

A New Method of Evaluation of Upper Airway in Patients with Obstructive Sleep Apnoea—Computer-assisted Quantitative Videoendoscopic Analysis[†]

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Abstract

Introduction: Prospective study to quantitatively examine the static and dynamic changes of upper airways in patients with obstructive sleep apnoea (OSA) by engaging a new inexpensive clinical method which accurately evaluates the morphology of obstructive sites of upper airway. The aim was to minimise the subjective visual estimations and eliminate individual variations of the traditional method of nasopharyngoscopic assessment of upper airway. **Method:** Videoendoscopic (video-nasopharyngoscopic) examinations of upper airways of 15 patients were carried out with a calibrator inserted through the scope and placed at the levels of interest. Images of upper airways during quiet respiration, muller manoeuvre at erect and supine positions were obtained, digitalised and analysed by computers to generate the actual dimensions, surface areas and hence collapsibility of obstructive sites of upper airways. These measurements were validated by comparing videoendoscopic measurements (supine, quiet respiration) with upper airway magnetic resonance imaging (MRI) scans. We compared the area measurements of 30 videoendoscopic images with MRI scans of 15 patients at two levels (points above uvula and epiglottis) and calculated the accuracy percentage by examining the differences of surface areas of these two methods of measurement. The MRI scan measurements were used as standard, and the differences were presented as an accuracy percentage. **Results:** The accuracy for the first level was 89.50% and the second level was 88.15%; the mean accuracy was 88.82%. The mean area of MRI was 1.50 cm² (SD = 0.69) and the mean area of videoendoscopic images was 1.45 cm² (SD = 0.64), with a correlation of 0.93 and a P value of less than 0.001. **Conclusion:** This new cost-effective and convenient clinical method of upper airway evaluation enables us to quantitatively and accurately examine the morphology of obstructive sites of upper airway, so that we could further research the pathophysiology of upper airway obstruction, engage the most appropriate treatment and provide accurate pre and postoperative assessments for patients with obstructive sleep apnoea.

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Key words: Computer-assisted quantitative airway assessment, Obstructive sleep apnoea

Introduction

Obstructive sleep apnoea (OSA) is characterised by a cessation of normal oronasal airflow for 10 seconds or longer, and repetitive closure of the upper airway during sleep, resulting in sleep fragmentation and daytime hypersomnolence. Snoring and OSA in adults are more common with increasing age, in the obese and those with high alcohol intake. Snoring occurs in 10% of men under 30 years of age and in 60% of men over 60 years of age.^{1,2} It can be immensely socially disruptive and may lead to marital difficulties. OSA is estimated to affect at least 4% of men and 2% of women in middle age;³ it fosters neurobehavioural alternations, inhibiting school and work performance and decreasing psychomotor vigilance, resulting in as much as 7 times increased risk of motor vehicles accidents, daytime somnolence, morning headaches, personality change, intellectual deterioration and impotence.⁴⁻⁶ OSA also has the added detriment of cardio-

vascular sequelae which include hypertension, cerebrovascular accidents, cardiac arrhythmias and myocardial infarction and increased mortality rate.⁴⁻⁶

However, little of the pathogenesis of OSA is understood despite the high prevalence of this disorder and its major public health ramifications. It is now well recognised that airflow obstruction in OSA is caused by collapse of the pharynx, although the precise anatomic and structural factors leading to pharyngeal collapse are not known. The airway is more dependent on the dilator muscle activity to maintain the patency as shown by the predisposition to closure.⁷ The vulnerability to closure relates to the greater sub-atmospheric inspiratory pressure generated in an attempt to achieve adequate airflow through the narrowed airway.⁸ Many studies^{9,10} have revealed the presence of underlying structural abnormalities of the upper airway in patients with OSA.

Examination of upper airway calibre (nasopharyngo-

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EPWORTH SLEEPINESS SCALE	
0	= would <i>never</i> doze
1	= <i>slight</i> chance of dozing
2	= <i>moderate</i> chance of dozing
3	= <i>high</i> chance of dozing
Situation	Chance of dozing
Sitting and reading	_____
Watching TV	_____
Sitting, inactive in a public place (e.g. a theatre or a meeting)	_____
As a passenger in a car for an hour without a break	_____
Lying down to rest in the afternoon when circumstances permit	_____
Sitting and talking to someone	_____
Sitting quietly after a lunch without alcohol	_____
In a car, while stopped for a few minutes in traffic	_____
Total	_____

Fig. 1. Epworth Sleepiness Scale.

scopy) during the application of negative intraluminal pressure is important for understanding the pathophysiology of upper airway closure in patients with sleep-disordered breathing. Muller manoeuvre,¹⁰⁻¹³ which is performed by inhaling against a closed oral and nasal passage, is to evaluate the collapse of the velopharyngeal tissues, base of tongue and lateral pharyngeal walls. The increased intraluminal negative pressure with this manoeuvre attempts to duplicate the sleep related pressure changes, to more accurately assess the dynamic upper airway changes. Nasopharyngoscopy with the muller manoeuvre¹⁰⁻¹³ is an ideal modality to examine the dynamic changes in the upper airway. Several studies have demonstrated the preoperative predictive usefulness of nasopharyngoscopy with muller manoeuvre. These studies, however, did not quantify changes in the upper airway anatomy (airway area, transverse/lateral, longitudinal/anterior-posterior dimensions). Many surgeons depend on subjective visual estimation when assessing the upper airway during nasopharyngoscopy and with muller manoeuvre, and this may result in inaccurate assessments or vast subjective variations among surgeons.

Computer-assisted quantitative videoendoscopy is specially designed to overcome these problems of subjective inaccuracy and variations among surgeons while assessing the upper airway during nasopharyngoscopy.

Materials and Methods

Fifteen patients were involved in this prospective study. All underwent comprehensive ENT examinations, biodata recording (age, sex, BMI, neck circumference, etc), Epworth sleepiness score assessment (Fig. 1), calibrated cephalo-

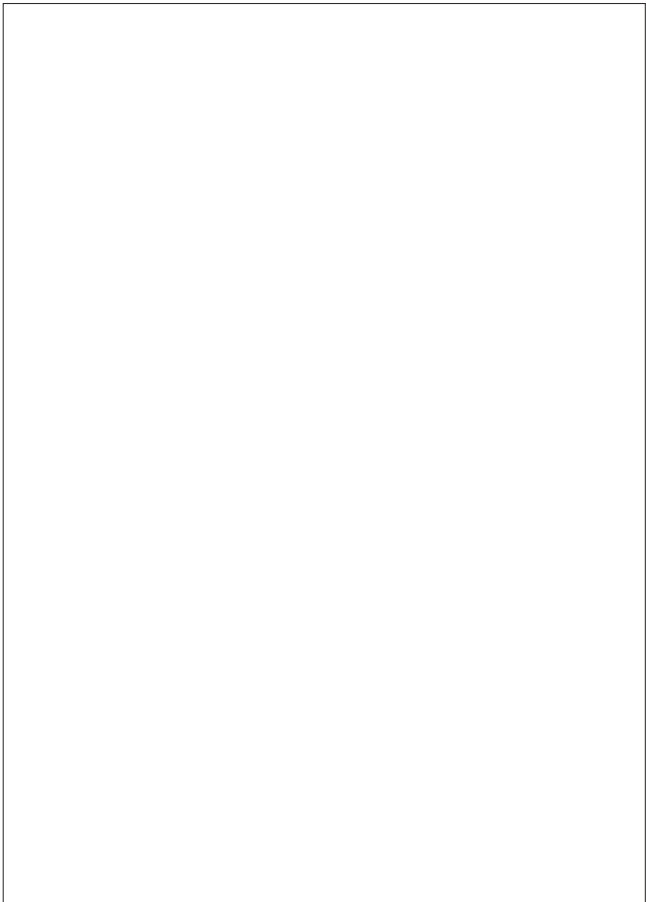


Fig. 2. Calibrated cephalometric radiological analysis.

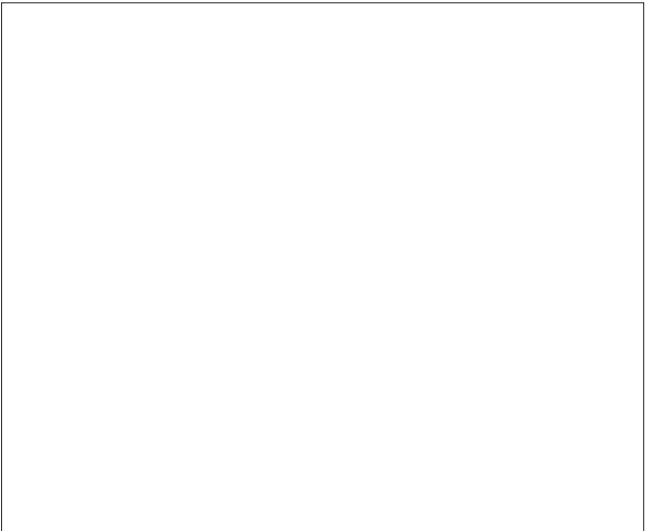


Fig. 3. Sagittal image of an upper airway MRI scan.

metric radiological analysis (Fig. 2), sleep study, as well as upper airway magnetic resonance imaging (MRI),¹⁴⁻¹⁶ which was used to measure these narrow segments of the upper airway sagittally (Fig. 3) and exact static surface areas of these segments of interest on the axial scans (Figs. 4 & 5).

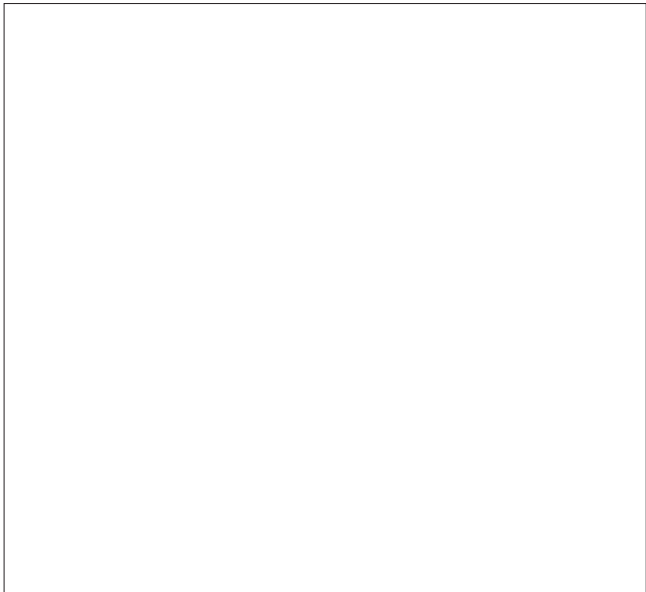


Fig. 4. Axial image (uvula) of an upper airway MRI scan. Surface area measurement as indicated in Area 1.

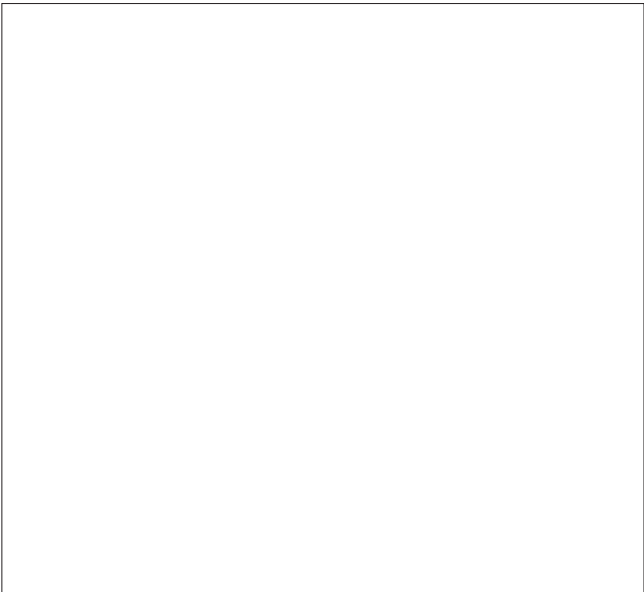


Fig. 5. Axial image (epiglottis) of an upper airway MRI scan. Surface area measurement as indicated in Area 1.

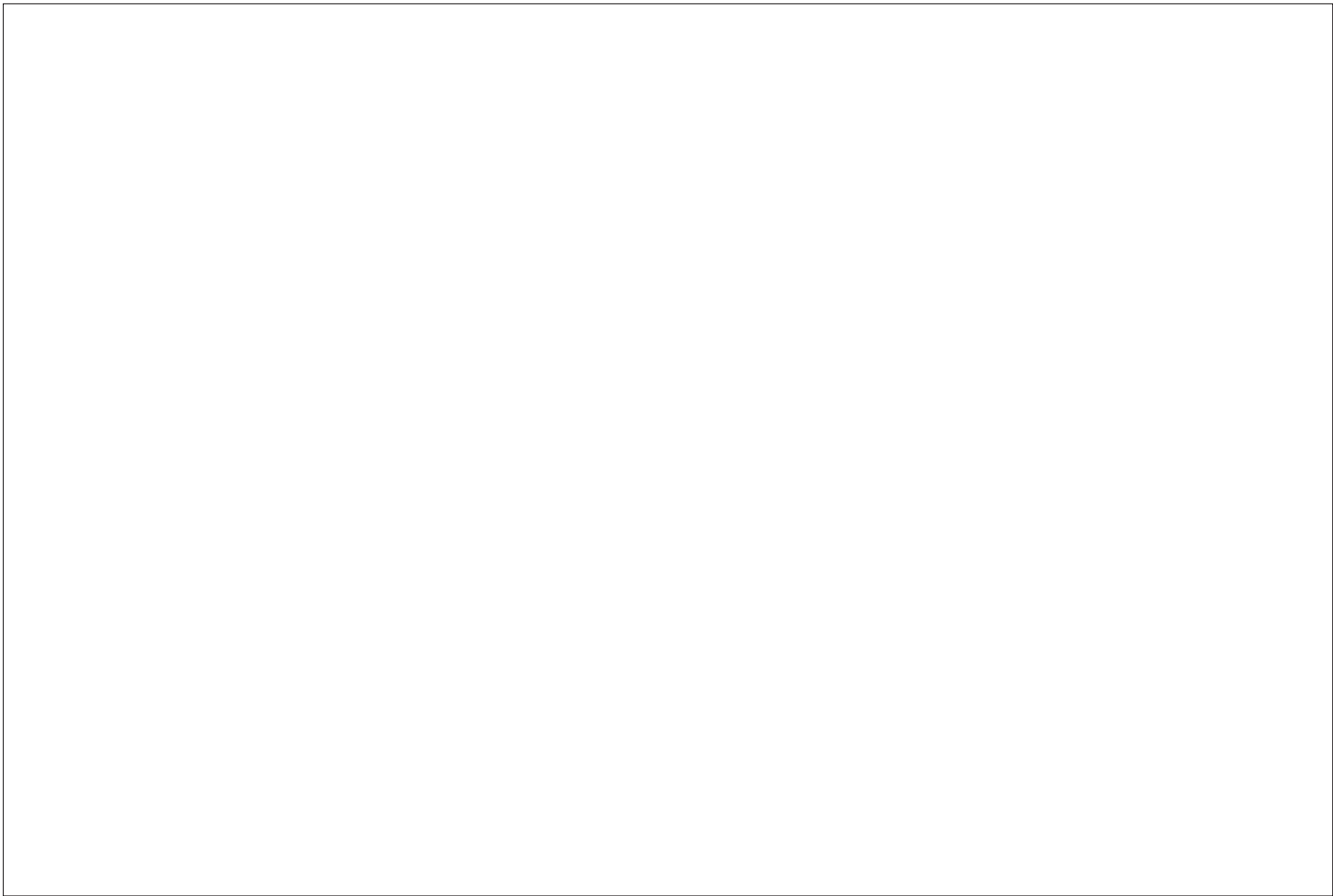


Fig. 6. OSA database containing patient’s bio-data, visit details, and measurements of MRI and endoscopic images, and cephalometric analysis. Note: This OSA database is able to perform auto-calculation upon data entry.

Patient HRN:		Name:		C-metry	Erect	Supine
℄ / D	Pre / Post	Visit Date: 29/12/2000		SNA:	80°	80°
DOB: 03/07/1961		Lowest O ₂ sat: 60 %		SNB:	78°	78°
Age: 40 Sex: M		MRI: Y/N (02/01/2001)		NSBa:	140°	140°
Race: Chinese		Dietician: Y/N		N-ANS:	45 mm	45 mm
Wt: 95 kg Ht: 1.7 m		CPAP: Y/N On Trial		ANS-Gn:	72 mm	72 mm
Neck Circum: 48 cm		Epworth : 20		PAS:	14 mm	10 mm
Neck Length: 8 cm		Nasal:		MP-H:	24 mm	28 mm
BMI: 32.87		Septum: Deviated		PNS-P:	35 mm	40 mm
AHI: 68/h		I-turbinate: Normal		R-Pa:	9 mm	4 mm
AI: 28/h				Pa:	12 mm	9 mm
Erect Level One		Erect Level One Muller		History		
				A 40-year-old male, Chinese taxi driver complained of increasing daytime sleepiness over the last 3 years which severely affects his job and marriage life.		
Erect Level Two		Erect Level Two Muller		Collapsibility (%)		
				Erect level 1 (Uvula) Surface Area : 91.35 % Transverse Diameter : 79.72 % Longitudinal Diameter : 54.44 % Erect level 2 (Epiglottis) Surface Area : 69.23 % Transverse Diameter : 23.53 % Longitudinal Diameter : 52.63 %		
Supine Level One		Supine Level One Muller		Collapsibility (%)		
				Supine level 1 (Uvula) Surface Area : 100.00 % Transverse Diameter : 100.00 % Longitudinal Diameter : 100.00 % Supine level 2 (Epiglottis) Surface Area : 33.63 % Transverse Diameter : 0.83 % Longitudinal Diameter : 19.44 %		
Supine Level Two		Supine Level Two Muller		Comment:		
				On weight reduction programme, diet control, behaviour counselling and CPAP trial. To be reviewed in 2 months.		

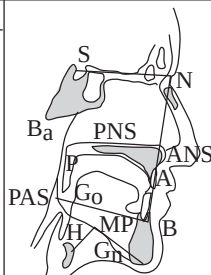


Fig. 7.

Videoendoscopic (nasopharyngoscopic) examinations of upper airways were carried out with a calibrator (known dimension—5 mm) inserted through the scope and placed at the levels of interest. Images were recorded throughout the entire examinations, which included during quiet respiration, muller manoeuvre and at both erect and supine positions.

Images of upper airways were thus recorded, digitalised and analysed by our computer to generate the actual dimensions (transverse and longitudinal dimensions, surface areas and calculated the collapsibility of obstructive sites of upper airway). These actual dimensions were obtained by comparing the calibrator (5 mm) with these videoendoscopic images; this procedure was repeated for each new image, including quiet respiration, muller manoeuvre, erect and supine positions at two levels (8 images per patient). This information was subsequently transferred to our OSA database together with other data for further analysis (Figs. 6 & 7). These final measurements were validated by comparing videoendoscopic measurements of patients during quiet respiration (supine) with upper airway MRI scans (supine, quiet respiration), especially at two landmark levels, the first level being the point just immediately above the soft palate, the second level is at the point immediately above the tip of the epiglottis, at the greatest convexity of the tongue base. Two videoendoscopic images per patient were compared with MRI scans. Once these two images were validated by MRI scans, we could extrapolate the remaining videoendoscopic images (muller manoeuvre or erect position) to have the same accuracy. Hence, we could obtain abundant and detailed information of the static and dynamic changes of obstructive sites of upper airways.

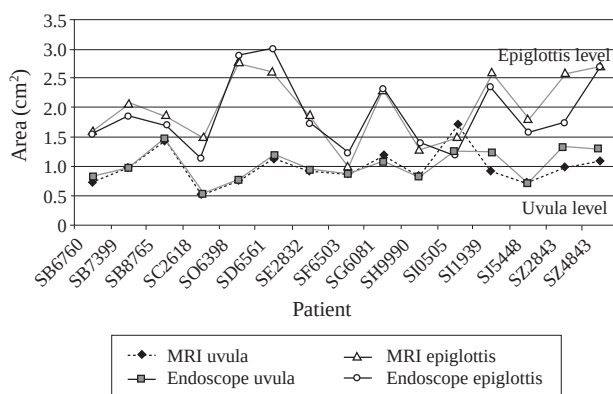


Fig. 8. MRI and endoscopic image surface area measurement comparison. Surface area measurements of MRI and endoscopic images were plotted against 15 patients, at uvula and epiglottis levels in supine position. Hence, 30 pairs of image measurements were captured. The surface area measurement of endoscopic image was compared with the MRI measurement in each pair. This figure shows that the close proximity between the two methods of measurements. The percentage of its accuracy is shown in Figure 9.

Results

There were 15 patients (12 males and 3 females) involved in this prospective study, with a mean age of 39.8 years, all with OSA proven by positive sleep studies. Other important biodata and parameters were recorded, calibrated cephalometric radiological analysis were also performed for soft and skeletal morphology of the upper airway. All these information were entered into our OSA database (Figs. 6 & 7), together with the results of videoendoscopic analysis and MRI scans. The results of analysis of our database, which include many other patients and normal subjects, are not reported in this study, and will be discussed in our subsequent studies. The aim of this study was to seek a new cost-effective clinical method of upper airway evaluation.

In this study, we compared the surface area measurements of 30 videoendoscopic images with upper airway MRI scans of these 15 patients at two levels as mentioned above and calculated the accuracy percentage of our new clinical methods (Figs. 8 & 9). The accuracy percentage was calculated by examining the differences of surface area measurements of these two methods, using upper airway MRI scan measurements as standards, and the differences presented as accuracy percentage. The average accuracy for the first level was 89.50% and the second level was 88.15%; the mean accuracy was 88.82%. The mean area of MRI was 1.50 cm² (SD 0.69) and the mean area of videoendoscopic images was 1.45 cm² (SD 0.64), with a correlation of 0.93 and a *P* value <0.001.

Discussion

This study combined medicine (OSA research) with modern radiological and computer technology. The results of this study showed that the surface area measurements by videoendoscopic method are highly reliable and accurate as compared with upper airway MRI scans, and without the disadvantages of high costs and time spent on arranging

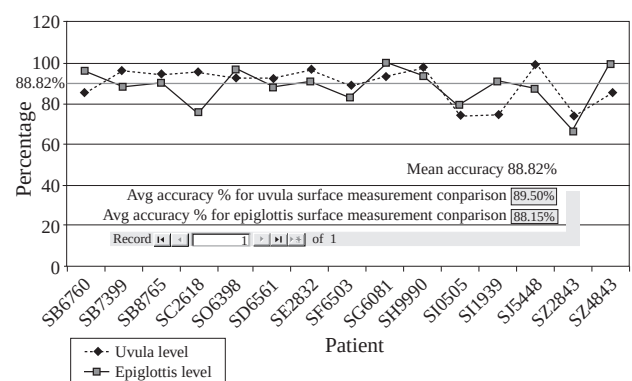


Fig. 9. Accuracy of computer-assisted quantitative videoendoscopic analysis. This figure shows that the mean accuracy is 88.82%.

scans. Moreover, we could also obtain dynamic information (collapsibility) of upper airways, which could not be achieved by static radiological investigations. We have since adopted this new clinical method to evaluate the upper airway morphology of our patients.

This new cost-effective and convenient clinical method of upper airway evaluation enables us to minimise the subjective visual estimations and eliminate individual's variations of the traditional method of nasopharyngoscopic assessment of upper airway. We could also quantitatively and precisely pinpoint the morphology of obstructive sites, static and dynamic changes, collapsibility of surface areas, transverse and longitudinal dimensions of upper airway.

More importantly, we could advise and engage the most appropriate non-surgical and surgical treatment, provide accurate pre and postoperative clinical assessments of upper airways for patients with OSA.

We could also further research the pathophysiology of upper airway obstruction in OSA with computer-assisted videoendoscopic analysis, and study the correlation with other important parameters and biodata. This clinical method could also be used to study the comparisons between normal subjects and patients with OSA, especially in local populations, as most of the upper airway studies for OSA were done on western populations.

In addition, we know that there are certain variations in facial, head and neck features between local and western populations, including variations in upper airway anatomy and physiology as well, which may contribute uniquely to the aetiology of OSA in Singapore.

We are still in the process of collecting more data to be included into this prospective database and hope that the subsequent results of data analysis would help in increasing our understanding about snoring and OSA in Singapore.

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