMV) and to find preoperative risk factors for this procedure.
Methods. Based on methods used for overcoming some difficulties with bag-mask ventilation (MV), classification has been made into four categories: easy MV, awkward MV, difficult MV, and impossible MV. A univariate analysis was performed to identify potential risk factors predicting DMV, followed by a stepwise forward binary logistic regression, and the odds ratio and 95% confidence interval were calculated.
Results. A total of 576 patients were studied. Incidence of easy MV, awkward MV, and difficult MV were found to be 75.5% ($n = 435$), 16.7% ($n = 96$), and 7.8% ($n = 45$), respectively. Height, weight, age, male gender, increased Mallampati class, history of snoring, lack of teeth, and beard were found to be DMV risk factors ($P < 0.05$). Using a multivariate analysis, Mallampati class 4, male, history of snoring, age, and weight were found to be significantly associated with DMV. Although the incidence of DMV in general was 7.8% ($n = 45$), the incidence of DMV among patients with difficult intubation ($n = 123$) was found to be 15.5% ($n = 19$).
Conclusions. Mallampati class 4, male patients, history of snoring, increasing age, and increasing weight were found to be risk factors for DMV in our study.

Key words Airway · Difficult mask ventilation · Intubation

Introduction

Maintenance of a patent airway is a primary responsibility of anesthesiologists. The difficulty of achieving a patent airway varies with anatomical and other individual factors, and identification of the patient with a difficult airway is vital in planning anesthesia management so that endotracheal intubation and positive pressure ventilation can be achieved safely.

Difficult mask ventilation (DMV) may occur before attempting intubation or may occur after intubation failure [1]. The ability to ventilate and oxygenate a patient using a bag-mask breathing system may be lifesaving in the case of failure of the initial intubation attempt in the decisional algorithms published by the American Society of Anesthesiologists Task Force [2].

Difficulties or failure in managing the airway are the major factors underlying morbidity and mortality related to anesthesia [3]. Patients should be evaluated beforehand to predict the problems while maintaining a difficult airway. In the evaluation of airway in the preoperative period, Mallampati classification [4], mouth opening (interincisor distance) [5], head extension [6], thyromental distance [7], sternomental distance [8], protrusion of mandible [9], tooth morphology [5], the radiographic evaluation of head and neck [6], and history of difficult intubation have been used. However, the most dangerous situation is the case in which intubation is impossible and in which mask ventilation is or becomes inadequate. The prediction of difficult mask ventilation is therefore of vital importance.

In this study, we aimed to determine the incidence of DMV and to find preoperative risk factors for this procedure.

Materials and methods

After approval by the Ethics Committee, 576 patients older than 18 years who were undergoing elective surgery under general anesthesia over an 8-month period (January 2002–August 2002) were studied. Patients with obvious malformations of the airway, patients who

Address correspondence to: T.S. Yildiz, PK: 17, 41900 Derince, Kocaeli, Turkey
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Table 1. The classification of mask ventilation (MV)

Easy MV	There is no any sign of inadequate ventilation
Awkward MV The following maneuvers correct signs of inadequate ventilation	1. Insertion of an oral airway 2. Use of oxygen flush valve one or two times 3. Jaw thrust maneuver
Difficult MV Besides the factors mentioned for awkward MV, the following maneuvers correct signs of inadequate ventilation	1. Use of oxygen flush valve more than twice 2. Perform a two-handed mask ventilation technique 3. Requirement of operator change
Impossible MV	If all aforementioned techniques fail to overcome the signs of inadequate ventilation, the case is accepted as impossible to ventilate

required cricoid pressure for rapid sequence intubation, and patients undergoing regional anesthesia were excluded from the study.

Data were collected by two anesthesiologists during the peroperative period. Demographic properties [age, gender, weight, height, and body mass index (BMI)] and the following information were recorded: lack of teeth, presence of beard, history of snoring, Mallampati classification, thyromental distance, sternomental distance, and mouth opening (in millimeters).

All patients were given midazolam IV $0.03\,mg\,kg^{-1}$ for premedication. A firm pad (7 cm in height) was placed under the patient's occiput and the head was extended on the neck ("sniffing position"). Preoxygenation of each patient during 4 min by mask (Rüsch, Kernen, Germany; size 3, 4, 5) with 100% O_2 was applied. Each patient was routinely monitored during the whole procedure by electrocardiography, noninvasive arterial blood pressure, Sp_{O_2}, and end-tidal carbon dioxide tension (Draeger PM 8040, Löbeck, Germany). The anesthetists managing the airways had information about the results of the preoperative assessments. Difficult mask ventilation (DMV) was defined as the inability of an unassisted anesthesiologist to prevent or reverse signs of inadequate ventilation during positive pressure mask ventilation. Evaluation of mask ventilation was made after induction of anesthesia (using a technique appropriate for the individual patient and clinical circumstances). A neuromuscular blocking agent was given before direct laryngoscopy.

We used some criteria for classification of mask ventilation as in the study of Langeron et al. [10]. Langeron's definition of difficult mask ventilation had been found complex or confusing [11], so we aimed to make a simpler scale by modifying the definition. When we encountered some difficulties with bag-mask ventilation, we recorded signs of inadequate ventilation such as no perceptible chest movement, oxygen desaturation by pulse oximetry, and perception of severe gas flow leak around the mask. Based on methods used for overcoming these problems, classification has been made into four categories: easy (there is no any sign of inadequate ventilation), awkward (mask ventilation was recorded by the anesthetist as difficult and insertion of an oral airway, use of oxygen flush valve one or two times, or jaw thrust maneuvers correcting signs of inadequate ventilation were required), difficult [mask ventilation was recorded by the anesthetist as difficult and besides the factors mentioned for awkward MV, use of oxygen flush valve more than twice, performing a two-handed mask ventilation technique, or operator change (if the skill of the anesthesiologist was not enough, further attempts were made by the staff anesthesiologist) to correct signs of inadequate ventilation], and impossible mask ventilation (if all aforementioned techniques failed to overcome the signs of inadequate ventilation, mask ventilation was accepted as impossible) (Table 1).

Laryngoscopy was performed by an anesthetist using a laryngoscope (Heine, Herrsching, Germany) and Macintosh blade (size 3, 4, or 5), and the best view was obtained (applying external laryngeal pressure where necessary) and noted, using the classification of Cormack and Lehane [12]: I = vocal cords visible; II = only posterior commissure visible; III = only epiglottis visible; IV = none of the foregoing visible. Cormack–Lehane grade I–II was regarded as easy laryngoscopy while grade III–IV was regarded as difficult. We regarded the definition of difficult intubation as intubation of trachea after at least two attempts, using stylet, different laryngoscope blades, and external posterior and cephalad displacement of the larynx or procedures that last longer than 10 min. Intubations were performed by anesthesiology residents with at least 2 years of experience or by the staff anesthesiologist. The same anesthetist who evaluated the mask ventilation also assessed the laryngoscopic view and performed tracheal intubation.

Statistical analysis

Data are means ± SD. Main percentages were provided with their 95% confidence intervals (CIs).

The statistical analysis was performed by the Statistical Program for Social Science (SPSS) 10.00 package program, and P value < 0.05 was considered significant.

One-way analysis of variance (ANOVA) test was carried out to compare means of age, weight, height, body mass index (BMI), mouth opening, thyromental distance, and sternomental distance by groups between easy, awkward, and difficult mask ventilation. If the results of the comparisons were significant, the post hoc test (Tukey method) was used to show the cause. The Pearson χ^2 test was performed for comparing mask ventilation and categoric variables such as gender, Mallampati classification, history of snoring, tooth morphology (normal teeth or lack of teeth), and beard. The Pearson chi-square test was also used to determine the relationship between mask ventilation and laryngoscopy and tracheal intubation.

Mask ventilation was recategorized as easy and difficult (awkward plus difficult), and all variables (weight, male, age, Mallampati score, and history of snoring) were analyzed using a stepwise forward binary logistic regression. The odds ratios and their 95% CIs were calculated.

Results

A total of 576 consecutive adult patients (230 men and 346 women) were studied. Difficulties of mask ventilation were encountered in 141 of 576 (24%). Signs of inadequate ventilation encountered were severe gas flow leak around the mask (66%, $n = 93$), no chest movement (47%, $n = 66$), and oxygen desaturation (23%, $n = 33$). Alternative methods were used to facilitate mask ventilation, such as use of oxygen flush valve more than twice (48%, $n = 68$), necessity to perform a two-handed mask ventilation technique (45%, $n = 63$), and requirement of operator change (19%, $n = 27$). Incidence of mask ventilation according to degree of difficulty was found as follows: easy, 75.5% ($n = 435$); awkward, 16.7% ($n = 96$); and difficult, 7.8% ($n = 45$). There was no case of impossible ventilation.

In the univariate analysis, several risk factors for DMV were identified. Height, weight, age, male, increased Mallampati class, history of snoring, lack of teeth, and presence of beard were significantly different among the three groups (easy, difficult, very difficult) (standard residual was highest in men and in difficult intubation: 4.3) (Table 2). In contrast, BMI, mouth

Table 2. Comparison of patients according to difficulty of mask ventilation (MV)

Factor	Easy MV	Awkward MV	Difficult MV	P value
Height (cm)	163 ± 11	166 ± 11	170 ± 9	$P < 0.001$[b]
Weight (kg)	69 ± 14	76 ± 14	79 ± 15	$P < 0.001$[b]
BMI (kg/m^2)	31 ± 11	28 ± 5	27 ± 6	$P > 0.05$[b]
Age (year)	42 ± 16	50 ± 15	48 ± 12	$P < 0.001$[b]
Gender				
Female	295 (85.3%)	42 (12.1%)	9 (2.6%)	$P < 0.001$[a]
Male	140 (60.9%)	54 (23.5%)	36 (15.7%)	
Mallampati class				
1	261 (80.6%)	45 (13.9%)	18 (5.6%)	
2	112 (78.9%)	19 (13.4%)	11 (7.7%)	$P < 0.001$[a]
3	59 (59.6%)	28 (28.3%)	12 (12.1%)	
4	3 (27.3%)	4 (36.4%)	4 (36.4%)	
Mouth opening (mm)	46 ± 9	46 ± 10	44 ± 10	$P > 0.05$[b]
Tyromental distance (mm)	86 ± 17	85 ± 20	81 ± 17	$P > 0.05$[b]
Sternomental distance (mm)	147 ± 24	147 ± 31	141 ± 23	$P > 0.05$[b]
History of snoring				
No	274 (83.5%)	40 (12.2%)	14 (4.3%)	$P < 0.001$[a]
Yes	161 (64.9%)	56 (22.6%)	31 (12.5%)	
Beard				
No	407 (77.4%)	84 (16.0%)	35 (6.7%)	$P = 0.001$[a]
Yes	28 (56.0%)	12 (24.0%)	10 (20.0%)	
Teeth normal 1	276 (79.5%)	47 (13.5%)	24 (6.9%)	$P = 0.020$[a]
Lack of teeth 2	159 (69.4%)	49 (21.4%)	21 (9.2%)	

Standardized percentages are given according to lines
BMI, body mass index
[a] Pearson χ^2 analysis
[b] One-way ANOVA statistic

Table 3. Identification of risk factors for difficult mask ventilation with multivariate analysis ($n = 576$)

Variables	Odds ratio (Exp β)	Odds ratio (95% CI)	*P* value
Mallampati class 4	9.690	1.252–74.984	$P = 0.03$
Gender (male)	3.539	2.171–5.401	$P < 0.001$
History of snoring	2.182	1.381–3.450	$P = 0.001$
Age	1.031	1.015–1.046	$P < 0.001$
Weight (kg)	1.021	1.005–1.038	$P = 0.012$

Forward stepwise (likelihood ratio) binary logistic regression analysis with simple contrast
Exp β, exponential beta; CI, confidence interval

Table 4. Comparison of intubated patients according to difficulty of mask ventilation (MV)

	Easy MV *n* (%)	Awkward MV *n* (%)	Difficult MV *n* (%)	*P* value
CLs				
Gr I–II	391 (79.1%)	73 (14.8%)	30 (6.1%)	$P < 0.001$[a]
Gr III–IV	44 (53.7%)	23 (28.0%)	15 (18.3%)	
Intubation				
Easy	365 (80.6%)	62 (13.7%)	26 (5.7%)	$P < 0.001$[a]
Difficult	70 (56.9%)	34 (27.6%)	19 (15.5%)	

Standardized percentages are given according to lines
CL, Cormack–Lehane grade (Gr)
[a] Pearson chi-square analysis

opening, thyromental and sternomental distances were not significantly different among the three groups. Incidence of DMV increased in correlation with Mallampati classification. For Mallampati class 4, incidence of awkward and difficult mask ventilation was found to be highest (36.4%). Patients with beard and history of snoring had significantly increased incidence of DMV (20% and 12.5%, respectively).

In the multivariate analysis, the following criteria were found to be significantly associated with DMV: Mallampati class 4, male patients, history of snoring, age, and weight (Table 3). There was a significant relationship between mask ventilation and laryngoscopic view classified according to Cormack and Lehane. Mask ventilation was observed to become more difficult in correlation with Cormack and Lehane classification ($P < 0.001$; Table 4). There was also a significant relationship between the difficulty of tracheal intubation and mask ventilation ($P < 0.001$; Table 4). Although the incidence of difficult mask ventilation was 7.8%, the incidence of difficult mask ventilation in difficult intubated patients was found to be 15.5%.

Discussion

When failed intubation is associated with difficult or impossible mask ventilation (cannot intubate–cannot ventilate), establishing ventilation, not tracheal intubation, becomes the primary concern. In cannot ventilate–cannot intubate situations, Laryngeal Mask Airway (LMA), a Combitube, transtracheal jet ventilation, or cricothyrotomy can be used for establishing ventilation. Incidence of cannot ventilate–cannot intubate has been estimated to range between 0.01 and 2.0 of 10000 patients [13].

Incidence of DMV is related to its definition and has been rarely assessed in studies related to airway management [14–17]. The incidence of DMV has been reported in prospective studies by Asai et al. (1.4%) [17], Rose and Cohen (0.9%) [14], and El-Ganzouri et al. (0.07%) [15]. In contrast, in a retrospective study of 2000 incident reports during anesthesia, DMV incidence reached 15% when a difficult intubation occurred [16]. El-Ganzouri et al. [15] defined difficult ventilation as inability to obtain chest excursion sufficient to maintain a clinically acceptable capnogram waveform despite optimal head and neck positioning and use of muscle paralysis, use of an oral airway, and optimal application of a face mask by anesthesia personnel. Parmet et al. [18] determined that difficult ventilation/difficult intubation can occur in 1:1000 anesthetics, an incidence much greater than previously reported (0.01–2:10000) [13]. We defined DMV as the inability of an unassisted anesthesiologist to prevent or reverse signs of inadequate ventilation during positive pressure mask

ventilation. With this definition, we found the incidence of DMV to be 7.8%.

Difficult mask ventilation can occur more frequently in cases of difficult intubation [14–16]. Langeron et al. [10] observed a significantly higher incidence of difficult intubation in patients with DMV (30%) compared with those without DMV (8%). In our study, the incidence of DMV among difficult intubated patients was found to be 15.5%.

Although there is a strong relationship between increased Mallampati scores and difficult intubation, the relationship between Mallampati classification and mask ventilation is not clear. We found Mallampati (class 4) as a risk factor that has the highest odds ratio (9.69) for DMV. It can be considered that the reasons for the increased Mallampati score could be the length of the soft palate and lack of enough distance between the floor of the mouth and soft palate. Also, there is general agreement that face mask ventilation is often difficult in morbidly obese patients [10]. Obese patients often have an excess of pharyngeal tissue deposited mainly in the pharyngeal lateral walls. Theoretically, the larger the amount of pharyngeal tissue, the greater modified Mallampati and Cormack and Lehane scores [19]. We found the odds ratio to be 1.021 for weight. Weight loss can be recommended before an operation to prevent DMV, at least for some patients. In our study, degree of mask ventilation difficulty was found to be increased in correlation with age (odds ratio: 1.031); this could be a result of increased pharyngeal resistance to airflow in older patients, especially in men [20].

In conclusion, it should be kept in mind that risk factors for DMV in clinical practice are Mallampati class 4, being male, and increased age and weight.

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