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Obstructive Sleep Apnea- Role of Magnetic Resonance Imaging as Diagnostic Tool

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Abstract

Study objective: To evaluate diagnostic parameters in obstructive sleep apnea (OSA) using magnetic resonance imaging (MRI).

Method: The study is a prospective case study carried during the period from 2015-16 in the department of Oral Medicine and Radiology and Department of Radio diagnosis, IMS SUM Hospital, Bhubaneswar, Odisha, India. 40 diagnosed cases (as diagnosed by Type IV level study) of obstructive sleep apnea who were reported to the department of Oral medicine and Radiology with their age ranging from 28 to 75 years. Two transverse plane sections one at the retropalatal (posterior to soft palate) level and the other at retroglossal level (posterior to tongue base) were obtained. 50 images taken during 50 seconds obtained at each location for the midsagittal and two transverse plane section of the pharynx and viewed on a cineloop display.

Results: Among OSA patient in the study 75% of cases were having retropalatal in sagittal i.e. RP (SAG) >4.2 mm and 50% cases were having RP (SAG) >5.20 mm and 25% cases were having >6.0 mm. Similarly 75% of cases were having retroglossal sagittal i.e. RG (SAG) >6.40 mm, 50% cases having >9.0 mm and 25% cases were having >10.4 mm. Maximum cases the decrease was around 5 mm.

Conclusion: Retroglossal and retropalatal obstruction is one of the important diagnostic tool in obstructive sleep apnea.

Keywords: Obstructive sleep apnea; Magnetic resonance imaging; Retropalatal; Retroglossal obstruction

Introduction

American Academy of Sleep Medicine1 have defined as, "OSA is characterised by partial or complete obstruction of upper airway during sleep, interrupting (apnea) or reducing (hypopnea) the flow of air, followed by transient awakening leading to the restoration of upper airway permeability"2. OSA is the second disease in order of frequency among different respiratory disorders surpassed by asthma. In obstructive sleep apnea, there is repetitive collapse of upper airway takes place leading to snoring and repeated episodes of sleep interruption, hypoxemia and hypercapnia with a resultant change in intrathorasic pressure. OSA (obstructive sleep apnea) is a potentially life threatening disorder with periodic cessation of breathing (> 10 seconds) and which ultimately has a negative effect on patient's life causing fragmented sleep, behavioural problems, reduced intellectual activity and cardio-pulmonary defects. OSA being more common in males than in females, and with directly proportional relationship between increasing age and OSA (Godwin et al) ranging from 2% among children to 2.5-6% among adolescents [1]. OSA accounts to 2-4% of adult population between ages of 30-60 years. Reduction of oro-pharyngeal airway producing asphyxia and brief arousal from sleep followed by airway patency restoration and return of airflow level forms the basis of pathogenesis of OSA. During sleep, the upper airway muscle activity is greater so as to compensate for narrowing and high airway resistance. Advanced technologies like CT and MRI are used to evaluate the anatomical characteristics of upper airway and craniofacial structures and determine the site of obstruction. Due to advantages like low cost, easy accessibility, less radiation exposure conventional cephalometry has been clubbed with supine cephalometry so as to detect and characterize the site of obstruction. As the shape and anatomy of upper respiratory tract changes with respiratory movement, dynamic MRI has been introduced as it provides excellent temporal resolution and pharyngeal airway view in sagittal plane.

Methodology

A prospective case control observational study was conducted for a period of around two years in the department of Oral Medicine and Radiology and Department of Radiodiagnosis. The present study included 40 diagnosed cases with age ranging from 28 to 75 years (as diagnosed by Type IV level study) of Obstructive Sleep Apnea (OSA) in medical outpatient department and were sent to the department of Oral Medicine and Radiology for screening and evaluation to be done for the present study. Out of the total sample 6 are females and 34 are males.

- Samples were chosen on the basis of following criteria:
- Age over 25 years

- AHI >10 events/hour during an overnight Type IV level study.
- BMI >25,
- Who complained of habitual snoring and daytime sleepiness
- Patients satisfying Berlin's Questionnaire and STOP BANG Questionnaire.
- Individuals who were willing to undergo this investigation.
- Samples were excluded under the following criteria:
- No other race people are considered other than Asian population
- Children under <18 years are excluded.
- Any pathology related factors affecting the criteria of measurements should be avoided i.e. central causes are avoided.
- All central causes of obstruction were excluded like both airflow and respiratory effort are absent (Obstructive sleep apnea- Efforts to breathe continue, but airflow is absent at nose or mouth).

Ethical Consideration

The protocol of the study has been approved by Scientific and Ethical Committee of IMS, SOA University, Bhubaneswar, India. Each subject was explained about the entire procedure of the study. Those subjects who were ready to participate in the study signed an informed consent. To identify the site of obstruction patients were scanned by dynamic MRI using the machine OPTIMA MR 360 1.5 Tesla. The patients were supine with the head placed is a neutral position to ensure consistent positioning. The pharyngeal airway was imaged in a median sagittal plane. Two transverse plane sections one at the retropalatal (posterior to soft palate) level and the other at retroglossal level (posterior to tongue base) were obtained. 50 images taken during 50 seconds obtained at each location for the midsagittal and two transverse plane section of the pharynx and viewed on a cineloop display. (Figure 1 and 2) The most posterior aspect of hard palate to pharyngeal wall is retropalatal which is further divided into upper, upper mid, lower mid and lower retropalatal. Similarly most posterior point of soft palate to pharyngeal wall is retroglossal and is further divided into upper, upper mid, lower mid and lower retroglossal [2]. But in the present study lower mid retropalatal and upper retroglossal region in sagittal section is considered (FIGURE 3 and 4). Patients whose sagittal images showed obstruction only at the retropalatal region were assigned to Rp group and who showed obstruction at retroglossal region were assigned Rg group. (FIGURE 5) From the transverse axial image, the minimal cross-sectional areas of the airway at the retropalatal and retroglossal levels were measured with the aid of Advanced Workstation software. The normal retropalatal and retroglossal values in axial section as predetermined are 94 mm^2 and 180 mm2 respectively. If the cross sectional area <50% lower limit or degree of collapse >50 % it will be considered an obstruction. So the range will be < 47mm^2 for retropalatal obstruction and <90 mm^2 for retroglossal obstruction.

Results

The data obtained from the sample of 40 cases were recorded as per the protocol of the study. The data was entered into SPSS 16.0 software for statistical analysis. The analysis was divided onto two sections i.e. the first section deals with demographic characteristics of the cases and the second section deals with RP and RG level of obstruction and their correlation with OSA.

Demographic profile

Demographic characteristics like age and gender has a significant impact on the health parameters of human being. In TABLE 1 out of 40 cases of OSA, 14 cases (35%) were below the age of 40, 17 cases (42.5%) were in the age group 40-59 and 9 cases (22.5%) were in the age group >60. It is important to relate this finding to the age composition of Odisha's population. According to the sensus 2011, 9.3 % of Odisha's population are 60 or more years of age while we find 22.5% of OSA cases in the age group of>60 years or above. This indicated 60+age group may be more predominant among OSA. If we look at age pattern, above 60 years population among OSA is predominant in both male and female groups. The age and gender association is not significant among the OSA cases (p value 0.604).

Age	No.	%	2 'p' value
Below 40	14	35	0.294
40-59	17	42.5	
Above 60	9	22.5	
Total	40	100	
Mean ± SD			

Table 1: Distribution of OSA cases by age group.

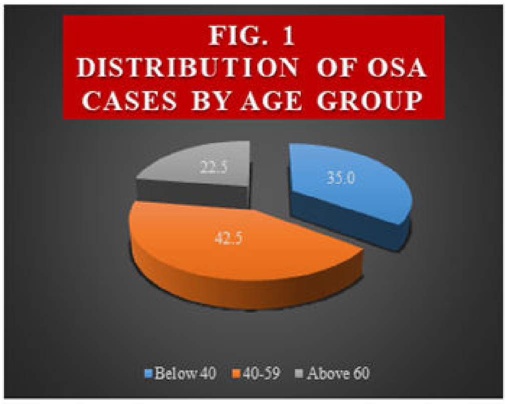

Figure 1: distribution of osa cases by age group.

TABLE 2 and Figure 2 presents distribution of OSA cases by male and female with Binomial test for euality of proportions. It was found that the male comprised of 78% while the female constituted 22% of OSA cases with a significant difference between the two proportions (p value 0.001). this implied the proportions of males among the OSA cases was significantly highest than the females [3]. This suggests that gender has a role to play in the development of OSA with males more prone to develop OSA which may be due to sedentary life style and body built.

Category	N	Observed Prop.	Test Prop.	p
Male	31	0.78	0.5	0.001
Female	9	0.22		
Total	40	1		

Table 2: Distribution of cases by gender(Binomial Test).

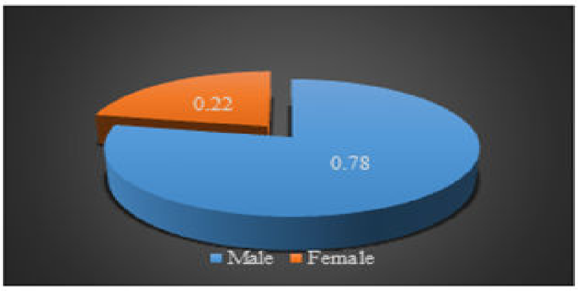

Figure 2: Evaluation of retropalatal and retroglossal characteristics under MRI.

Four parameters like RP (SAG), RG (SAG), RP (AXIAL), and RG (AXIAL) were measured for 40 OSA patients. The descriptive statistics for all these parameters are presented in TABLE 6. Modal value for RP (SAG) was 6 mm and the mean was 5.66±2.98 mm. The first, second and third quartiles were 4.12, 5.20 and 6 respectively. This implies that 75% of cases were having RP (SAG) >4.2 mm and 50% cases were having RP (SAG) >5.20 mm and 25% cases were having >6.0 mm. Similarly RG (SAG) has mean value of 8.94±2.64 mm. the first, second and third quartiles were 6.40, 9.0 and 10.4 respectively. This implies 75% of cases were having RG(SAG) >6.40 mm, 50% cases having >9.0 mm and 25% cases were having >10.4 mm. Modal value for RG(SAG) was 5 mm that means maximum cases the decrease was around 5 mm. This implies that retroglossal obstruction may be a factor next to retropalatal obstruction in the pathogenesis of OSA. has mean value of 8.94 ± 2.64 mm. the first, second and third quartiles were 6.40, 9.0 and 10.4 respectively. This implies 75% of cases were having RG(SAG) >6.40 mm, 50% cases having >9.0 mm and 25% cases were having >10.4 mm. Modal value for RG(SAG) was 5 mm that means maximum cases the decrease was around 5 mm. This implies that retroglossal obstruction may be a factor next to retropalatal obstruction in the pathogenesis of OSA.

	RP-SAG	RG-SAG	RP-Axial	RG-Axial
N	40	40	40	40
Mean	5.66	8.94	47.48	85.92
SE of Mean	0.472	0.418	5.796	6.953
Mode	6	5	30	60
SD	2.983	2.642	36.659	43.975

Table 3: Evaluation of retropalatal and retroglossal characteristics.

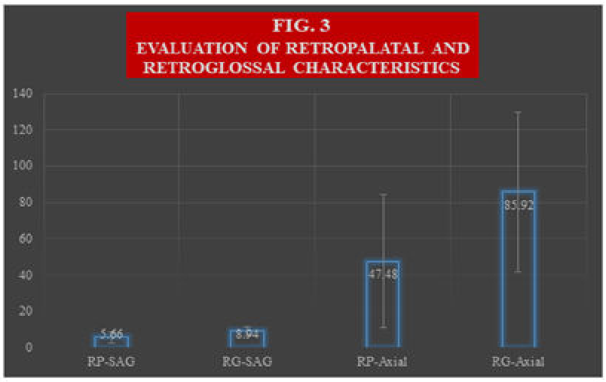

Figure 3: Evaluation of retropalatal and retroglossal characteristic

Mean value of RP (AXIAL) was 47.48 ± 36.66 mm2. The first, second and third quartiles were 26.00, 35.00 and 57.50 mm2 respectively. 75% of the observation were having RP (AXIAL) >26.00mm2, 50% were having >35.00mm2 and 25% were having >57.50mm2. The normal values for RP (AXIAL) is 94mm2 but the mean values and the quartiles values were all below the normal values [4]. The one samples t-test indicated the RP (AXIAL) values of OSA patients were significantly lower than the normal values. (Table 7) This may be the good predictor for severity of OSA.

	N	Mean	t	p
RP-Axial	40	47.48 ± 36.66	-8.027	0
RG-Axial	40	85.92 ± 43.98	-13.53	0

Table 4: Comparison of RP Axial and RG Axial with normal value.

Obstruction observed through MRI

The study was further taken ahead by dividing the samples according to the obstruction site i.e at retropalatal, retroglossal and both at retropalatal and retroglossal obstruction. Table 5 presents the obstruction as evident from the measurements of MRI characteristics. This was classified into four groups as

- Obstruction not evident
- Obstruction evident at RP
- Obstruction evident at RG
- Obstruction evident at RP and RG

It was noticed that in 7 out of 40 cases obstruction was not evident i.e RP and RG measurements could not find obstruction with the patients. In 11 cases obstruction was evident from RP measurements but not through RG. Similarly in 6 cases obstruction was noticed through RG but not through RP. RP and RG together indicated obstruction in 16 cases i.e. 40% of total cases. In 17.5% of the cases, neither RP and RG measurement could indicate any obstruction, this puts a challenge for MRI being a gold standard for the diagnosis of OSA; this requires further investigation.

Obstruction	Frequency	Percent
Obstruction Not Evident	7	17.5
RP Obstruction	11	27.5

RG Obstruction	6	15
RP & RG Obstruction	16	40
Total	40	100

Table 5: Obstruction through MRI characteristics.

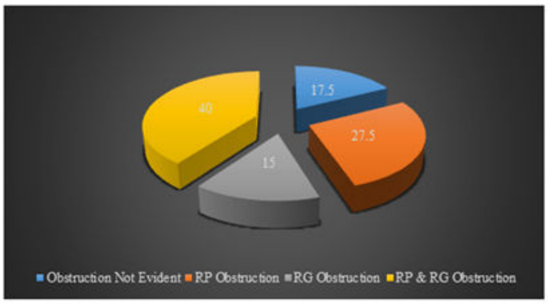

Figure 4: Obstruction through MRI.

Discussion

MRI is the gold standard for OSA patients. The site of obstruction i.e. retropalatal and retroglossal level was evaluated and the mean value was found to be 47.48 ± 36.66 mm2 and 85.92 ± 43.98 mm^2 respectively for RP (axial) and RG (axial). The one sample t-test has found to have a significant p value for both RP and RG (axial). 27.5% have witnessed obstruction with Rp level, 15% have shown RG obstruction and 40% have shown RP+RG obstruction but still 17.5% have witnessed no obstruction through MRI. Similarly according to the study by N.L.N.Moorthy et al, RP cross sectional area has been found with Mean ± SD to be 0.38 ± 0.21 and at Rg it is 0.68 ± 0.36 and in both the p value is 0.02 and 0.015 respectively (significant). Another cross-sectional study with retrospective data evaluated changes in the transverse and anteroposterior diameters of the retro lingual airway during a respiratory cycle in 35 snoring subjects. The degree of collapsibility was measured using axial and sagittal images by cine MRI. The study found 37.1% i.e. 13 subjects had shown airway collapse in the retropalatal area and in both retropalatal and retroglossal regions in 57.1% i.e. among 20 subjects. The degree and site of airway collapse was analysed and grouped into following four subgroups i.e. patent group (5 out of 35, 14.2%), anteroposterior collapse group (14 out of 35, 40%) and circumferential collapse group (15 out of 35, 42.9%). In another study by Bhawana Roy et al5 role of dynamic MRI in assessing OSA was performed among 22 patients. Two patients had normal findings i.e. with no obstruction even though diagnosed with PSG as OSA and AHI index ≤15. Eight patients had retropalatal narrowing, 5 had obstruction at RG and 7 had shown narrowing at multiple levels i.e. at RP, RG and beyond hypopharynx as well. All the sample size had collapse of lateral pharyngeal wall. Another case report by P R Maheswari et al6 wherein MRI was used to evaluate sleep apnea. The pharyngeal cavity is said to be disappearing in trans-axial and sagittal planes and are diagnosed as obstruction and narrowing was evident when pharyngeal cavity disappears in one of the images and there is 50% reduction in pharyngeal space during sleep in comparison to maximum area seen in wakeful state. Reduction in airway space upto 50% is considered. Study by Bhardwaj et al7 concluded that patients with both retropalatal and retroglossal obstruction show signs of skeletal discrepancy predisposing to obstruction at RG level and soft tissue components like soft palate and tongue predisposing to retropalatal obstruction. Those patients with retropalatal obstruction are diagnosed with increased BMI. Similar findings were found in the present study were Pearson correlation coefficient were found to be significant with soft palatal length and thickness and tongue length [5]. Soft palate length is significantly correlated with retroglossal parameters in sagittal dimensions with a value of 0.023 and tongue length significantly correlated with RP (sagittal) with a value of 0.017. Soft palate length is negatively correlated with RP (sagittal) but to a minimal level of -0.397 have found that upper airway volume is smaller in the RP region than in the retroglossal region in both cases and controls and that the length of the total airway and the individual regions (RP/RG) is not equivalent between apneic and normal subjects. Reduced airway in retropalatal region is mostly due to enlargement of lateral walls and the tongue but RG is not changing in calibres in soft tissue structures. The possible reasons being explained by authors are that the airway calibre in RG region is greater than RP Increase in volume of soft tissue region structures surrounding RP region may be a risk factor for apnea because of their effect in RP region but not because of effect in RP region. Volumetric enlargement of the tongue affecting airway calibre in both retropalatal and retroglossal region may not be uniform i.e. such effect is more apparent in RP region than in RG region. The study found size of the lateral pharyngeal wall and tongue is important in development of obstructive sleep apnea. A study by E. Butorova et al9 have found higher tongue dimensions (11.8 ± 1.4 vs. 9.1 ± 1.5 mm^3) and increased soft palatal volume (2.7 ± 0.4 vs. 2.1 ± 0.3 mm^3) increased volume of lateral walls at Rp region (3.5 ± 0.8 vs. 3.0 ± 0.6 mm^3) and RG region (4.5 ± 0.8 vs. 3.0±0.6 mm^3) in comparison with control sample all the above characteristics have a significant p value. They have found lower values of area of airway constriction at both Rp (29 ± 7 vs. 38 ± 11) and Rg (42 ± 6 vs. 57 ± 9 mm^2) and with a significant p value. These results have been found to be consistent with the present study but as no control group has been taken in the study they have not been compared with any control standards and as the objective of the present study was quite different so the necessity for control sample was not mandatory.

Conclusion

MRI is the gold standard in diagnosis of OSA as has been proved in the literature has found a place in the present study as well. The degree of decrease in retropalatal and retroglossal level of pharyngeal dimensions were approximately 6 and 5 mm respectively. This implies that retroglossal obstruction may be a factor next to retropalatal obstruction in the pathogenesis of OSA irrespective of the slice of MRI i.e. whether sagittal or axial as no role to play in diagnosing the OSA10. In 17.5% of the cases, neither retropalatal nor retroglossal measurement could indicate any obstruction, this puts a challenge for MRI being a gold standard for the diagnosis of OSA; this requires further investigation.

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