Predictors of difficulty in intubation in patients with obstructive sleep apnoea

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ABSTRACT

Objective: To evaluate predictors of difficult intubation in patients with obstructive sleep apnoea (OSA).

Methodology: Prospective series of 405 OSA patients (350 males/55 females) who had upper airway surgery. Procedures included functional endoscopic sinus surgery, septoplasty, turbinate reduction, palate/tonsil surgery, and/or tongue base surgery. Intubation difficulty (ID) was assessed using Mallampati grade, Laryngoscopic grade (Cormack and Lehane), and clinical parameters including BMI, neck circumference, thyromental distance, jaw adequacy, neck movements and glidescope grading.

Results: Mean age was 41.6 years old; mean BMI 26.6; mean neck circumference 44.5cm; mean Apnea Hypopnea Index (AHI) was 25.0; and mean LSAT 82%. The various laryngeal grades (based on Cormack and Lehane), grade 1 - 53 patients (12.9%), grade 2A - 127 patients (31.0%), grade 2B - 125 patients (30.5%), grade 3 - 93 patients (22.7%) and grade 4 - seven patients (1.7%); hence, 24.4% had difficulties in intubation. Parameters that adversely affected intubation were, age of the patient, opening of mouth, retrognathia, overbite, overjet, limited neck extension, thyromental distance, Mallampati grade, and macroglossia ($p<0.001$). Body mass index (BMI) ($p=0.087$), neck circumference ($p=0.645$), neck aches ($p=0.728$), jaw aches ($p=0.417$), tonsil size ($p=0.048$), and AHI ($p=0.047$) had poor correlation with intubation. BMI-adjusted for Asians and Caucasians, showed that Asians were more likely to have difficulties in intubation (adjusted OR = 4.6 (95%Confidence Interval: 1.05 to 20.06) ($p=0.043$), compared to the Caucasian group.

Conclusion: This study illustrates that difficult intubation can be predicted pre-surgery in order to avert any anaesthetic morbidity.

KEY WORDS:
Intubation, Sleep Apnoea, Anaesthesia
Level of evidence: IV

INTRODUCTION

Obstructive sleep apnoea (OSA) is a common illness affecting 9% of the middle age men in North America and 3% of the women.[1] It is a condition that affects the cardio-vascular, psychomotor and neurological systems of the patients.[2-6] Young et al., studied 602 state employees who attended overnight polysomnography and found that the incidence of Sleep Disordered Breathing (SDB) was 24% in men and 9% in women.[7] It is estimated that up to 93% of females and 82% of males have moderate to severe OSA remain undiagnosed.[8] OSA occurs due to the collapsibility of the upper airway during sleep. When subjected to negative pressure within the upper airway, these collapsible soft tissues may lead to complete or partial obstruction of the upper airway, with associated increased sympathetic activity, increased blood pressure, and hypoxaemia resulting in increased oxidative stress in the body and increased catabolic state. Collapse of the upper airway is often multilevel; at the level of the palate/velopharynx, the base of tongue, and/or the lateral pharyngeal walls. Many of these areas of collapse should be addressed, if the aim is to relieve the apnoeas in the patient. Hence, these OSA patients are a unique group of patients with an intrinsically narrow airway (which collapses during sleep), resulting in hypoxemia (which makes them at higher risk to heart related diseases, cardiovascular accidents,[2-6] and medically a peri-operative challenge for both the surgeons and the anaesthesiologists. The Sleep Heart Health Study and the Wisconsin Sleep Cohort have demonstrated a strong link between OSA and hypertension.[9,10] This is believed to be due to sleep fragmentation, nocturnal hypoxemia and increased sympathetic tone.[11] This increased sympathetic tone is manifested not only during the nocturnal hypoxic events but also during the day as systemic hypertension. There is strong evidence of the association between OSA and cardiovascular diseases.[10] The physiological changes that are the result of recurrent apnoeas and hypoxemia can cause acute thrombotic events, atherosclerosis, and cerebrovascular accidents. There is a higher mortality rate among patients with cardiovascular disease who also have OSA.[9-11]

This prospective study aims to illustrate and identify the predictors of difficulty in intubation in OSA patients with narrow upper airways, so as to prepare the physicians, patients and anaesthesiologists, to circumvent any airway difficulties and potential airway mishaps leading to morbidity and/or mortality of patients.

This article was accepted: 2 January 2019
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METHODS AND MATERIALS

This was a non-randomised prospective clinical study of 405 consecutively collected patients with OSA. Patients were evaluated in the snoring/sleep subspecialty clinic. The inclusion criteria were age >18 years, all BMI categories, all tonsil size grades, all Friedman clinical stages, retropalatal and/or retro-glossal obstruction, no previous oro-nasal or upper airway/jaw surgical procedures and all grades of Apnea Hyponea Index (AHI). The study protocol and methodology was reviewed and approved by the hospital Ethics Committee Review Board (ASC/01/02-2017).

All patients underwent a comprehensive clinical assessment including a thorough physical examination, blood pressure readings, naso-endoscopy, and an overnight polysomnography (PSG) (in the form of the Watch PAT 200). Patients completed the Epworth Sleepiness Scale (ESS) and a visual analogue scale (VAS) for snoring before and after surgery. Their respective sleep partners completed a similar scale for snoring. Physical examination included height, weight, neck circumference, body-mass index (BMI), and blood pressure, and an endoscopic assessment of the nasal cavity, posterior nasal space, oropharyngeal area, soft palatal redundancy, uvula size and thickness, tonsillar size, Mallampati grade and Friedman grade. Patients who complained of nasal obstruction and/or persistent runny nose with clinical endoscopic findings of either turbinate hypertrophy, septal deviation and/or nasal polyps were offered nasal surgery at the same sitting as the palate/tongue surgery. The nasal surgery included functional endoscopic sinus surgery, septoplasty and/or bilateral radiofrequency turbinate reduction. Patients with retro-palatal collapse underwent palatal surgery (either expansion sphincter pharyngoplasty, anterior palatoplasty, uvulopalatopharyngoplasty with or without tonsillectomy/tonsillotomy) based on upper airway evaluation. Tongue surgery included tongue base radiofrequency volumetric reduction, tongue base coblation and/or tongue suspension procedures. All patients were given dietary advice regarding daily calorie counts and intake. There were no drop-outs or withdrawals in this study.

Pre-operatively, all the patients were re-assessed by the anaesthesiologist again separately, and the data was recorded independently by the anaesthesiologist and the registered nurse. At the time of induction, during mask ventilation, the information related to the ventilation and intubation were collected by an anaesthesiologist. The parameters used for assessing difficult intubation were; age, snoring history, obstructive sleep apnea, dental and mandibular abnormalities, macroglossia, Mallampatti, thyromental distance, teeth position and mouth opening (based on anaesthesiologist's own fingers, i.e., 2, 2.5, 3 etc. finger breath, FB) were collected during the preoperative visit or just before the surgery. Cormack and Lehane grade of laryngoscopy view was assessed during laryngoscopy. The head and neck of patients were placed in a sniffing position with an appropriately sized head ring so that the head of the patient remains in neutral position to improve laryngoscopy with the Macintosh Laryngoscope blade and intubation outcome. Pre-oxygenation was given to each patient for three minutes prior to induction of anaesthesia. All patients were routinely monitored intra-operatively with electro-cardiography (ECG), electro-encephalography (EEG via Bispectral Index (BIS) monitor), neuromuscular transmission (NMT) monitor, blood pressure, oxygen saturation (SpO2), and end-tidal carbon dioxide. Should intubation be difficult after the best attempt under direct laryngoscopy, the Glidescope video laryngoscope is used to secure the endotracheal intubation. After intubation with muscle relaxation, the correct positioning of the endotracheal tube was confirmed by bilateral auscultation of lungs and presence of end-tidal.

Based on Cormack and Lehane grade of laryngoscopy view was assessed during intubation laryngoscopy, we grouped the findings into two groups; group 1 (easy intubation) – grade 1, 2A and 2B; and group 2 (difficult intubation) – grade 3 and 4.

We assessed the different various clinical parameters recorded pre-operatively and intra-operatively and analysed it, with the primary focus on the predictive factors that might suggest a difficult intubation in a patient with OSA, so as to prepare the physicians, the patients and the anaesthesiologists, in order to circumvent any airway difficulties and potential airway mishaps leading to patient morbidity and/or mortality.

Statistical Analysis

All analyses were performed using SPSS24.0 with statistical significance set at $p<0.05$. Focus on the differences in ethnicity on the difficulty of intubation was discussed.

RESULTS

A total of 405 patients were recruited consecutively. There were 377 Asians patients and 28 Caucasian patients, 350 males and 55 females. The mean age was 41.6 years old (18-66 years), mean BMI 26.6 (18.9-37.6), mean neck circumference 44.5cm (37-60cm), mean AHI was 25.0 (7.2-93.2), mean RDI 30.0 (8.4-93.2), mean lowest oxygen saturation (LSAT) 82% (61-91%). There was only a total of 15 cases (3.7%) that were documented to have difficult mask ventilation.

In terms of distribution of the various laryngeal grades (based on Cormack and Lehane), grade 1 - 53 patients (12.9%); grade 2A - 127 patients (31.0%); grade 2B - 125 patients (30.5%); grade 3 - 93 patients (22.7%); and grade 4 - seven patients (1.7%). Based on these findings, 24.4% (100 out of 405) for patients had a difficult intubation with grade 3 and 4 (Table I).

Correlating the clinical parameters with the 405 patients who underwent intubation and upper airway surgery, only the following parameters showed to have statistical significance. These parameters (that proved to adversely affect intubation) include, age, mouth opening (finger breaths), retrognathia (small jaw), overbite, overjet (protruding teeth), limited neck extension, thyromental distance, Mallampati grade, and macroglossia (all parameters at $p<0.001$). While these parameters did not show any or had poor correlation in terms of difficulty of intubation, BMI ($p=0.087$), neck circumference

Table I: Laryngeal grading

Cormack + Lehane Grade	n (405)	%	%
1	53	12.9	75.6
2A	127	31.0	
2B	125	30.5	
3	93	22.7	24.4
4	7	1.7	

Table II: Clinical parameter correlation with laryngeal grade difficulty

	P-value	Statistical Significance
Age	P<0.001	Y
BMI	P=0.087	N
Neck Circumference	P=0.645	N
Neck Aches	P=0.728	N
Jaw Aches	P=0.417	N
Mouth opening finger breaths	P<0.001	Y
Retrognathia	P<0.001	Y
Overbite	P<0.001	Y
Overjet	P<0.001	Y
Limited Neck Extension	P<0.001	Y
Thyromental Distance	P<0.001	Y
Tonsil size	P=0.048	N
Mallampati	P<0.001	Y
Macroglossia	P<0.001	Y
AHI	P=0.047	N
LSAT	P=0.026	Y

Y=Yes, N=No

Table III: Laryngeal grade distribution based on race.

	Race		Total
	Caucasian	Asians	
Grade 1 + 2A + 2B	26 92.9%	279 74.0%	305 75.3%
Grade 3 + 4	2 7.1%	98 26.0%	100 24.7%
Total	28 100.0%	377 100.0%	405 100.0%

Original Cormack and Lehane Grade	Full view of the glottis 1	Partial view of the glottis or arytenoids 2		Only epiglottis visible 3	Neither glottis nor nor epiglottis 4
View at laryngoscopy					
Modified Grading	1 As for original Cormack and Lehane above	2a Partial view of the glottis	2b Arytenoids or posterior part of the vocal cords only just visible	3 As for original Cormack and Lehane above	4 As for original Cormack and Lehane above

Fig. 1: Diagrammatic illustration of Cormack and Lehane Grading system.
Longnecker DE, Brown DL, Newman MF, Zapol WM. Anaesthesiology, 2nd Edition (23)

(p=0.645), neck aches (p=0.728), jaw aches (p=0.417), tonsil size (p=0.048), and AHI (p=0.047), there was a slight correlation noted in these 405 patients, i.e. the difficulty of intubation with the lowest oxygen saturation (LSAT) with a p value of 0.026 (Table II).

Of the 100 cases of difficult intubation, all cases were smoothly intubated using Glidescope video laryngoscope. The Glidescope video laryngoscope intubation had reduced the laryngeal grade (based on Cormack and Lehane) from grade 3 and 4 to grade 1 (30 cases), grade 2A (60 cases) and grade 2B (10 cases).

Dividing the demographics into race, it was found that Asians had higher rate of difficult intubation (98 out of 377 (25.99%) Asian patients with grade 3 and 4) compared to the Caucasian group (two out of 28 (7.14%) patients) (p=0.019) (Table III). Having controlled for BMI across both Asian and the Caucasian groups, the data showed that Asians are more likely to have difficult intubation (grade 3 and 4) (adjusted OR = 4.6 (95% Confidence Interval (CI) 1.05 to 20.06) (p=0.043), compared to the Caucasian group.

DISCUSSION

It is well accepted that patients with OSA are a special group of patients (unlike normal individuals with patent upper airways) who require special considerations and extra peri-operative care,[12] as these patients are unique (a) anatomically, (b) physiologically and (c) surgically. From an anatomical perspective, these patients are usually obese, with short, thick and fat neck; they may have small mandibles, crooked over-jet teeth, big tongue (macroglossia), thick redundant palate and/or big tonsils.[13-15] Physiologically, OSA patients are prone to hypoxaemia, and may have background hypercapnia with central sleep apnoea. Some might have hypoventilation syndrome, with narcotic sensitivity and upper/lower airway resistance.[13-15] These OSA patients with already a narrowed airway (due to the disease process itself), have additional issues when the airway has to be shared by the anaesthesiologists and the surgeons performing upper airway surgery. With the manipulation and surgery done on the upper airway, post-operative swelling, and oedema may further compromise the breathing passage, hence airway obstruction is highly likely requiring closer post-operative monitoring and care.

A difficult airway is one of the most important factors in the management of an OSA patient undergoing upper airway surgery. As the upper airway of an OSA patient is very different compared to a non-OSA patient, it would be prudent if the anaesthesiologist and/or surgeon would be able to pre-empt a difficult airway and take preventive measures or prepare the needed equipment to secure the airway. Magalhaes et al.,[16] showed that in 88 patients (44 obese patients and 44 controls) that physical status, prevalence of snoring, hypertension, diabetes mellitus, neck circumference, and Mallampati index were higher in the obese group and these obese patients had a higher incidence of difficult facemask ventilation and laryngoscopy. Kurtipek et al.,[17] demonstrated in 40 patients (20 OSA patients and 20 controls) that OSA patients had more difficult airways compared to their controls, and these correlated with BMI, Mallampati grading, Wilson weight scores, Laryngoscopic grading (Cormack and Lehane), sternomental distance, thyromental distance, and doses of reversal agent. Corso et al., in 2018, showed in a systemic review of the medical literature and documented that OSA is associated with a number of comorbidities and increased perioperative risks; OSA patients are associated with a higher risk of both difficult ventilation and intubation.[18] Preoperative screening of OSA patients is of important given the increased perioperative morbidity of these patients. Similarly, Leong et al.,[19] reviewed 10 publications and demonstrated that the incidence of difficult tracheal intubation was higher in OSA patients versus non-OSA patients [56/386 (14.5%) vs. 69/897 (7.7%); P=0.0002]. Moreover, OSA patients also have a higher incidence of difficult mask ventilation [115/4626 (2.5%) vs. 471/64,684 (0.7%); P<0.0001].

We had very similar findings and found that in our 405 patients with OSA, 24.4% had difficult airway with grade 3 and 4 (Cormack and Lehane), and these patients required the use of the Glidescope video laryngoscope to secure the airway. The parameters that made intubation more difficult included, age of the patient, mouth opening (<2finger breaths (FB), 3.5cm), retrognathia (small jaw), overbite, overjet (protruding teeth), limited neck extension, thyromental distance (<3FB, 5.5cm), Mallampati grade 4, and macroglossia (all parameters at p<0.001). However, of particular interest, we noted that we did not find any correlation of BMI (p=0.087), neck circumference (p=0.645), neck aches (p=0.728), jaw aches (p=0.417), tonsil size (p=0.048), nor AHI (p=0.047), with the difficulty of intubation. We attribute these findings to the fact that 93% of our patients were Asian, and it has been well established that while neck fat/circumference, BMI, and parapharyngeal fat play an important role in the pathophysiology in Caucasian OSA patients; the jaw size (retrognathia) plays a critical role in Asian OSA patients.[20-22] Hence, we were not surprised that we did not find any correlation with BMI nor neck circumference. There was no correlation between AHI (severity of OSA) and intubation difficulty (p=0.047); however, there was a mild correlation between LSAT and difficulty of intubation (p=0.026), which might be indicative of the critically narrowed upper airway. When we adjusted for BMI, for both Asian and the Caucasian groups, the data showed that Asians were more likely to have difficult intubation (grade 3 and 4) (adjusted OR = 4.6 (95% CI 1.05 to 20.06) (p=0.043), compared to the Caucasian group. This finding supports the understanding that in Asians, jaw size is of greater importance (in the upper airway) than BMI or neck circumference.

From this largest series of OSA patients who underwent upper airway surgery, we highlight that these characteristics should alert physicians to a difficult and challenging intubation: (1) Asian, (2) smaller than 2 finger breath mouth opening, (3) retrognathia, (4) overbite and overjet teeth, (5) limited neck extension, (6) shorter than 2 finger breath thyromental distance, (7) higher Mallampati grade, and (8) macroglossia. Lastly, this study demonstrated that of the 100 cases of difficult intubation, all cases were seamlessly intubated by using the endoscopic guided intubating Glidescope. The endoscopic guided intubation consistently reduced the laryngeal grade (based on Cormack and Lehane) from grade 3 and 4 to grade 1 (30 cases), grade 2A (60 cases) and grade 2B (10 cases). This shows the need and importance for the anaesthesiologists to be experienced with the endoscopic intubation techniques, especially for OSA patients.

Limitations of this study include: (1) although the sample size is fairly adequate, it could have been larger; (2) the patients were predominantly Asian, so the results may not be generalised to a broader population; and (3) there were no precise measurements of thyromental distance or mouth opening, except for finger breaths of the anaesthesiologist. 2 FB (3.5cm); 2.5FB (4.5cm) 3 FB (5.5cm); 3.5 FB (6.25cm); 4 FB (7cm)

CONCLUSION

This study shows the need to be aware that the OSA patients are unique and have a very narrow upper airway. Such patients may often difficulty to surgeon and anaesthesiologist with their difficult upper airway. Hence, it is imperative that the physicians are able to predict clinically, a possible difficulty in intubation and thus avoid an anaesthetic mishap or patient morbidity.

Ethical approval: All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

DECLARATIONS

Ethics approval and consent to participate – This study was approved by the Institute Review Board IRB

Consent for publication – There are NO individual person data involved in the study

Availability of data and material - The data that support the findings of this study are available from Asia Sleep Centre but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of Asia

Sleep Centre

Competing interests – There are no competing nor financial interest in this study

Funding – There was no funding involved

Authors' contributions – The authors all declare that they have no competing interest. CWMZ, KPP, TSG, conceived the study, collected the patients, analyzed the data, and wrote the article. KAP, EBP, TYNC, BWR – wrote the article, results, conclusion and methodology. CYH – performed the statistical analysis and wrote the statistical section

Acknowledgements – NONE

There are no financial disclosures and no conflict of interest for all the authors.

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