ASSESSMENT OF STANDARD ANTHROPOMETRIC AIRWAY CHARACTERISTICS RELEVANT FOR AIRWAY MANAGEMENT OF PATIENTS WITH OBSTRUCTIVE SLEEP APNEA SYNDROME DURING SLEEP BREATHING DISORDER SURGERY: A RETROSPECTIVE, SINGLE CENTER STUDY

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SUMMARY – The aim of this study was to explore standard anthropometric airway characteristics of patients with obstructive sleep apnea syndrome (OSAS) and determine the incidence and risk factors for difficult airway management. Final analysis included 91 patients with polysomnography-verified diagnosis of OSAS who underwent sleep breathing disorder surgery under general anesthesia with direct laryngoscopy oroendotracheal intubation. The incidence of difficult manual mask ventilation during anesthesia induction, difficult intubation and immediate postextubation respiratory complications was 17.6%, 7.7% and 7.7%, respectively. Compared to patients without difficult manual mask ventilation, the group of OSAS patients with difficult manual mask ventilation had a higher rate of body mass index (BMI) ≥25 kgm-2 (p=0.010), Mallampati score ≥3 (p=0.024) and Cormack-Lehane score ≥3 (p=0.002). The OSAS patients with difficult intubation had more Cormack-Lehane score ≥3 (p=0.002) in comparison to those without difficult intubation. Our study demonstrated that manual mask ventilation during anesthesia induction was the most troublesome airway management task in OSAS patients during sleep breathing disorder surgery. Cormack-Lehane score was a relevant determinator of difficult mask ventilation and difficult intubation, while Mallampati score and BMI were relevant determinators only for difficult manual mask ventilation.

Key words: *Airway management; Sleep apnea, obstructive; Intubation; Ventilation; Anesthesia, general*

Introduction

Airway management during general anesthesia for undergoing surgery is a continuous and particularly important process that includes different airway techniques for different airway management stag-

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es. The most critical parts of airway management are mask ventilation and endotracheal intubation during induction to general anesthesia and extubation at the end of surgery. Any airway mismanagement may have devastating consequences as it directly compromises essential ventilation and oxygenation and may cause hypoxia and irreversible brain damage in patients[1,2].

Patients with obstructive sleep apnea syndrome (OSAS) show a high-risk tendency towards difficult airway management, particularly difficult intubation during induction to general anesthesia[3]. It is reported that the incidence of difficult intubation in OSAS patients is twice to five times the incidence in non-OSAS patients[4,5]. Difficult face mask ventilation is reported to be twice as often in OSAS patients[5]. However, no difference has been reported in the use of supraglottic airway devices[5].

Different independent anthropometric measurements of body and airway have relevance for predicting possible difficulties with airway management. Difficult ventilation can be expected in patients with age >57, body mass index (BMI) $\geq$30 kgm^{-2}, Mallampati classification 3 or 4, and thyromental distance <6 cm[6]. Difficult ventilation with difficult intubation has been associated with BMI $\geq$30 kgm^{-2}, severely limited jaw protrusion, thick/obese neck anatomy and sleep apnea[6]. A recent prospective, observational study addressed BMI, Cormack-Lehane score and Mallampati score, which were significantly higher in the group of patients with airway complications during induction to general anesthesia than those with no complications[7]. It seems that anthropometric measures influence less early postoperative airway complications, as so far only BMI[8] and age extremes[9], particularly older age[10], have been described as independent predictors of unanticipated early postoperative intubation.

The aim of this study was to present our experience in managing the airway during sleep breathing disorder surgery in OSAS patients and to determine the incidence and anthropometric risk factors for difficult airway management.

Patients and Methods

After obtaining approval from the Sveti Duh University Hospital Ethics Committee (No. 01-3995, November 19, 2013), we retrospectively reviewed anesthetic medical charts of 152 patients with polysom-nography-verified diagnosis of OSAS who underwent sleep breathing disorder surgery at the Department of Otorhinolaryngology and Head and Neck Surgery, Sveti Duh University Hospital, Zagreb, in the period from January 2009 until the end of August 2013. Sleep breathing disorder surgery included uvulopalatopharyngoplasty and/or nasal septoplasty under general anesthesia with direct laryngoscopy oroendotracheal intubation.

From the anesthetic medical charts, we collected and analyzed patient basic, preoperative, intraoperative and early postoperative data relevant to airway management. The basic patient data collected were gender, age, American Society of Anesthesiologists (ASA) classification of physical status score, body weight, and body height. The ASA physical status score includes six categories: I otherwise healthy patient undergoing surgery; II patient with mild systemic disease; III patient with severe but compensated systemic disease; IV patient with decompensated systemic disease; V moribund patient; and VI donor[11]. BMI was calculated according to the standard equation: patient's weight in kilograms divided by square of height in meters (kg/m^{-2})[12]. The collected preoperative data relevant to patient airway management included modified Mallampati score[13]. Modified Mallampati score describes three anatomic structures of the oropharynx (uvula, palate and tonsils) when the patient opens the month in sitting position, extrudes the tongue and says the vowel 'A'. It includes 4 categories: 1) uvula, tonsils, and palate visible; 2) tonsils and palate visible, uvula not visible; 3) only palate visible, tonsils and uvula not visible; and 4) none of the three structures (uvula, tonsils and palate) visible. The following intraoperative data were collected: Cormack-Lehane score, type of laryngoscope (Macintosh *vs.* McCoy), type of endotracheal tube (simple polyvinyl *vs.* reinforced), duration of anesthesia in minutes, and duration of surgery in minutes. Cormack-Lehane score describes visualization of the laryngeal inlet (glottis)[14]. It includes four categories: 1) whole glottis visible; 2) epiglottis partially obscures full visualization of the glottis; 3) only epiglottis visible, glottis not visible; and 4) neither epiglottis nor glottis visible. The data collected in early postoperative period were postextubation respiratory complications (bronchospasm, mild or severe laryngospasm). Medical charts of 61 patients were partially insufficient for the required data, so final analysis included 91 patients (Table 1).

Table 1. Preoperative and intraoperative OSAS patient characteristics (N=91)

Variable	n (%)
Male gender	61 (67%)
Age[a], years	48 [range 38-54]
ASA I/II/III	9 (9.9%)/74 (81.3%)/8 (8.8%)
BMI ≥25 kgm^{-2}	70 (76.9%)
BMI 25-29.9 kgm^{-2}	23 (25.3%)
BMI 30-34.9 kgm^{-2}	30 (33%)
BMI 35-39.9 kgm^{-2}	14 (15.4%)
BMI ≥40 kgm^{-2}	3 (3.3%)
Mallampati 1/2/3/4	11 (12.7%)/46 (50.5%)/27 (29.7%)/7 (7.7%)
Cormack-Lehane 1/2/3/4	14 (15.4%)/51 (56%)/25 (27.5%)/1 (1.1%)
Macintosh/McCoy laryngoscope	83 (91.2%)/8 (8.8%)
Reinforced tube	66 (72.5%)
Pressure/volume-controlled ventilation	34 (37.4%)/57 (62.6%)
Duration of surgery/anesthesia[a], minutes	60 [50-80]/80 [65-100]

[a] data not normally distributed presented as median (25th percentile to 75th percentile); ASA = American Society of Anesthesiologists score; BMI = body mass index; OSAS = obstructive sleep apnea syndrome

Table 2. Preoperative, intraoperative, and early postoperative characteristics of OSAS patients with and without difficult manual ventilation during anesthesia induction (N=91)

Variable	OSAS with difficult manual ventilation (n=16)	OSAS without difficult manual ventilation (n=75)	p value
Male gender	12 (75%)	49 (65.3%)	0.332
Age[a], years	53.5 [42.75-60.25]	47 [37-54]	0.5427
BMI ≥25 kgm^{-2}	16 (100%)	54 (72%)	0.010
Mallampati ≥2	14 (87.5%)	66 (88%)	0.616
Mallampati ≥3	10 (62.5%)	24 (32%)	0.024
Mallampati ≥4	3 (18.8%)	4 (5.3%)	0.101
Cormack-Lehane ≥2	16 (100%)	59 (78.7%)	0.052
Cormack-Lehane ≥3	10 (62.5%)	16 (21.3%)	0.002
Cormack-Lehane ≥4	1 (6.3%)	0	0.176
Difficult intubation	3 (18.8%)	4 (5.3%)	0.101
Macintosh/McCoy laryngoscope	13 (81.3%)/3 (18.8%)	70 (93.3%)/5 (6.7%)	0.143
Reinforced tube	12 (75%)	54 (72%)	0.538
Pressure/volume-controlled ventilation	7 (43.8%)/9 (56.3%)	27 (36%)/48 (46%)	0.378
Postextubation respiratory complications	2 (12.5%)	5 (6.7%)	0.357
Duration of surgery[a], minutes	60 [46.25-80]	60 [50-80]	0.241
Duration of anesthesia[a], minutes	87.5 [55.5-100]	80 [65-95]	0.514

The percentages reported relate to total n in column heading; [a] data not normally distributed presented as median (25th percentile to 75th percentile); BMI = body mass index; OSAS = obstructive sleep apnea syndrome

For the purpose of this study, we used the following definitions; so, difficult mask ventilation means that it is not possible to provide adequate ventilation because of one or more of the following problems: inadequate mask seal, excessive gas leak, or excessive resistance to the ingress or egress of gas; difficult intubation means that tracheal intubation requires multiple attempts[15].

Statistical methods

Data were first processed by descriptive methods and the results were presented tabularly and graphically. Categorical data (gender, ASA, BMI, Mallampati score, Cormack-Lehane score, type of laryngoscope, type of tube, type of mechanical ventilation, postextubation respiratory complications) were expressed in absolute numbers and corresponding percentages. Distribution of quantitative variables was determined by the Kolmogorov-Smirnov test of normality. Since quantitative data did not show normal distribution

(age, duration of surgery, duration of anesthesia), they were presented as median ± interquartile range. The χ^2-test was used to compare categorical variables between groups with difficulties during manual mask ventilation or intubation or postextubation. The Mann-Whitney U test was used to compare quantitative variables between groups with difficulties during manual mask ventilation or intubation or postextubation. The results were interpreted at the 5% significance level. We used IBM® SPSS software for Windows, version 19.0 (IBM SPSS Inc., Chicago, IL, USA) statistical program.

Results

Table 1 depicts the incidence of difficult manual ventilation, difficult intubation and postextubation difficulties. The incidence of difficult manual mask ventilation during anesthesia induction was more

Table 3. Preoperative, intraoperative, and early postoperative characteristics of OSAS patients with and without difficult intubation (N=91)

Variable	OSAS with difficult intubation (n=7)	OSAS without difficult intubation (n=84)	p value
Male gender	6 (85.7%)	55 (65.5%)	0.260
Age[a], years	50 [38-53]	48 [37.25-54.75]	0.499
BMI ≥25 kgm^{-2}	7 (100%)	63 (75%)	0.148
Mallampati ≥2	6 (85.7%)	74 (88.1)	0.608
Mallampati ≥3	5 (71.4%)	29 (34.5%)	0.065
Mallampati ≥4	1 (14.3%)	6 (7.1%)	0.440
Cormack-Lehane ≥2	7 (100%)	70 (83.3%)	0.297
Cormack-Lehane ≥3	6 (85.7%)	20 (23.8%)	0.002
Cormack-Lehane ≥4	0	1 (1.2%)	0.923
Difficult ventilation	3 (42.9%)	13 (15.5%)	0.101
Macintosh/McCoy laryngoscope	4 (57.1%)/3 (42.9%)	79 (94%)/5 (6%)	0.014
Reinforced tube	4 (57.1%)	62 (73.8%)	0.292
Pressure/volume-controlled ventilation	2 (28.6%)/5 (71.4%)	32 (38.1%)/52 (61.9%)	0.475
Postextubation respiratory complications	1 (14.3%)	6 (7.1%)	0.440
Duration of surgery[a], minutes	65 [50-80]	60 [46.25-80]	0.667
Duration of anesthesia[a], minutes	80 [80-100]	80 [65-98.75]	0.555

The percentages reported relate to total n in column heading; [a] data not normally distributed presented as median (25th percentile to 75th percentile); BMI = body mass index; OSAS = obstructive sleep apnea syndrome

than twice as high as the incidence of difficult intubation. There was no case of impossible intubation or any record of difficult maintaining the tube *in situ* during surgery. However, immediate postextubation respiratory complications were recorded in seven cases, i.e., two cases of mild laryngospasm, three cases of severe laryngospasm, and two cases of bronchospasm. Two cases of severe laryngospasm required reintubation.

Compared to patients without difficult manual mask ventilation, the group of OSAS patients with difficult manual mask ventilation had a higher rate of BMI ≥25 kg/m^{-2} (p=0.010), Mallampati score ≥3 (p=0.024) and Cormack-Lehane score ≥3 (p=0.002) (Table 2). OSAS patients with difficult intubation had a higher rate of Cormack-Lehane ≥3 (p=0.002) in comparison to those without difficult intubation (Table 3). There was no difference between OSAS patients with and without postextubation respiratory

complications according to gender, age, BMI, Mallampati score and Cormack-Lehane score, type of laryngoscope and tube, or intraoperative ventilation mode (Table 4).

Discussion

The aim of this study was to explore the incidence of difficult airway management and anthropometric upper airway characteristics of OSAS patients. Our results confirmed that OSAS patients had significant difficulties in airway management, particularly during manual ventilation, intubation, and postextubation period. However, our findings correlate partially with literature data. In 2009, Kheterpal *et al.* highlighted OSAS as a predictor of difficult mask ventilation[16]. OSAS was repeatedly described as a risk predictor of a combined clinical situation of difficult ventilation and difficult tracheal intubation[17]. However, Leong *et al.*

Table 4. Preoperative, intraoperative, and early postoperative characteristics of OSAS patients with and without postextubation respiratory complications (N=91)

Risk factor	OSAS with postextubation respiratory complications (n=7)	OSAS without postextubation respiratory complications (n=84)	p value
Male gender	6 (85.7%)	55 (65.5%)	0.260
Age[a], years	43 [38-57]	48.5 [37.25-54]	0.563
BMI ≥25 kgm^{-2}	7 (100%)	63 (75%)	0.148
Mallampati ≥2	5 (71.4%)	75 (89.3%)	0.194
Mallampati ≥3	2 (28.6%)	32 (38.1%)	0.475
Mallampati ≥4	1 (14.3%)	6 (7.1%)	0.440
Cormack-Lehane ≥2	6 (85.7%)	71 (84.5%)	0.707
Cormack-Lehane ≥3	4 (57.1%)	22 (26.2)	0.100
Cormack-Lehane ≥4	0	1 (1.2%)	0.923
Difficult ventilation	2 (28.6%)	14 (16.7%)	0.357
Difficult intubation	1 (14.3%)	6 (7.1%)	0.440
Macintosh/McCoy laryngoscope	5 (71.4%)/2 (28.6%)	78 (92.9%)/6(7.1%)	0.114
Reinforced tube	6 (85.7%)	60 (71.4%)	0.377
Pressure/volume-controlled ventilation	2 (28.6%)/5 (71.4%)	32 (38.1%)/52 (61.9%)	0.475
Duration of surgery[a], minutes	40 [35-70]	60 [50-80]	0.133
Duration of anesthesia[a], minutes	80 [60-100]	80 [66.25-100]	0.751

The percentages reported relate to total n in column heading; [a] data not normally distributed presented as median (25th percentile to 75th percentile); BMI = body mass index; OSAS = obstructive sleep apnea syndrome

report on the incidence of difficult mask ventilation in OSAS patients as low as 2.5%[5]. Our results show the highest incidence of difficult mask ventilation compared to intubation or postextubation airway difficulties, and almost seven times higher compared to the findings reported by Leong *et al.* Obviously, this was our weak point. The incidence of difficult intubation in OSAS patients in the literature varies between 14.5% and 24%[3,5,18], with a decreasing trend that may result from better preoperative and intraoperative airway management. However, these figures are almost two to three times as high as our results. This might be explained with our specific local organization as we did not have any advanced airway technology except for McCoy blade laryngoscope during the study period, but we had a dedicated ear-nose-throat (ENT) anesthesiologist experienced in specific ENT surgery. It is well recognized that dedicated airway team is desirable for advanced airway management in severe pediatric OSAS and craniofacial anomalies[19]. We believe that dedication and experience of our airway management team influenced the low rate of difficult intubations. Similar to our results, Riley *et al.* report that all tubes were removed with the patient awake in the operating room with two transient episodes of airway obstruction[18].

The upper airway of OSAS patients is indigenously collapsible and consequently difficult to manage. The OSAS patients, by definition, have inadequate motor tone of the tongue and/or airway dilator muscles, which causes partial or complete obstruction of the upper airway during sleep[20]. Adding any sedative or anesthetic drugs reduces the upper airway patency additionally, making these patients more challengeable for airway management[21]. In addition, similar anatomic and anthropometric characteristics of difficult airway have been described in OSAS patients. In 1998, Hiremaths *et al.* showed in 30 patients that OSAS patients and difficult airway patients had some characteristics in common but also some specific anatomical characteristics. Similarities were as follows: greater Mallampati score, greater anterior mandibular length, and smaller mandibular and cervical angles[22]. In our study, we used Mallampati score only because it is part of the routine preoperative assessment in our hospital and is included in every anesthetic medical chart. Our study showed that OSAS patients with Mallampati ≥3 had difficult mask ventilation.

Hiremath *et al.* also emphasized that OSAS patients, in contrast to difficult airway patients, had increased neck circumference, larger tongue size, larger craniocervical angle, smaller neck extension, shorter mandibular ramus length, and shorter atlanto-occipital distance[22]. Moreover, Riley *et al.* found positive correlation of neck circumference (>45.6 cm) and skeletal deficiency (Sella-Nasion-Point B <75 degrees) with difficult intubation[18].

In addition to anatomical features, certain clinical indices have been shown to be useful in identifying the risk of difficult tracheal intubation in OSAS. The apnea-hypoxia index (AHI) ≥40[4] has been identified as a factor in the prevalence difference between the OSAS group with difficult tracheal intubation and control group of OSAS patients with mild tracheal intubation. Lee *et al.* analyzed 115 OSAS men undergoing palate muscle resection to determine risk factors for difficult tracheal intubation[23]. Factors significantly associated with difficult tracheal intubation were high AHI ≥50 and neck circumference ≥40 cm[23]. Interestingly, no significant correlation of difficult tracheal intubation with weight and BMI in OSAS patients has been described[23]. In our study, we were focused on anthropometric characteristics only and found that greater BMI impaired mask ventilation in OSAS patients.

Newer cephalometric methods revert the focus of prediction of difficult tracheal intubation in OSAS patients to basic anatomical features rather than to derived indices. Zhou *et al.* have recently published a cephalometric radiological observation in patients under general anesthesia showing that OSAS patients who had a higher laryngoscopic Cormack-Lehane score, which defined difficult tracheal intubation, had a significantly longer length of tongue and soft palate overlap, greater tongue, and hyoid-mental distance[24]. Similar, we found that higher Cormack-Lehane score had an impact on difficult intubation, but additionally we found that OSAS patients with higher Cormack-Lehane score had difficult mask ventilation. In the sequence of clinical airway manipulation, the patient is first ventilated manually and then follows direct laryngoscopy, meaning that in clinical thinking Cormack-Lehane is a consequence rather than prediction of difficult mask ventilation. However, having in mind that new VL techniques allow for indirect glottic laryngoscopy and identification of Cormack-Lehane score even in awake patients[25], knowing Cormack-Le-

hane score still can be clinically applicable to predict difficult mask ventilation too.

Our study demonstrated that OSAS patients presented difficulties in managing airway during sleep breathing disorder surgery and revealed that manual mask ventilation during anesthesia induction was the most troublesome task. We recommend high vigilance for difficult manual mask ventilation in overweight OSAS patients and those with Mallampati score ≥3 and Cormack-Lehane score ≥3. In addition, we recommend high vigilance for difficult intubation in the presence of Cormack-Lehane score ≥3.

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Sažetak

PROCJENA STANDARDNIH ANTROPOMETRIJSKIH OBILJEŽJA DIŠNOGA PUTA U BOLESNIKA SA SINDROMOM OPSTRUKCIJSKE APNEJE PRI SPAVANJU ZA KIRURGIJU POREMEĆAJA DISANJA PRI SPAVANJU: RETROSPEKTIVNO ISTRAŽIVANJE U JEDNOM KLINIČKOM CENTRU

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Cilj ovoga istraživanja bio je odrediti standardna antropometrijska obilježja dišnoga puta u bolesnika sa sindromom opstruktivne apneje pri spavanju (OSAS), utvrditi incidenciju i rizične čimbenike zbrinjavanja otežanoga dišnog puta. Završna analiza je uključivala 91 bolesnika s potvrđenom dijagnozom OSAS polisomnografijom, koji su bili podvrgnuti kirurškom zahvata poremećaja disanja kod spavanja u općoj anesteziji s oroendotrahealnom intubacijom. Učestalost otežane manualne ventilacije maskom tijekom uvoda u anesteziju, otežane intubacije i neposredne poslijeekstubacijeke komplikacije su bile slijedom 17,6%, 7,7% i 7,7%. U usporedbi s bolesnicima bez otežane manualne ventilacije maskom skupina bolesnika s OSAS i otežanom manualnom ventilacijom na masku je češće imala indeks tjelesne mase (ITM) ≥25 kgm^{-2} (p=0,010), Mallampatijevu ocjenu ≥3 (p=0,024) i Cormack- Lehaneovu ocjenu ≥3 (p=0,002). Bolesnici s OSAS i otežanom intubacijom su češće imali Cormack-Lehaneovu ocjenu ≥3 (p=0,002) u usporedbi s onima bez otežane intubacije. Naše istraživanje je pokazalo da je najproblematičniji zadatak zbrinjavanja dišnoga puta u bolesnika podvrgnutih kirurgiji poremećaja disanja kod spavanja manualna ventilacija na masku tijekom uvoda u anesteziju. Cormack-Lehaneova ocjena je relevantni rizični čimbenik za otežanu ventilaciju na masku i otežanu intubaciju, dok su Mallampatijeva ocjena i ITM bili relevantni rizični čimbenici samo za otežanu ventilaciju na masku.

Ključne riječi: *Zbrinjavanje dišnog puta; Apneja pri spavanju, opstruktivna; Intubacija; Ventilacija; Anestezija, opća*