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Evaluation of upper airway obstruction using nasopharyngoscopy, videofluroscopy, cephalometry and computed tomography obstructive sleep apnea - a prospective study of 60 cases

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Abstract

Aim: The aim of the study was to evaluate the anatomical and structural changes in the upper airway in cases of obstructive sleep apnoea and to evaluate the efficacy of the various modalities available in diagnosing the site of obstruction in case of obstructive sleep apnoea.

Study design: Prospective analysis

Patients: 60 adults patients Patients who were diagnosed as cases of obstructive sleep apnea on the basis of nocturnal polysomnography and has not undergone any surgical operation for obstructive sleep apnea were included in study.

Methodology: All patients were subjected to detailed history taking and clinical examination. Majority of the patients that is 48 (80%) in our study were males whose mean age was 49.1 years. There were 12 females (20%) whose mean age was 57.5 years. The mean age of the study population was 50.8 years. The patients then underwent Nasopharyngolaryngoscopy, Cephalometry, Non Contrast Computed Tomography and Videofluroscopy.

Result: In our Study out of the 60 patients who underwent Nasopharyngolaryngoscopy (fiberoptic), 10 Patients (16.7%) had complete obstruction at nasopharynx level. 58 (96.7%) patients had complete obstruction at oropharyngeal level one patient had only 80-90% obstruction. Whereas all of the 60 patients (100%) had complete obstruction at hypopharyngeal level. Cephalometry could detect abnormality in 42 out of 60 patients i.e 70% cases in our study. Videofluroscopy showed significant change in length of softpalate in inspiration and expiration amounting to collapse of Nasopharynx, Oropharynx and Hypopharynx in all the patients (Mean% change is 12.55 and SD is 3.23 $p < 0.001$). Non Contrast Computed Tomography inferred that 56 patients (93.3%) had decreased cross sectional area at any part of pharynx (either nasopharynx or oropharynx or hypopharynx).

Conclusion: Nasopharyngolaryngoscopy and Videofluruoscopy are very useful in studying the dynamics of upper airway and depicting the changes that occur during apneic events. Cephalometry and Static Computed Tomography are able to assess anatomic abnormalities in the upper airway but efficacy of detection is less as compared to Nasopharyngolaryngoscopy and Videofluroscopy.

Keywords: Obstructive sleep apnoea**,** Nocturnal Polysomnography, Nasopharyngolaryngoscopy, Cephalometry, Non Contrast Computed Tomography Videofluroscopy

Introduction

Snoring and Obstructive sleep apnea(OSA) are the two commonest respiratory sleep disturbances which have gained importance in the recent years.They are commonly seen in our population. Although Charles Dickens is credited with the classic description of a typical OSAS patient in Pickwick papers in 1837, not much was known about the disorder until Guilleminault and colleagues [1,2] described the syndrome more accurately in 1970s. This has led to a further understanding of the serious health problems associated with this disorder and currently an increased awareness exists in our country too currently.

It is a common form of sleep breathing disorder characterised by repetitive episodes of partial or complete upper airway obstruction.It usually causes sleep fragmentation , reduced blood oxygen levels, and excessive day time sleepiness. Cognitive deficits, reduced driving competence, cardiovascular morbidity and mortality have been reported. Because the clinical significance of OSA is increasing, more exact diagnosis for successful treatment is required. It has been suggested that patients with OSA have narrower pharyngeal airways than normal persons because of fat infiltration, the weight of the soft tissue of the neck, and reduced pharyngeal muscle tone. Common abnormalities leading to airway narrowing include: soft palate elongation, adenotonsillar hypertrophy, macroglossia, retrognathia and micrognathia. Obesity has been identified as the major risk factor in adults for development of obstructive breathing. These patients chiefly present with the complaint of snoring and excessive daytime sleepiness. Meticulous general survey, otolaryngological examination as well as systemic examination is necessary. Since obesity is one of the major risk factors for obstructive sleep apnea syndrome. A complete life style change is needed as it is often difficult for patients to maintain the weight loss overtime.

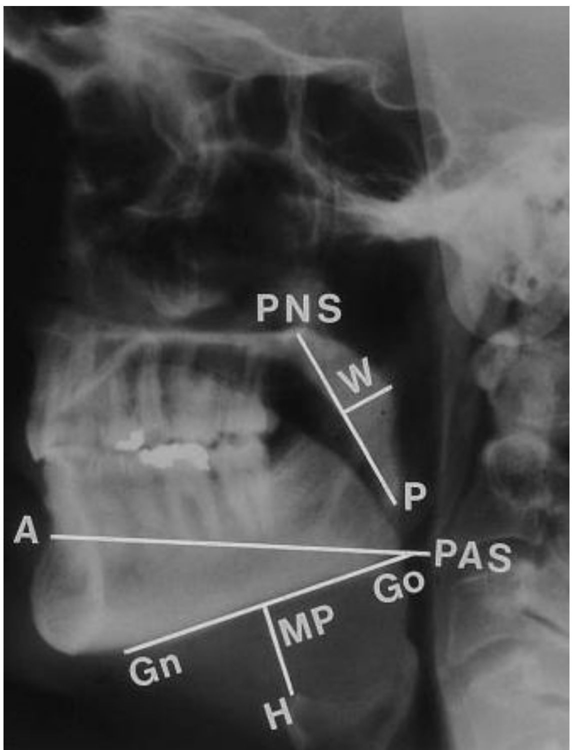
To precisely localise the site of the obstruction in obstructive sleep apneic patients we performed Nasopharyngoscopy, Cephalometry, Computed Tomography and Videofluoroscopy.

Materials and methods

Ourwas a prospective study conducted in the Department of Otorhinolaryngology at Dr. Ram Manohar Lohia Hospital, PGIMER, NEW DELHI. 60 adult patients who were diagnosed as obstructive sleep apnea on the basis of nocturnal polysomnography, who were regular in follow up and gave their consent but has not undergone any surgical operation for obstructive sleep apnea were included in the study. A detailed sleep history was obtained from the patient and his bed partner. History included details about yawning through out the day, falling asleep while watching TV, while sitting up, while eating, during work, during conversation, while driving, pauses during sleep, nocturia, restless sleep.

Symptoms of morning headache, unrefreshening sleep, poor concentration, decreased attention, reduced dexterity, drooling, dry mouth, personality change, depression was also significant.

Other key points included history of blood pressure, hypothyroidism, smoking, alcohol, sedative,recent increase in weight and snoring. All the patients were then subjected to Nasopharyngolaryngoscopy,Cephalometry, Videofluroscopy and Non Contrast Computed Tomography.. Following measurements were made in Cephalometry[3,4] : 1)MP-H distance From the mandibular plane (a plane constructed from the gnathion (Gn) through the gonion (Go)) to the hyoid bone (H). 2) PAS The posterior airway space. 3) PNS-P From the posterior nasal spine to the tip of the palate.4) ANB angle From subspinale (A; deepest point on the premaxillary outer contour between the anterior nasal spine and central incisor) to the nasion (N) and to the supramentale (B; deepest point on the outer mandibular contour between the mandibular incisor and the pogonion). This angle measures discrepencies between the mandible and the maxilla.

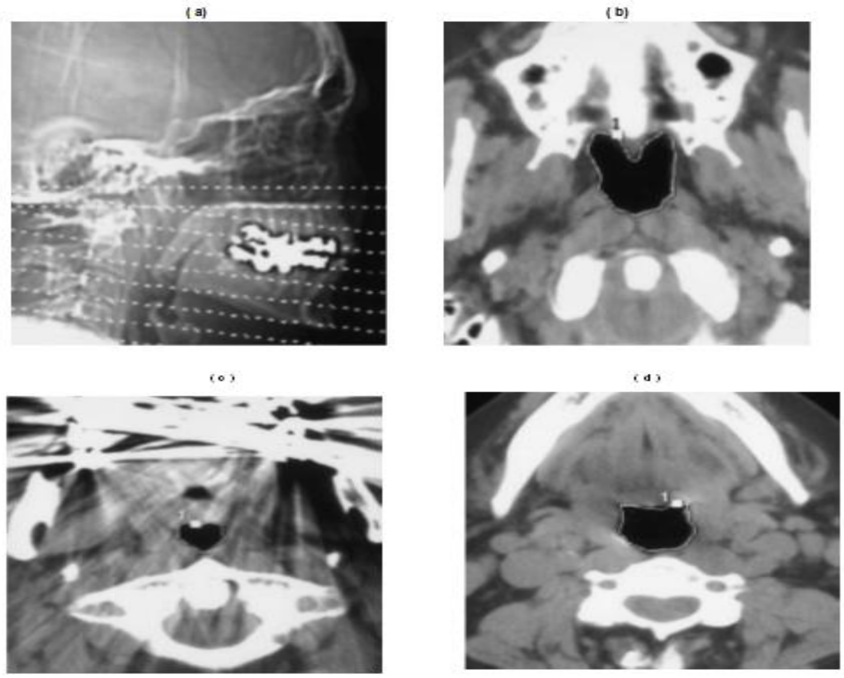


Cephalometry[5,6]: A-subspinale: deepest point on the premaxillary outer contour between anterior nasal spine and central incisor; B-supramentale: deepest point on the outer mandibular contour between mandibular incisor and pogonion;
N-nasion: the most anterior point of the nasalfloor; H-the most anterior-superior point on the body of the hyoid bone; P-tip of the soft palate; Go-gonion: the most posterior-inferior point on the convexity of the angle of the mandible; Gn-gnathion: the most inferior point in the contour of the chin; MP-mandibular plane, constructed from the gnathion through the gonion; PNS-posterior nasal spine: the most posterior part of the contour of the hard palate; PAS-posterior airway space.

Computed Tomography was done to measure the luminal area of the airway at the level of the nasopharynx, oropharynx, and hypopharynx to see whether narrowing could be observed at more than one level. CT scans machine available in our hospital setup is SEIMENS 16 slice machine. Patients were closely observed to ensure that they remain awake throughout the procedure and did not swallow during imaging. Scanning was performed during quiet breathing.

All the subjects then underwent Videofluroscopy. Videofluroscopy was carried out either in LISTEM or ITLARY fluoroscopy machine available in our hospital setup. The subjects were placed on a table in supine position with the head on a pillow. They were instructed to breathe in and out naturally.The obstruction sites were classified as the SP, tongue base, or both. The length of the SP is defined as the distance from the posterior nasal spine to the uvula tip. The angle of the SP is defined as the angle between the extension of the nasal floor and the uvula tip. The percentage change in the SP length or elongation is calculated as follows:

$$\frac{\text{SP Length (Inspiratory Effort)} - \text{SP Length (Expiratory Effort)}}{\text{SP Length (Expiratory Effort)}} \times 100$$



Images show the parameters measured on CT scans[5]. CT was performed to obtain measurements of the luminal area of the airway (outlined areas in b, c, and d) at the levels of the nasopharynx, oropharynx, and hypopharynx. (a) Lateral scout view shows the levels (dashed lines) at which CT sections were obtained. CT scans obtained at the (b) nasopharynx (hard palate level), (c) oropharyngeal level (20 mm caudal to b), and (d) hypopharyngeal level (50 mm caudal to b).

Analysis of upper airway obstruction by sleep videofluoroscopy in obstructive sleep apnea

Upper airway obstruction pattern in videofluoroscopy([7,8]). Images show upper airway obstructions due to the soft palate at the oropharyngeal level (A), the tongue base at the oropharyngeal level (B), both the soft palate and tongue base at the oropharyngeal and hypopharyngeal levels at the same time (C), the tonsils at the oropharyngeal level (D), the epiglottis at the hypopharyngeal level (E), and the soft palate at the velopharyngeal level (F).

Fiberoptic Nasopharyngolaryngoscopy is done to evaluate airway dynamics of sleep apnea patients. During this examination the patient was asked to perform Mueller's maneuver that consists of forced inspiratory effort with the mouth & nose closed. Then we observed upper airway patency at three different levels. Nasopharyngeal level; Oropharyngeal level (soft palate and junction of nasopharynx); hypopharyngeal level (just above epiglottis).

Fiber Optic Laryngoscope

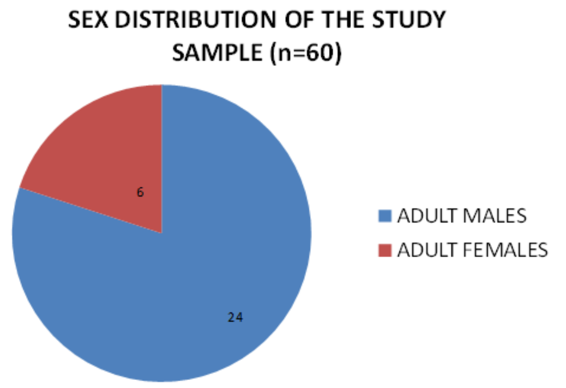
Statistical analysis

The paired *t* test will be used to analyze SP elongation and angulation in Videofluoroscopy. Rest of the measurements will be expressed in average with standard deviation.

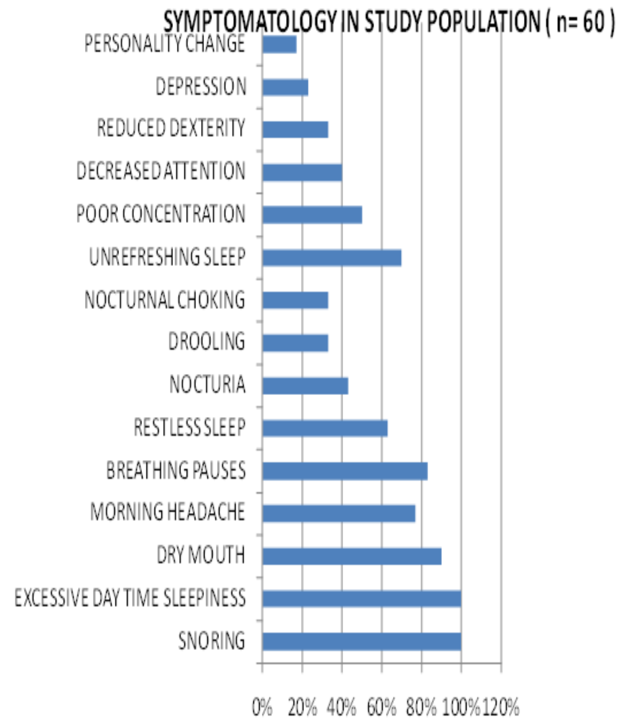
Observation

Majority of the patients that is 48 (80%) in our study were males whose mean age was 49.1 years. There were 12 females (20%) whose mean age was 57.5 years. The mean age of the study population was 50.8 years.

In our Study, Snoring and Excessive daytime sleepiness was complained by all the patients (100%). Dry mouth was also very common,54 patients (90%) had complained of it , is basically due to mouth breathing and constant opening of the mouth.



The following illustration explains the symtomatology:



On analysing in detail the upper airway clinically in all the 60 patients, it was found that high Mallampati grading (GRADE III-IV) was seen in 40(66.7%) patients and correlates well with obstruction of upper airway.

In our Study out of the 60 patients who underwent Nasopharyngolaryngoscopy (fiberoptic), the result depicted is as follows:

18 patients (30%) had entirely normal cephalometry results whereas all other patients had at least one of the four cephalometry measurement outside the normal range. Thus cephalometry could detect abnormality in 42 out of 60 patients i.e 70% cases of the study population.

Videofluroscopy was carried out either in LISTEM or ITLARY fluoroscopy machine available in our hospital setup. Then the percentage change in the SP length or elongation was calculated. Following observations were made:

Mean SPL length during inspiration (n=60) is 25.76mm and SD is 3.03.

Mean SPL length during expiration (n=60) is 22.87mm and SD is 2.55.

NASOPHARYNGOLARYNGOSCOPY EVALUATION OF STUDY POPULATION (n=60)

NASOPHARYNGOLARYNGOSCOPY FINDINGS	**NUMBER OF PATIENTS**	**PERCENTAGE**
OBSTRUCTION AT NASOPHARYNX LEVEL	10	16.7%
OBSTRUCTION AT OROPHARYNX LEVEL	58	96.7%
OBSTRUCTION AT HYPOPHARYNX LEVEL	60	100%

Following inferences were made in Cephalometry:

CEPHALOMETRY IN STUDY POPULATION (n = 60)

CEPHALOMETRY PARAMETER	**NUMBER OF PATIENTS WITH ABNORMAL MEASUREMENT**	**PERCENTAGE**
MP-H (abnormal is > 18.4 mm)	38	63.3%
PAS (abnormal is < 9 mm)	8	13.3
PNS-P (SOFT PALATE LENGTH abnormal is > 34mm)	12	20%
ANB ANGLE (abnormal > 2^0)	0	0%

VIDEOFLUROSCOPY-PAIRED SAMPLES TEST

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	SPLENINSP – SPLENEXP	2.89000	.80702	.14734	2.58866	3.19134	19.614	29	.000

The Mean % change in soft palate length in inspiration and expiration is 12.55 and SD is 3.23.

VIDEOFLUROSCOPY – PERCENTAGE CHANGE IN SP LENGTH

	N	Minimum	Maximum	Mean	Std. Deviation
PERCENT CHANGE	60	7.50	19.70	12.5567	3.23938

Minimum % change in every subject was more than 5%. So all 60 patients who underwent this test had significant change in soft palate length. Therefore Videofluroscopy was able to detect abnormality in upper airway in all the 60 subjects.

The purpose of computed tomography was to measure the luminal area of the airway at the level of the nasopharynx, oropharynx, and hypopharynx to see whether narrowing could be observed at more than one level.

For area of nasopharynx, oropharynx and hypopharynx, mean –SD is taken as cut off.

NASOPHARYNX- CROSS SECTIONAL AREA (RANGE 153+/- 84 mm^2) = 69

OROPHARYNX- CROSS SECTIONAL AREA (RANGE 279+/- 129 mm^2) =150

HYPOPHARYNX- CROSS SECTIONAL AREA (RANGE 303+/- 112 mm^2)=191

Narrowing of nasopharynx is defined as area less than or equal to 69 mm^2. Our findings showed that 4 patients (6.7%) had reduced area on computed tomography at Nasopharynx. Computed tomography findings concluded that 26patients (43.3%) had narrowing of the oropharynx that is area less than or equal to 150mm^2. But 34 patients (56.7%) had normal oropharynx. Narrowing was deeced at hypopharynx in 38 patients (63.3%) that is area less than or equal to 191mm^2 and hypopharynx was normal in 22patients (36.7%). Therefore by subjecting the study population to non contrast computed tomography it can be inferred that 56 patients (93.3%) had decreased cross sectional area at any part of pharynx (either nasopharynx or oropharynx or hypopharynx). 14 patients (23.3%) had reduction in cross-sectional area in two parts of pharynx. 20 patients (33.3%) had narrowing throughout the pharynx (nasopharynx, 0ropharynx and hypopharynx). Only 4patients (6.67%) had normal cross sectional area at nasopharynx, oropharynx and hypopharynx.

Discussion

The prevalence of OSA among adult population is between 6-9 % among men between 40-60 years of age. Young et al[9] estimated that maximum number of snorers is in middle aged working population . The mean age of presentation in our study of adult patients was 50.8 years. Studies by Chaudhary et al[10] and Young et al [9] have shown the preponderance in the male population. The ratio of male to female in our study is 4:1. In all patients Snoring and Excessive Daytime Sleepiness was the presenting symptoms. Snoring in obstructive sleep apnea is typically loud which can be heard from one room away, continuous and in all positions. .In all our 60 patients snoring as loud and in 20 patients the snoring was extremely loud and disturbing to entire household. In our Study out of the 60 patients who underwent Nasopharyngolaryngoscopy (fiberoptic) 16.7% had complete obstruction at nasopharynx level with muller's maneuvre . 96.7% patients had complete obstruction at oropharyngeal level, with muller's manoeuvre . 100% patients had complete obstruction at hypopharyngeal level. Baharudin Abdullah et al [11] too evaluated the severity of upper airway obstruction in obstructive sleep apneic patients using videoendoscopy . A total of 59 patients participated in his study. He concluded that all obstructive sleep apneic patients had obstruction at retropalatal or retroglossal area or both, with severity more in retropalatal area as compared to retroglossal area either in erect or supine position. All the patients of the study sample underwent Cephalometry. In our study 38 patients (63.3%) had inferiorly placed hyoid bone that is MP-H more than 18.4mm (MPH distance normal mean is 15.4 and SD is 3, therefore mean ±SD i.e 18.4 is taken as cut-off). Only 8(13.3%) patients had narrowed posterior airway space that is < 9 mm (11mm+/- 2mm) . 12patients (20%) had a long soft palate that is PNS-P length > 34mm [3,4]). None of the patient in our study population had abnormal angle (ANB angle > 2^0)[3,4] . 18 patients (30%) had entirely normal cephalometry results whereas all other patients had at least one of the four cephalometry measurement outside the normal range. Thus cephalometry could detect abnormality in 42 out of 60 patients i.e 70% cases in our study. Our findings matches significantly to J L Pepin et al [5]who did cephalometry in 11 patients with the obstructive sleep apnoea syndrome and found that only one patient had entirely normal cephalometric results where as all the other patients had at least one of the four cephalometric measurements outside the normal range . In his Study the greatest abnormality found by cephalometry was in the measurement of MP-H with eight of the 11 patients having an inferiorly placed hyoid bone (MP-H greater than 18.4 mm), three patients had an inadequate PAS ,two had an abnormal length of soft palate (PNS-P over 43 mm) and only one showed evidence of mandibular deficiency at cephalometry (ANB 4'). Videofluroscopy showed significant change in length of softpalate in inspiration and expiration amounting to collapse of Nasopharynx, oropharynx and hypopharynx in all the patients (Mean % change in soft palate length in inspiration and expiration is 12.55 and SD is 3.23 p< 0.001 in our study). Our findings support the study of Chul Hee Lee, MD, PhD et al[8] who analysed a total of 63 consecutive patients with snoring or sleep apnea (53 with obstructive sleep apnea [OSA] and 10 simple snorers) and concluded that Sleep videofluroscopy quantitatively showed that the SP was considerably elongated and angulated in patients with OSA even in an awake state. Of all the patients who were evaluated using Non Contrast Computed Tomography, it was inferred that 56 patients (93.3%) had decreased cross sectional area at any part of pharynx (either nasopharynx or oropharynx or hypopharynx). 14patients (23.3%) had reduction in cross-sectional area in two parts of pharynx. 20 patients (33.3%) had narrowing throughout the pharynx (nasopharynx, 0ropharynx and hypopharynx). Only 4 patients 6.67) had normal cross sectional area at nasopharynx, oropharynx and hypopharynx .Our findings are consistent with Haponik EF et al [12]who evaluated 20 awake patients with obstructive apnea and 10 control subjects using computed tomography and found that cross-sectional areas of the nasopharynx, oropharynx, and hypopharynx in apneic patients were significantly reduced (p less than 0.05) compared with those in the control subjects.

Thus the discrepancy between the findings of the static (CEPHALOMETRY and COMPUTED TOMOGRAPHY) and the dynamic (NASOPHARYNGOLARYNGOSCOPY and VIDEOFLUROSCOPY) examinations emphasises the importance not only of anatomical factors but also of functional determinants of collapse. Fluoroscopic examination of the airway in the obstructive sleep apnoea syndrome was first described in 1967 in a case report by Schwartz et al [13], and Smith et al in 1978[14]first described the use of this technique to show the extent and progression of airway collapse. Suratt et al (1982)[15] compared fluoroscopy and computed tomography, using thick barium to help to outline the pharynx, though this may have changed upper airway muscle control. They, like us, found that the narrowest area of the pharynx on the computed tomogram was the area most likely to collapse at fluoroscopy. They described fluttering of the soft palate, which was associated with snoring.

Conclusion

In conclusion we have observed that Nasopharyngolaryngoscopy and Video-fluruoscopy are very useful in studying the dynamics of upper airway and depicting the changes that occur during apneic event in the upper airway in the patients of Obstructive Sleep Apnea. Both the modalities are useful for rapid clinical evaluation of obstruction sites in Apneic patients. Cephalometry and Static Computed Tomography are able to assess anatomic abnormalities in the upper airway but efficacy of detection is less as compared to Nasopharyngolaryngoscopy and Videofluroscopy, with Computed Tomography faring better than Cephalometry. More importantly Cephalometry and Computed Tomography did not assess the dynamic changes which are equally important in evaluation of upper airway collapsibility in cases of obstructive sleep apnea.

In view of the above findings we feel that Nasopharyngolaryngoscopy and Video-fluroscopy are important tools in the diagnosis of Obstructive Sleep Apnea.

Conflict of interest

No Conflict of Interest.

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