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Original Research Article

Efficacy of dynamic MRI sleep study in the management of obstructive sleep apnea: an observational study

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ABSTRACT

Background: Obstructive sleep apnea has become a more common health problem owing to a more sedentary lifestyle and work culture. Dynamic MRI in the preoperative evaluation of these patients aims at diagnosing the actual cause, level and pattern of obstruction and guides the surgeon in decision making among the various treatment options established.
Methods: In this retrospective study, Dynamic MRI was performed in 66 patients who were previously diagnosed with polysomnography. The levels and pattern of obstruction were analysed with the severity of AHI grading and their significance in planning the treatment protocol is discussed.
Results: 62 patients had significant retropalatal collapse and 53 had lateral pharyngeal wall collapse in the Dynamic MRI. Retroglossal collapse is usually presenting with the retropalatal collapse and are found in six patients. Collapse at all three levels namely retropalatal, retroglossal and hypopharyngeal are present in three patients. 48 patients were advised for surgical management after pre-operative evaluation with MRI and 30 patients who underwent surgery had promising results at the six month follow up visit.
Conclusion: This study shows that lateral pharyngeal wall collapse is majorly contributory to the AHI severity although multilevel collapse is seen in both mild and severe OSA patients. Hence, Dynamic MRI is suggested before proceeding with the management of the OSA patients.

Keywords: Obstructive sleep apnea, Dynamic MRI, Apnea hypopnea index, Retropalatal collapse, Lateral pharyngeal wall collapse

INTRODUCTION

Obstructive sleep apnea (OSA) as a clinical entity is less understood by the suffering patients and is characterised by episodes of a complete or partial reversible upper airway collapse during sleep.[1] This is caused by the relaxed pharyngeal muscles that block the upper airway in addition to already existing anatomical obstruction. Although polysomnography (PSG) is the gold standard for diagnosing OSA, a few modified standard of care investigations in recent times have been added to the armamentarium of diagnostic test battery.[2] This study aims to audit different levels of collapse and its pattern of obstruction using Dynamic MRI after an initial working clinical diagnosis of OSA. Dynamic MRI captures a series of images while the patient is asleep during normal sleep and records the airway dynamics and patterns of upper airway obstruction and collapse at the retropalatal, retroglossal, retrohyoid, lateral pharyngeal wall and hypopharyngeal regions. It also assesses the bulkiness along with movements of tongue and soft palate against posterior pharyngeal wall.[3] NCCT scans of the region with bone windows help in identifying other static causes of nasal obstruction contributing to OSA. This non-invasive investigative mode establishes correlation between anatomical structures and its dynamic motion during sleep which can help in the better understanding of the actual mechanisms of airway obstruction. Earlier studies conducted focused on the role of dynamic MRI in the evaluation of the OSA. However, this study correlates the sleep MRI findings with the Apnea - Hypopnea Index (AHI) severity and their role in planning whether the patient would benefit from the appropriate treatment strategies tailor made for the patient.

This study aims at establishing the correlation between the polysomnography (PSG) and dynamic MRI in diagnosing the subset of OSA patients and its efficacy in considering the options within the spectrum of treatment protocols. AHI from PSG and various levels of obstruction obtained from dynamic MRI are compared to determine their significance in the OSA patients. This study also correlates various clinical findings noted in the endoscopic evaluation of nose and throat along with the findings of CT PNS and the dynamic MRI images for anatomical variations.

METHODS

A retrospective study of 66 patients who presented to the department of ENT, Head and Neck surgery out-patient department at MGM Healthcare with the clinical symptoms of OSA between February' 2023 to January' 2024 were evaluated with dynamic MRI – sleep study.

Inclusion criteria

18 to 80 years of age, body mass index (BMI) between 18.5-39.9 kg/m^2, clinical symptomatology suggestive of OSA. AHI >5.

Exclusion criteria

We excluded patients whose BMI were greater than 40 kg/m2 and those with contraindications to do MRI.

Dynamic MRI imaging was done in all patients who presented with clinical features of OSA. Demographic details of everyone were collected and assessed along with detailed history, STOP-BANG questionnaire, Epworth sleepiness scale, co-morbid status and personal history.[4,5] General examination findings included height, weight, BMI calculation. BMI of patients were classified based upon the WHO criteria for Asian population.

Clinical examination was done including ear, nose, throat examination. Standard method of assessment included Diagnostic nasal endoscopy, video laryngoscopy, CT PNS in addition to PSG and dynamic MRI sleep study. We noticed anatomical obstructions during endoscopic evaluation like deviated nasal septum, hypertrophied turbinates, adenoid hypertrophy, polypi filling the nasal cavity, reduced oropharyngeal isthmus, circumferential collapse and lateral pharyngeal wall collapse which contribute to the OSA assessment.[6] Sleep study was done in all the patients prior to dynamic MRI and Apnea Hypopnea index was considered before proceeding. Sample size was calculated using Andrew Fisher's formula. Sampling technique used was simple random sampling. Data were entered in excel sheet and Microsoft Word. The variables of the study (AHI severity and level of collapse in dynamic MRI) were analyzed statistically using Pearson chi-square test with the help of SPSS software. This study was submitted for Ethical committee approval on 28/08/2024, with reference cited – IEC 28/AUG/06 and committee approved the article.

Statistical analysis

The resultant data was entered into a prefixed proforma. All statistical analyses were performed using SPSS (SPSS Inc., USA). The χ^2 test or Fisher exact test and independent 2-tailed t-tests were used to compare the clinico-pathological parameters and surgical outcomes, wherever appropriate. Continuous variables were stratified and analyzed as categorical data. The level of statistical significance was set at $p < 0.05$.

MRI protocol

The dynamic MRI, sleep study was performed on a 3 Tesla scanner post lunch or dinner. The imaging was done with the patients in supine position during sleep in the MRI gantry. No sedation was given to make the patients sleep. T1W sequences taken in axial and sagittal planes and run in dynamic mode. Dynamic sequential images were obtained at the rate of one image per second for a duration of one minute in the midsagittal section to represent different levels like retroglossal, retropalatal and hypopharyngeal obstructions and are correlated with corresponding axial cuts in dynamic mode. The duration of each study was approximately 15 minutes.

RESULTS

Of the 66 patients evaluated for obstructive sleep apnea, 17 % of the patients were female and the rest were males (Figure 1). It was also found that OSA is more common in the age group 41- 60 years (53%) (Figure 2). Patients with class I obesity (n=42) presented with the complaints of OSA to the OPD more compared to other categories (Figure 3).

When the 66 patients were further analysed based on the symptomatology, 98 % (n=65) had snoring as primary complaint and 70% (n=46) had apneic spells during sleep as the second primary complaint (Table 1). Out of that, 33 patients had associated co-morbidities in the following frequency: systemic hypertension in 42% (n=28) of the patients, dyslipidemia in 33% (n=22), type II diabetes mellitus in 24% (n=16), coronary artery disease in 6% (n=4), bronchial asthma in 5% (n=3) and hypothyroidism in 3% (n=2). We also found anatomical obstructions such as significant symptomatic deviated nasal septum in 89%

(n= 59) of them, reduced oropharyngeal isthmus in 76% (n=50), tonsillar hypertrophy in 55% (n=36), hypertrophied turbinates in 53% (n=35) and adenoid hypertrophy in 9% (n=6). According to the level of obstruction, 62 patients had collapse at retropalatal level and only 4 patients had no noticeable collapse even with AHI suggestive of OSA.

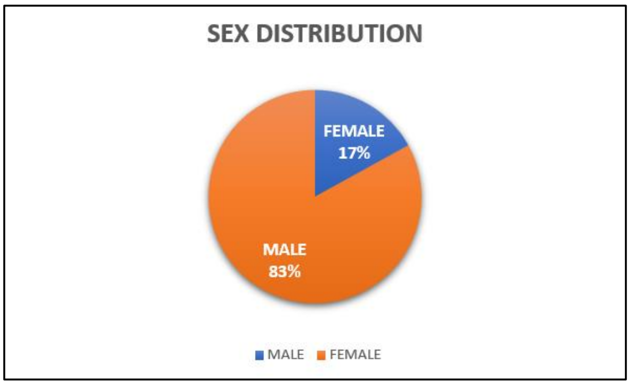

Figure 1: Sex distribution of patients diagnosed with OSA.

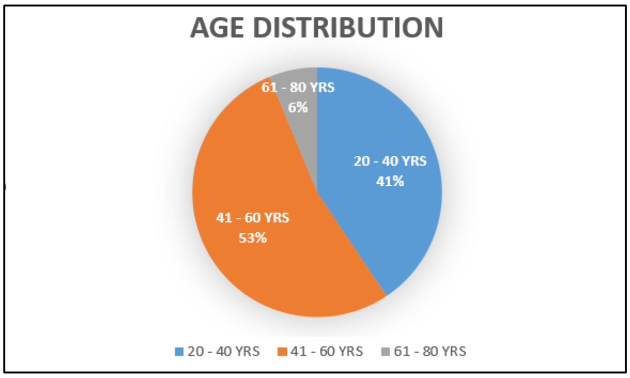

Figure 2: Age distribution of patients.

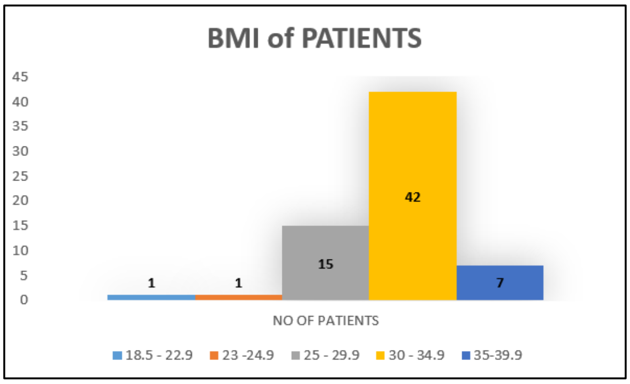

Figure 3: BMI of patients suffering from OSA.

Retroglossal collapse was seen in 9 % (n=6) of the patients and hypopharyngeal level collapse in only 5% (n=3). Lateral pharyngeal wall collapse is seen in 80% (n=53) of the patients evaluated with dynamic parameters (Table 2). All the dynamic parameters were correlated with AHI findings (Table 4-7). Based on the severity of OSA according to the AHI grading from polysomnography, 17% (n=11) had mild level, 29% (n=19) had moderate and 5.4% (n=36) had severe OSA (Table 3).

Of the 66 patients diagnosed with OSA, two patients with mild OSA according to AHI grading had no collapse but had deviated nasal septum. Four patients have mild level of obstruction at the retropalatal level and they were advised for lifestyle modification and weight reduction measures.

Four patients with mild OSA were found to have collapse at retropalatal and lateral wall collapse and one patient had collapse at all four levels. Two patients with moderate and severe OSA patients had no collapse in the dynamic MRI.

Seven patients were class II obese and they were advised for weight reduction measures before surgery for better outcome and advised to use CPAP trial for symptomatic relief in the meantime. Surgery was advised for 48 patients, out of them 30 underwent sleep surgery.

Table 1: Clinical symptomatology of the patients presented to the OPD.

S. no	Clinical features	No of patients	%
1	Snoring	65	98
2	Apneic spells	46	70
3	Nasal block	45	68
4	Daytime sleepiness	37	56
5	Sleep disturbances	43	65
6	Mouth breathing	39	59

Table 2: Dynamic obstructions occurring at various levels in the upper airway.

S. no	Level of obstruction	No of patients	%
1	Retropalatal level collapse	62	93
2	Lateral pharyngeal wall collapse	53	80
3	Retroglossal level collapse	6	9
4	Hypopharyngeal level collapse	3	5

Table 3: Severity of OSA according to their AHI levels.

S. no	AHI	OSA severity level	No of patients	%
1	5-15	Mild OSA	11	17
2	15-30	Moderate OSA	19	29
3	>30	Severe OSA	36	54

Table 4: Severity-retropalatal level collapse.

Crosstab					
			Retropalatal level collapse		Total
			Nil	Present	
Severity	Mild	Count	2	9	11
		% within severity	18.2	81.8	100.0
	Moderate	Count	1	18	19
		% within severity	5.3	94.7	100.0
	Severe	Count	1	35	36
		% within severity	2.8	97.2	100.0
Total		Count	4	62	66
		% within severity	6.1	93.9	100.0
Chi-square tests					
		Value	df	Asymp. Sig. (2-sided)	
Pearson chi-square		3.541[a]	2	.170	
Likelihood ratio		2.774	2	.250	
No. of valid cases		66			

a. 3 cells (50.0%) have expected count less than 5. The minimum expected count is .67.

Table 5: Severity -retroglossal collapse.

Crosstab					
			Retroglossal collapse		Total
			Nil	Present	
Severity	Mild	Count	10	1	11
		% within severity	90.9	9.1	100.0
	Moderate	Count	19	0	19
		% within severity	100.0	0.0	100.0
	Severe	Count	31	5	36
		% within Severity	86.1	13.9	100.0
Total		Count	60	6	66
		% within Severity	90.9	9.1	100.0
Chi-Square Tests					
		Value	df	Asymp. Sig. (2-sided)	
Pearson chi-square		2.903[a]	2	0.234	
Likelihood ratio		4.498	2	0.105	
No. of valid cases		66			

3 cells (50.0%) have expected count less than 5. The minimum expected count is 1.00.

Table 6: Severity-hypopharyngeal collapse.

Crosstab					
			Hypopharynegal collapse		Total
			Nil	Present	
Severity	Mild	Count	11	0	11
		% within Severity	100.0	0.0	100.0
	Moderate	Count	19	0	19
		% within Severity	100.0	0.0	100.0
	Severe	Count	33	3	36
		% within Severity	91.7	8.3	100.0
Total		Count	63	3	66
		% within Severity	95.5	4.5	100.0
Chi-square tests					
		Value	df	Asymp. Sig. (2-sided)	
Pearson chi-square		2.619[a]	2	.270	
Likelihood ratio		3.756	2	.153	
No. of valid cases		66			

3 cells (50.0%) have expected count less than 5. The minimum expected count is .50.

Table 7: Severity-lateral pharyngeal collapse.

Crosstab					
			Lateral pharyngeal collapse		Total
			Nil	Present	
Severity	Mild	Count	5	6	11
		% within severity	45.5	54.5	100.0
	Moderate	Count	4	15	19
		% within severity	21.1	78.9	100.0
	Severe	Count	3	33	36
		% within severity	8.3	91.7	100.0
Total		Count	12	54	66
		% within severity	18.2	81.8	100.0
Chi-square tests					
		Value	df	Asymp. Sig. (2-sided)	
Pearson chi-square		7.952[a]	2	.019	
Likelihood ratio		7.219	2	.027	
N of valid cases		66			

a:2 cells (33.3%) have expected count less than 5. The minimum expected count is 2.00.

DISCUSSION

Obstructive sleep apnea can be caused by both static obstructive pathology and dynamic factors of the upper airway. The dynamic factor plays a key role by the posterior movement of soft tissues in the upper airway causing temporary obstruction and cessation of breathing in an episodic manner.[7-10] The intermittent episodes of apnea and hypopnea during sleep due to the collapse of upper respiratory airway at various levels leads to sleep disturbances. Sleep disordered breathing ranges from habitual snoring, upper airway resistance syndrome, mild, moderate and severe OSA to central sleep apnea, cheyne stokes ventilation and obesity hypoventilation syndrome.

This study showed that OSA is more common in male patients than females aligning with the findings of epidemiology study by Huang et al and also in the study conducted by Franklin et al.[11,12] According to Dong et al, there is an increased association of obesity with obstructive sleep apnea.[13] In this study, majority of the patients fall under the BMI 30-34.9 (n=42). The highly accepted pathophysiology is that increase in the body mass index causes thickening of the fat pad in the soft palate and base of tongue causing it to fall back due to bulkiness and laxity of these structures. Overweight and obesity is a major risk factor and weight reduction and active lifestyle stays as the first measure in the treatment protocol of OSA paralleling with the results of Kuna et al.[14]

OSA coexists with many systemic disorders, most common being systemic hypertension and this statement is supported by the findings of the studies conducted by Lombardi et al and Altay et al.[15,16] This study also demonstrated systemic hypertension is more prevalent in the OSA patients followed by dyslipidemia, diabetes mellitus and other associated cardiovascular events being less commonly seen in this study group. Obstructive sleep apnea is associated with cardiovascular consequences such as pulmonary and systemic hypertension, increased ventricular afterload and congestive heart failure as mentioned by Yeghiazarians et al.[17] Many studies like those of Alshaer et al, have concluded that snoring is the primary symptom reported by majority of the patients and the loudness of snoring is directly related to the severity of the OSA.[18,19] This study shows almost 98% of the patients presented with the complaints of snoring followed by 70% with apneic spells during nocturnal sleep.

PSG was performed for all the patients and who experienced more than five apnea and hypopnea events were taken into the study group. Hence, the diagnosis of all the subjects were confirmed by the gold standard polysomnography.[2] According to the AHI grading 54% had severe OSA in our study group. Endoscopic evaluation of the nose and throat was done and patients were found to have the following anatomical obstructions, deviated nasal septum in 89% of the patients, hypertrophied turbinates in 53 %, adenoid hypertrophy in 9%, tonsillar hypertrophy in 55% and reduced oropharyngeal isthmus in 76%. All these findings were documented and correlated with dynamic MRI and were found to align with it. Although endoscopic evaluation in awake patients provide us with these static parameters, an adjunct investigation of dynamic MRI is contributory.

Dynamic MRI sleep study helps in tailoring the management of OSA patients according to the radiological findings and their direct impact on day to day living. It provides reliable information about obstructive pathology and dynamic factors involved in the causation of OSA.[20] And in correlation with AHI, severe OSA patients are noticed to have more frequent fluttering and posterior movement of the soft palate and the base of tongue. In this study, 62 patients (93%) had retropalatal collapse making it the most common finding in our OSA patients' group and lateral pharyngeal wall collapse in 80%(n=53) of the patients aligning with the study conducted by Han et al.[21] Retropalatal and retroglossal collapse were present in 9% (n=6) and all three level collapse seen in only 5% (n=3) of the patients. This is found to be in correlation with the meta-analysis conducted by Volner et al, except the finding where there are only 9 % patients with retropalatal and retroglossal level obstruction in our study failing in line with their study.[22]

All the dynamic MRI findings were correlated with the OSA severity level obtained from the PSG findings. Among the 11 patients with mild OSA (17%) two patients had no collapse in the dynamic MRI imaging but were noticed to have deviated nasal septum. Remaining nine patients had collapse at various levels. Among 19 patients with moderate OSA according to AHI, three patients had isolated retropalatal collapse, whereas 15 patients had retropalatal and lateral pharyngeal wall collapse.

On analysing remaining 36 patients with severe OSA, 28 patients had retropalatal and lateral pharyngeal wall collapse, two patients had multilevel collapse at retropalatal, retroglossal and lateral pharyngeal wall collapse and three patients had collapse at all these levels along with hypopharyngeal level obstruction. Two patients had no noticeable collapse even though AHI grading were indicative of moderate and severe OSA. As the level of severity increases, multilevel collapse is observed in more patients in our study group.

From the variables, AHI severity and the level of collapse were assessed using Pearson Chi-square test (Table 4-7). However, when considering lateral pharyngeal wall collapse with AHI severity, it is found significant (p=0.019) in reciprocating the apnea and hypopnea of PSG study. Hence, the AHI value is majorly affected by the lateral pharyngeal wall collapse according to this study.

All patients irrespective of the severity of obstruction would benefit from the lifestyle modification.[23] Mild OSA patients with isolated collapse will benefit from this alone while moderate and severe OSA patients will require surgical management or CPAP ventilation according to their needs. A retropalatal level of collapse will require surgery to expand the oropharyngeal isthmus. Obstruction at multiple levels require correction at corresponding regions for the successful outcome of the surgery.

Anatomical obstructions have to be taken into account while performing sleep surgery as patients presenting with snoring along with nasal blockade may have deviated nasal septum that needs correction before addressing the oropharyngeal airway. Sang Woo Yeom et al also associated deviated nasal septum to OSA and nasal surgery also helps in improving quality of life in OSA patients.[24]

In our study, 48 patients were advised for either an isolated sleep surgery or multilevel sleep surgery based on the dynamic MRI evaluation. Out of them, 30 patients were managed surgically while the rest were given options of weight reduction measures and CPAP trial as alternative treatment. Five patients who had only retropalatal level collapse underwent coblation assisted expansion pharyngoplasty, five patients with retropalatal level of obstruction and deviated nasal septum underwent endoscopic septoplasty and bilateral reduction turbinoplasty with coblation assisted expansion pharyngoplasty.

Two patients with mild OSA but no collapse noticed in the dynamic MRI evaluation had deviated nasal septum and found improvement after endoscopic septoplasty surgery. Four patients who were diagnosed with retropalatal level collapse along with deviated nasal septum and adenoid hypertrophy were taken up for endoscopic septoplasty and adenoidectomy with coblation assisted expansion pharyngoplasty and 13 patients who had retropalatal level collapse and lateral pharyngeal wall collapse underwent anterior palatoplasty and expansion pharyngoplasty. Out of three patients with combined retropalatal, retroglossal and hypopharyngeal level collapse, two opted for CPAP trial and 1 patient underwent coblation assisted tongue base reduction and glosso epiglottopexy with thyrohyoid approximation (hyoid suspension) with coblation assisted relocation pharyngoplasty.

According to a study conducted by Anwar et al, dynamic MRI imaging provides valuable information in considering surgical management of OSA patients.[25] All patients who underwent sleep surgery had symptomatic improvement when followed up for a period of six months postoperatively and endoscopic assessment showed significant expansion in the nasopharyngeal and oropharyngeal airway.

The limitation of this study is patients with higher BMI more than 40 kg/m^2 were not able to fit into the MRI gantry and those patients were excluded from the study although having severe OSA. Dynamic MRI will not be useful to differentiate between Upper airway resistance syndrome and Obstructive sleep apnea as the respiratory effort related events (RERA) will be documented by means of level I PSG. Hence, all patients had to undergo PSG as a standard of care for diagnosis of OSA.

CONCLUSION

Dynamic MRI is an imaging modality used in the evaluation of OSA patients and aims at determining the actual site and pattern of obstruction and tailoring the management protocol for the patients. This study verifies that male population are more commonly affected with OSA and the most prevalent finding is retropalatal level of obstruction due to the lengthened and thickened uvula fluttering towards the posterior pharyngeal wall. The major advantage of this investigative method is it is non-invasive and the finding are obtained while the patient is naturally asleep requiring no sedation. Our observation suggests that although PSG is considered gold standard.

Dynamic MRI helps in guiding the surgeon who will benefit from surgical intervention and determining the surgical procedure rather than as a diagnostic tool. This study also suggests that AHI is significantly influenced by the lateral pharyngeal wall collapse rather than other multilevel obstruction caused at retropalatal, retroglossal and hypopharyngeal level collapse. Hence, suggesting that even patients with mild OSA can have significant multilevel collapse and vice versa. This study findings also reiterates the need for the importance of non-invasive methods of assessment of OSA with better patient compliance.

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