“DYNAMIC MR IMAGING OF THE UPPER AIWAY DURING MULLER’S MANOUVRE VERSUS DURING SLEEP – A COMPARATIVE STUDY”

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CERTIFICATE

Thisistocertifythatthedissertationtitled **"DYNAMIC MR IMAGING OF THE UPPER AIWAY DURING MULLER'S MANOUVRE VERSUS DURING SLEEP – A COMPARATIVE STUDY"** submittedby **Dr.S.MUBARAKSAZIRA**appearingfor**M.D (Radiodiagnosis)** degree examination in April 2016 is a bonafide record of work done by her under my guidance and supervision in partial fulfillment of requirement of the TamilNadu Dr. M.G.R Medical University, Chennai. I forward this to the TamilNadu Dr. M.G.R Medical University,Chennai.

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DECLARATION

I **Dr.S.MUBARAKSAZIRA**, solemnly declare that this dissertation titled **"DYNAMIC MR IMAGING OF THE UPPER AIWAY DURING MULLER'S MANOUVRE VERSUS DURING SLEEP – A COMPARATIVE STUDY**" is a bonafide work done by me at the Barnard Institute of Radiology, Madras Medical College and Government General Hospital, under the supervision of the "Dr. S.Babu Peter, M.D., DNB., Professor, Barnard Institute of Radiology," Madras Medical College and Rajiv Gandhi Government General Hospital.This dissertation is submitted to The Tamil Nadu Dr. M.G.R Medical University, towards partial fulfillment of requirement for the award of M.D. Degree Radiodiagnosis.

Place:Chennai

Date: 30.9.2015 **Dr.S.MubarakSazira**

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ABSTRACT

INTRODUCTION:

OSA is characterized by repetitive partial or complete upper airway collapse duringsleep, resulting in disrupted normal sleep architecture and associated with arterial desaturations.The diagnosis of obstructive sleep apnoea is confirmed by overnight polysomnography (PSG). Sleep MRI is a new emerging non invasive modality in the preoperative evaluation of patients with obstructive sleep apnoea.

AIMS AND OBJECTIVES:

- To depict and delineate the various pathologies in the upper airway that contribute to Obstructive Sleep Apnoea.
- To determine the most common level of obstruction and the most common cause of obstruction .
- Dynamic MR imaging during Muller's manouvre can depict these pathologies accurately .
- To correlate these parameters with DISE (Drug Induced Sleep Endoscopy) and overnight polysomnographywhich is considered as the gold standard investigation

MATERIALS AND METHODS:

- This is a prospective study that involved 50 adult patients with moderate to severe grades of Obstructive sleep apnoea with no previous history of upper airway surgery or adenoidectomy or tonsillectomy presenting with symptoms of snoring, excessive daytime sleepiness were selected and

subjected to dynamic MR imaging of the upper airway during awake, asleep and muller manouvre and images were compared.

EXCLUSION CRITERIA :

- History of prior surgery such as tonsillectomy and adenoidectomy or upper airway surgery .
- Uncooperative patients
- Patients with contraindications to MRI such as claustrophobia, MR incompatible metal implants , pacemakers, cochlear implants and other devices.

CONCLUSION :

- It was observed that Muller's maneuver could depict the airway pathologies accurately at par with the images acquired during sleep

INTRODUCTION

BACKGROUND

"Obstructive sleep apnea (OSA)" and **"Upper Airway Resistance Syndrome (UARS)"** are two distinct and related terms in the spectrum of **Sleep-Disordered Breathing (SDB).(1)**

OSA is characterized by repetitive partial or complete upper airway collapse during sleep, resulting in disrupted normal sleep architecture and associated with arterial desaturations.

If the respiratory events occur > 5 times per hour of sleep and associated with symptoms, most commonly snoring, excessive daytime fatiguability, and witnessed apneas, the term obstructive sleep apnea/hypopneasyndrome (OSAHS) is applied. (2)

UARS describes patients with symptoms of OSA and polysomnographic evidence of sleep fragmentation but who have minimal obstructive apneas or

hypopneas (Respiratory Disturbance Index < 5) and do not exhibit oxyhemoglobin desaturation.OSAHS is a gradually progressive disease, even in the absence of weight gain since upper airway damage characterized by palatal denervation with polyneuropathy and inflammatory cell infiltration of the soft palate caused by snoring-related vibrations superimposed with large intraluminal pressure oscillations in the setting of obstruction. (3,4)

The diagnosis of obstructive sleep apnoea is confirmed by overnight polysomnography (PSG). MRI has been highlighted for its ability to perform multiplanar imaging without radiation hazard to localize the site of obstruction and to decide on future management. Sleep MRI is a new emerging non invasive modality in the preoperative evaluation of patients with obstructive sleep apnoea. Cine MR imaging has been scrutinized as an effective alternative for the gold standard investigation of ‘’DISE’’ (Drug Induced Sleep Endoscopy) for localizing

the site of obstruction. It provides information not only about the level of obstruction but also certain important airway measurements which are crucial for preoperative planning .

The incidence of obstructive sleep apnoea is on the rise on par with the global epidemic of obesity and with it also increases the occurrence and probability of the comorbid conditions such as coronary artery disease, diabetes , syndrome X, hypertension , and thus impaired daily life activities and sometimes marital discordance . when it occurs in children , it becomes a source of parental anxiety since it causes increased daytime sleepiness and impairs school performance.

The causes of obstructive sleep apnoea shows a gross variation depending on age. In children the most important cause being adenoid or lingual tonsillar hypertrophy whereas in adults the most common cause is underlying obesity which in turn leads to bulky and thick velum , increased parapharyngeal fat deposition leading to increased parapharyngeal soft tissue thickness or advancing age which

in turn leads to laxity of the muscles leading to glossoptosis, posterior pharyngeal wall collapse , floppy epiglottis which closes the laryngeal inlet during sleep.

Thus the crucial part in managing a patient with obstructive sleep apnoea lies not only in providing with symptomatic relief but also in altering the underlying primary pathology for which surgery is a must in most of the cases .

For decision of the type of surgery , one has to be equipped with information about the type of airway , airway anatomy , level of obstruction , cause of obstruction , length and thickness of soft palate , volumetric analysis of tongue , airway dimensions and their alterations during sleep or snoring to name a few.

It is at this juncture imaging dons its role .

Cephalometry is the age old radiological tool for assessment of craniofacial morphological alterations which could contribute for the pathology such as low placed hyoid bone, altered maxilla mandibular relationship, extrinsic compressions

of the air passage .

Next radiological tool is the computed tomography (CT) which can successfully differentiate the physiological and the pathological pattern of airway and increased parapharyngeal fat or adenoid or tonsillar hypertrophy if any in addition to the craniofacial morphometric alterations but the limitation of CT is multi planar reformation , inability to provide information about the dynamic alterations of the airway which occurs predominantly during sleep .

Sleep MRI as the name implies is acquired during sleep so it can easily detect the dynamic alterations occurring during sleep in addition to the multiplanar reformation, superior soft tissue resolution .

AIM OF THE STUDY

- To depict and delineate the various pathologies in the upper airway that contribute to Obstructive Sleep Apnoea.

- To determine the most common level of obstruction and the most common cause of obstruction .

- Dynamic MR imaging during Muller's manouvre can depict these pathologies accurately .

- To correlate these parameters with DISE (Drug Induced Sleep Endoscopy) and overnight polysomnography which is considered as the gold standard investigation

REVIEW OF LITERATURE

RISK FACTORS FOR OBSTRUCTIVE SLEEP APNOEA

DEMOGRAPHIC CORRELATES :

1.Middle Aged Males (40-70 yrs)

2.Familial Aggregation

ESTABLISHED RISK FACTORS:

1. obesity , central fat distribution .

2.large neck girth (>17inches for males , >18 inches for females)

3.Craniofacial and upper airway abnormalities

Tonsillar hypertrophy, glossoptosis , micrognathia ,inferior placed hyoid

4.Metabolic syndrome

5.Gastrooesophageal Reflux (GERD)

SUSPECTED RISK FACTORS:

1. Genetics (family history)
2. Smoking
3. Menopause
4. Alcohol use before sleep
5. Use of Sedation or Tranquilisers
6. Night time nasal congestion
7. nasal obstruction (deviated nasal septum)
8. Allergic or Atopic Individuals.

CORRELATION OF RISK FACTORS WITH OSA- A SCIENTIFIC BASIS:

1.INCREASING AGE &OSA :

Increased prevalence is due to increased parapharyngeal fat deposition, palatal lengthening, and changes in body structures surrounding the pharynx.

2.GENDER &OSA ;

Males – more incidence (due to increased pharyngeal airway fat deposition)

3.OBESITY &OSA :

Visceral obesity contributes to various anatomical alterations in the airway which in turn is the key factor for increased risk of OSA in these individuals :

1. Reduced lung volume.
2. Loss of caudal traction on the upper airway.
3. Increased airway collapsibility.

4.GENETICS AND OSA :

The gene APO E4 is linked with increased risk of OSA in younger patients .

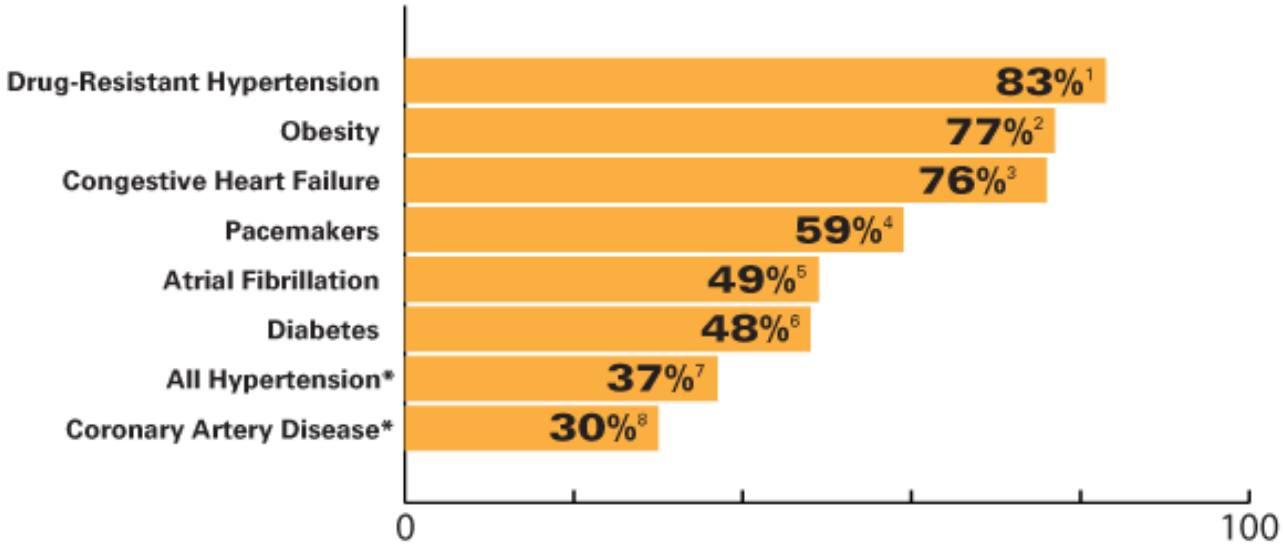
5.SMOKING AND ALCOHOL :

Smoking is associated with increased risk of OSA because of

1. smoking induced inflammation which damages and alters the structure and function of the upper airway

2.alcohol causes relaxation of the upper airway dilator muscles

COMORBIDITIES ASSOCIATED WITH OBSTRUCTIVE SLEEP APNOEA



OSA AND HYPERTENSION :

The risk of developing drug resistant hypertension escalates with the severity of airway obstruction. During normal sleep the blood pressure decreases but in patients with OSA , blood pressure is constantly elevated and prolonged cardiovascular stress even during the day .

OSA AND STROKE :

Patients with sleep disordered breathing are at risk of future stroke episodes

1. Repetitive intermittent hypoxia is an activator of multisystem inflammation

2. Sleep fragmentation results in hypersympathetic activity.

OSA AND TYPE 2 DIABETES:

OSA and type 2 diabetes always go hand in hand since the risk factors are almost identical for both of these multisystem affections.

EPIDEMIOLOGY OF OBSTRUCTIVE SLEEP APNOEA

GLOBALLY:

Consolidated Results of Recent studies carried out in different ethnic groups all over the world. All these prevalence studies were carried out with the aid of overnight polysomnography.(5)

Study population	**Age groups**	**Prevalence**	**Researcher & yr**
American males and females	30-60 yrs	Males: 4-20% Females: 2-20%	*Young 1993*
Spanish males and females	30-70 yrs	Males: 14-26% Females: 7-28%	*Duran 2001*
Chinese males	30-60 yrs	4-8%	*Ip et l 2001*
Chinese females	30-60 yrs	2-7%	*Ip et 2004*
Korean males and females	40-69 yrs	Males: 4-28% Females: 3-16%	*Kim 2004*
Indian males and females	30-60 yrs	Males: 4-28% Females: 2-8%	*Sharma et al 2006*

The 4-year Wisconsin Sleep Cohort Study and Sleep Heart Health Study are the landmark studies till date which assessed the impact of body weight on OSA.

The overall incidence of moderate to severe OSA over a 5-year period was 11.1% for males and 4.9% for females .

IN INDIAN POPULATION :

In India , the epidemic of obesity will certainly propel forwards the OSA syndrome to an increasingly alarming public health issue in the next few years.

Prevalence of sleep disordered breathing and OSA in middle aged urban Indian men as studied by Udwadia et al in a two phased cross sectional study, in Mumbai, reported that the prevalence of SDB was found as 19.5 % and that of OSA as 7.5%. It was also observed that these affected individuals had higher body mass index (BMI), neck girth, waist circumference and waist hip ratio compared to their normal counterparts.(6)

A study of paediatric population carried out in New Delhi showed 12.7% of school children as affected with SDB noted in 4.8% .In those subset of children with snoring and mouth breathing, 60% of the children on PSG showed severe SDB and 30% showed moderate SDB.(7)

CURRENT STATUS OF AWARENESS ABOUT SLEEP MEDICINE IN INDIA

The first scientific meeting in India on sleep research and sleep medicine was organized by Dr.V.Mohan kumar in NewDelhi on September 1992 . During this international conference, the Indian society for sleep research was laid foundation.

DEFINITIONS RELATED TO OSA

APNOEA

Apnoea is defined as "decrease in nasal airflow >90% from the baseline for atleast 10 seconds and atleast 90% of the event's duration must meet the amplitude reduction criteria for apnoea"(8)

HYPOPNOEA :

Hypopnea is defined as "decrease in nasal airflow by more than 30% from the baseline for atleast 10 seconds and >4%oxygen desaturation from the pre event baseline and atleast 90% event duration should meet the amplitude reduction

criteria for hypopnea”(8)

APNOEA/HPOPNOEA INDEX (AHI) :

Defined as total number of apnoea and hypopnoea episodes per hour of sleep(8)

RESPIRATORY DISTURBANCE INDEX(RDI):

Defined as total number of apnoea , hypopnea , and RERA events per hour of sleep

RERA –“Respiratory Event Related Arousals” – increased respiratory effort (for >10secs) in esophageal pressure recording to maintain a normal airflow leading to sleep arousal in EEG (8)

OSAS:

Obstructive Sleep Apnoea Syndrome – OSA + excessive daytime sleepiness(8)

‘’ANATOMICAL ABNORMALITIES IN OSA PATIENTS’’

- **Redundancy of oropharynx**
  1.bulky and thick uvulae

2.’widened mucosa of posterior pillar’ (‘ web formation’)

3. ‘redundant mucosal folds of the lateral and posterior pharyngeal wall ‘

- **‘’A low palatal arch with a long low - hanging soft palate ‘’**

contributes to pharyngeal narrowing which causes airway

collapse due to ‘flap valve mechanism ‘ in inspiration combined with that hypotonic pharyngeal dilator muscle

- **macroglossia**
- **floppiness of epiglottis**
- **tonsillar hypertrophy**
- **redundancy of lateral pharynx**

PATHOPHYSIOLOGY OF OSA

Three factors contribute to the pathophysiology of snoring :

1.surgical anatomy of the upper airway

2.decreased activity of the pharyngeal muscle dilators

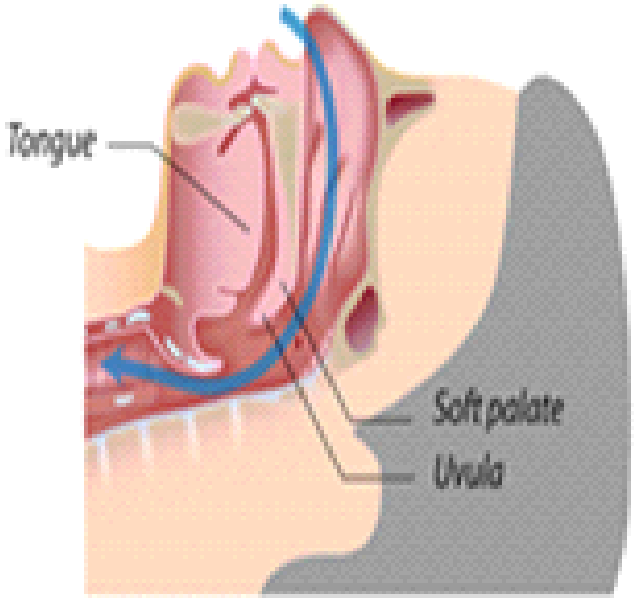
3.exaggerated vacuum created in the upper airway during breathing .

1.''SURGICAL ANATOMY OF THE UPPER AIRWAY'':

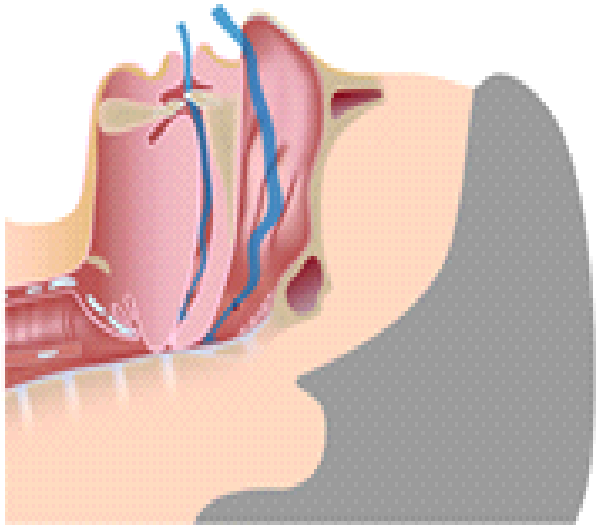
- Incompetent tone of palatal , lingual ,pharyngeal muscles (hypothyroidism) -Adult onset snoring
- Space occupying masses impinging on the upper airway (tonsils & adenoids)
- Excessive length of soft palate and uvula causing compression of the nasopharyngeal aperture
- Restriction to nasal airflow causing increased negative pressures.

The following diagram provides a prompt pictorial representation of the mechanism behind obstructive sleep apnoea:

NORMAL BREATHING

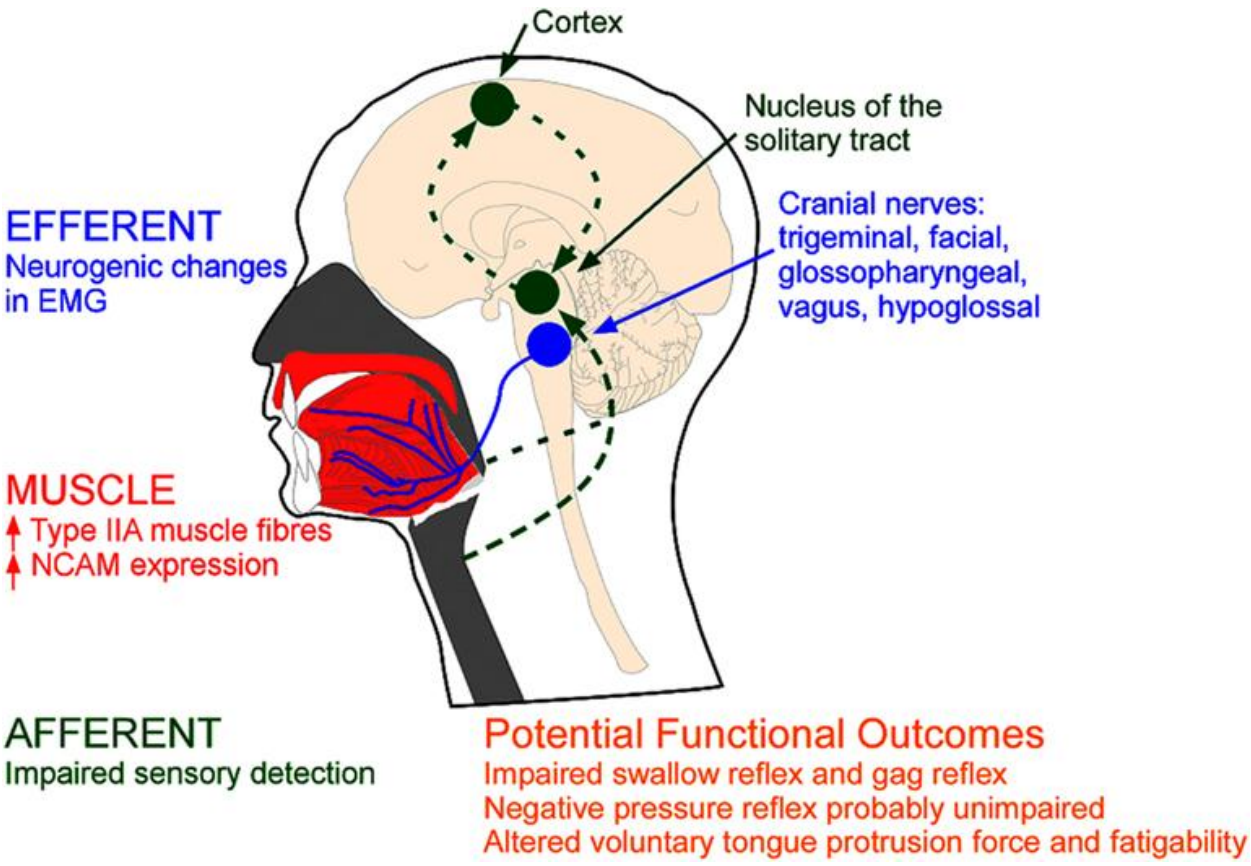


OSA-COMPLETE AIRWAY OBSTRUCTION



NEURAL INJURY IN OBSTRUCTIVE SLEEP APNOEA

‘’Neural injury affecting the upper airway muscles due to repetitive exposure to intermittent hypoxia and/or mechanical strain resulting from snoring and recurrent upper airway closure have been proposed to contribute to OSA disease progression. ‘’



The upper airway muscles are made of both fats and slow variety muscle fibre .

‘’Many Studies have shown that the type 2 A muscle fibre type percentage are on the higher side in ‘uvula’, ‘genioglossus’ , ‘palatopharyngeus’ muscles and they can use both aerobic and anaerobic types of metabolism. Repetitive neural loading with neurotransmitters coupled with nightly eccentric contractions advance the tongue anteriorly with hypoxia can give rise to fibre type alterations’’ – ‘’ Hildebrand’’

MUSCLE	NON OSA %			OSA%		
	TYPE 1	TYPE 2A	TYPE 2B	TYPE 1	TYPE 2A	TYPE 2B
GENIOGLOSSUS	33.3	43.8	18.3	33	53.3	11.6
PALATOPHARYNGEUS	13.7	31.5	1.6	21.6	58.4	0.5
PHARYNGEAL CONSTRICTOR	49	41	9	22	75	2.4
UVULA	10.6	73.5	5.9	8	82	9

The table inference is that percentage of type 2 a muscle fibres contribution to the total muscle bulk of genioglossus, uvula, palatopharyngeus is on the higher

side .

ANATOMICAL CHANGES CONTRIBUTING TO UPPER AIRWAY

MUSCLE REMODELING IN OSA

1.‘’Soft palate and uvula biopsy revealed degeneration of myelinated nerve fibres, axons , muscle fibre atrophy and disruption of muscle architecture ‘’

-‘’Woodson et al’’

2.’’ Palatopharyngeal muscle biopsy revealed an increase in the number of angulated atrophic nerve fibres’’

-[Edstrom et al](45)

3. ‘’soft palate mucosal biopsy showed increase in the density of afferent nerve fibres and increased number of varicose nerve endings ‘’ -‘’Friberg Et Al’’(46)

4.‘’uvula biopsy revealed absence of connective tissue papillae and acanthosis of epithelium and leukocytosis within the lamina propria’’ –‘’paulsen et al’’(47)

5, ‘’Softpalate and tonsillar pillar biopsies showed increased expression of PGP9.5

and increased sarcolemmal expression of N-CAM ‘’ – ‘’Boyd et al”(48)

1. Palatopharyngeal biopsies showed increased variability in the muscle fibres , rounded and atrophic muscle fibres and moth eaten muscle architecture – ‘’De Vuono Et Al’’(49)
2. “Uvula and palatopharyngeal biopsies showed increased capillary density around the muscle fibres and abnormal mitochondrial distribution” -“stal et al” (51,52)

3. “ The vibration due to snoring coupled with the chronic mechanical strain is associated with inflammatory changes to soft tissue structures of the upper airway “(Berger et al., 2002;) (50)

4. “Fatty infiltration of parapharyngeal muscles alters the dynamics of the airway and contractile performance leading to ‘passive’ properties”

- (Busha et al., 2002) (53)

UPPER AIRWAY EFFERENT CHANGES IN OSA PATIENTS

1. " OSA patients demonstrate higher levels of multiunit electromyographic activity (EMG)"- ("Mezzanotte et -al -1992").
2. the genioglossus demonstrated increase in motor unit discharge frequencies with higher neural drive - ("Bailey et al., 2007;)" (54)
3. "increased excitability of the genioglossus was observed in OSA patients and earlier timing of the initial activation of phasic inspiratory motor units is noted" -("Saboisky et al., 2007").(56)
4. "The conduction times of motor evoked potentials are shorter in the genioglossus in OSA patients " - ('Wang et al., 2010'). (55)
5. **NEUROGENIC REMODELING.**

"Chronic denervation of muscle fibers accompanied by reinnervation of the orphaned muscle fibers by collateral sprouting of surviving motor axons " ('Boyd et al., 2004')

EVIDENCE FOR UPPER AIRWAY AFFERENT CHANGES

1. ‘’It is observed that the detection of inspiratory resistive loads to breathing is reduced in OSA patients’’

- (‘’McNicholas 1984’’) (57)

2.’’Edema in the upper aurway reduces airway sensation in OSA patients who are freshly diagnosed and has not undergone any treatment.

Partial resumption of sensation has been observed after 4 months of treatment with CPAP ‘’ – (‘’kimoff’’).

4. ‘’In another study it has been proved that resumption of upper airway sensation has been found to occur even after 2 weeks of CPAP therapy’’- (‘’Tun et a, 2000’’).

5. ‘’Impaired detection of inspiratory resistive load is correlated with diminution of ventilator response to increased levels of carbondioxide’’

-‘’Mc.nicholes et al’’(57)

6. ‘’It has been observed contrary to the expected that the brainstem auditory evoked responses are normal in OSA patients’’- ‘’Mosco Et al’’

7. ‘’ It has been postulated that latency and amplitude measured in the early N1 component of the response to auditory stimuli appear normal and unaltered in OSA patients’’- ‘’Afifi et al ‘’

8. ‘’ it has been noted that there is definite reduction in amplitude but the latency of the early RREP remains constant during inspiration ‘’ - ‘’Akay et al’’

8. ‘’ it has been noted that there is definite reduction in amplitude but the latency of the early RREP remains constant during expiration’’- ‘’grippo et al’’(60)

9.’’It has been postulated that there is significant reduction in the amplitude of the latter N550 component which is a reflector of sensory processing in OSA patients’’- ‘’Gora et al ‘’ (61)

5.‘’Some of the studies were met with the inference that no difference was noted in the P1 amplitude or latency of the RREP which reflects the arrival of sensory information to the cortex in OSA patients ‘’

- ‘’Gora et al ‘’(61)

6.‘’ It was experimentally proven that there was mild axonal neuropathy in the sural, median and ulnar nerves in OSA patients ‘’

- ‘’Mayer et al’’ (62)

7. ‘’ It was also postulated that electroneurography findings of sensory neuropathy was observed in nerves supplying limb muscles and organs in OSA patients’’

– ‘’Fanfulla et al’’(63)

8.‘’ In another study it was proven that notable changes were observed for the compound muscle action potential in the median and ulnar nerves”

-‘’Dziewas et al”

5. ‘’in short it has been observed that there is sensory impairment to various degrees noted in OSA patients. Using this concept it has been postulated that sensory testing using calibrated airflow can be used as a screening test for OSA ‘’

– ‘’Dematteis et al ‘’ (64,65)

FUNCTIONIONAL IMPAIRMENT IN OSA

UPPER AIRWAY REFLEXES :

1. ‘’It has been observed that there is an overall impairment of the swallowing reflex in OSA patients on comparison with the controls. It has also been observed that more bolus volume is required to initiate the swallowing reflex and there is a delay in the latent period of swallowing reflex and increased chances of bolus leakage thro the pharynx’’- ‘’zohar et al’’ (66,67)
2. ‘’In OSA patients the physiological inhibition of inspiration is less pronounced’’ - (‘’Teramoto et al., 1999’’).(68)

3.‘’In patients with severe OSA , diminished reflex to tactile stimuli were observed such as gag reflex” - (‘’Valbuza et a)’’ (69,70)

4.‘’in a recent study based on neurophysiological parameters no difference in the timing and amplitude in the genioglossus muscles could be found during wakefulness in OSA patients” - ‘’Eckert et al”

5.‘’it has also been noted that there was reduced EMG activation in the palatal musculature”-‘’Mortimore et al” (71)

6.The impaired functional reflexes of the velopharynx which are naturally defensive makes the airway prone for aspiration and infection in OSA patients.

TONGUE PROTRUSION FORCE AND FATIGUABILITY

1. ‘’In OSA patients there is an observable obvious increase in the maximum voluntary force of the muscles which help in protrusion of the tongue .” -‘’ MORTIMORE ET AL ‘’ (71)

2. ‘’ Fatiguability which can be defined as the time taken to task failure during sustained isometric protrusion of the tongue at 30, 50 and

80% of maximum .

3.‘’It was observed that there is prolongation of time for recovery of maximal force capacity after submaximal isometric tongue protrusion tasks in OSA patients’’

- (‘’Blumen et al., 2004’’).

4. ‘’In a study carried out at an earlier stage , severity of OSA correlates linearly with maximal tongue protrusion force and did not correlate linearly with fatiguability to a submaximal isometric sustained task”

-(Mortimore et al., 2000). (71)

POTENTIAL ROLE OF NEURAL INJURY IN OSA

1.In short , in OSA patients,

- remodeling of upper airway muscles and proportionate increase

in the type 2 A muscle fibres

- chronic partial denervation like action potentials in neurography
- upper airway muscles appear remodeled .

CLINICAL ASSESSMENT IN OSA PATIENTS

SYMPTOMS OF OBSTRUCTIVE SLEEP APNOEA :

1.DAYTIME SYMPTOMS :

- Excessive Daytime Sleepiness
- Cognitive disturbance
- Erectile dysfunction in males
- Executive dysfunction
- Morning headache
- Gastro oesophageal reflux
- Depression

1. SYMPTOMS DURING SLEEP :

- Snoring
- Gasping / choking

- ❖ Sleep interruptions
- ❖ Nocturnal polyuria
- ❖ Restless sleep
- ❖ Dryness of mouth

ASSESSMENT OF SLEEPINESS:

Subjective assessment :

This involves the use of sleep questionnaires such as:

1. Epworth sleepiness
2. Berlin questionnaires,
3. STOP BANG questionnaire

1. EPWORTH SLEEPINESS SCALE :

In Epworth Sleepiness Scale (ESS), the patient's propensity to fall asleep during seven situations is rated :

1.sitting and reading

2.watching TV

3.lying down to rest

4. sitting inactive in a public space

5.sitting down for lunch

6.conversing

7.sitting in a car stopped a few minutes for traffic

The likelihood of falling asleep is rated on a scale from 0–3, with 3 representing the highest likelihood of falling asleep.

The total score ranges between 0–24, score of more than 10 suggestive of excessive daytime sleepiness .

2. **MODIFIED BERLIN QUESTIONNAIRE :**

It assesses presence , frequency of snoring , day time sleepiness, associated obesity and if hypertension is present and finalizes the Risk categorization and is a reliable predictor for categorizing OSA as mild and moderate degrees .(9)

3. **STOPBANG QUESTIONNAIRE :**

Recently introduced clinical assesment tool which addresses the key

issues regarding OSA and also takes into account the additional risk factors such as neck circumference and collar size of the shirt .(10)

The questionnaire goes this way :

- do you *s*nore loudly ?
- do you feel *t*ired ?
- has anyone *o*bserved you stopping breathing during sleep ?
- do you have high blood *p*ressure ?
- *B*MI > 35kg/m2?
- *A*ge >50 yrs?
- *N*eck circumference > 40 cm ?
- *G*ender male ?

Then the total score is assessed based upon the patient's responses to the above mentioned questions .

SLEEP RELATED BREATHING DISORDERS AND THE RELATED TESTING

There are four subtypes of sleep monitoring procedures available at the outset according to American Academy Of Sleep Medicine .

Type 1 – attended in - laboratory polysomnography (gold std)

Type 2 - portable monitoring methods

Type 3 - cardiorespiratory sleep study

Type 4 - continuous single recording (overnight pulse oximetry)

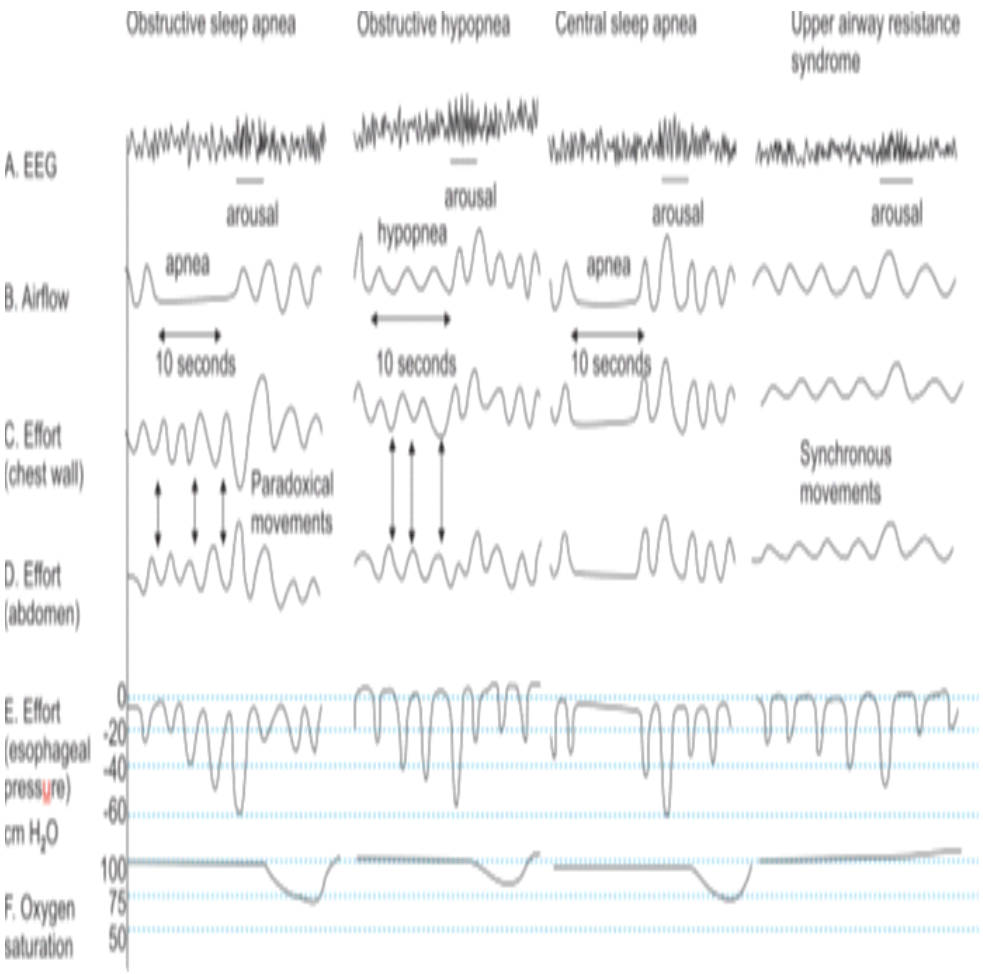
- **POLYSOMNOGRAPHY:**

It is the gold standard multi-parametric test used in the study of sleep. The name is derived from Greek and Latin roots: the Greek word ‘’*polus*’’for "many, much", indicating many channels, the Latin *somnus* ("sleep"), and the Greek ‘’*graphein’’*, "to write". The test result is called a polysomnogram (PSG).

Polysomnography is a comprehensive recording of the biophysiological changes that occur during sleep. It is usually performed at night, when most people sleep,

though some labs can accommodate shift workers and people with circadian rhythm sleep disorders and do the test at other times of day.

The PSG monitors many body functions including brain (EEG), eye movements (EOG), muscle activity or skeletal muscle activation (EMG) and heart rhythm (ECG) during sleep.



DISE (DRUG INDUCED SLEEP ENDOSCOPY)

- It is a powerful tool for studying the dynamic airway in a sleeping patient with obstructive sleep apnea (OSA).

- Using the knowledge gained from sleep endoscopy, the surgeon can tailor the operative procedure to the specific condition .
- Croft and Pringle first proposed sleep endoscopy using midazolam in 1991, they demonstrated the utility of passing a fiberoptic endoscope through a sleeping patient's nasal cavity to assess pharyngeal structures for evidence of obstruction.
- Grading was based on whether the obstruction was
  - palatal,
  - multilevel, or
  - tongue-based.
- Another grading system that uses sleep endoscopy to assess airway obstruction utilizes 3 separate evaluations of the pharynx.

- The first analysis uses a dichotomous assessment to identify individual

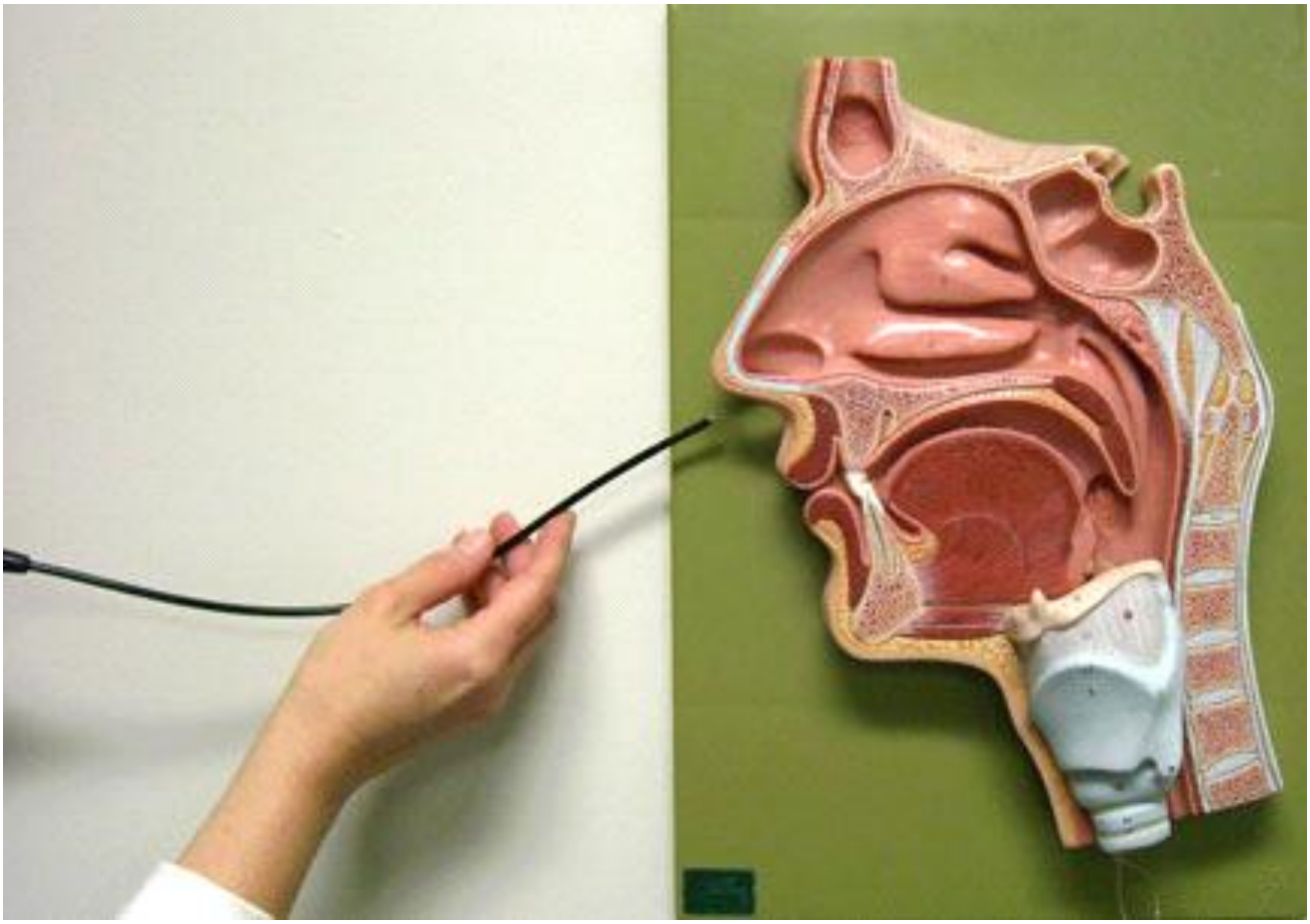
areas of obstruction in the palate and hypopharynx regions.

The second analysis assesses the percentage of obstruction in each area:

<50% - mild

50-75% - moderate

> 75% - severe obstruction



AWAKE FIBEROPTIC ENDOSCOPY

It also affords the opportunity to examine the airway during the Mueller Maneuver.

MUELLER MANEUVER:

It consists of a forced inspiratory effort with the mouth and nose closed performed with the patient in both upright and supine positions and the fiber optic endoscope is passed trans nasally to observe upper airway patency at two different levels :

1.the oropharyngeal level (soft palate and the junction of the nasopharynx)

2.the hypopharyngeal level (just above the epiglottis)

The degree of airway collapse is noted and is graded as follows:

Grade 0	No collapse
Grade 1	25% reduction of cross sectional area
Grade 2	50%reduction in area
Grade 3	75%reduction in area

Grade 4	Complete obstruction

Studies have confirmed that snorers generate more negative inspiratory pressures, prolonged inspiratory time, limitation of respiratory flow.

These changes are pathological exaggerations of the normal respiratory changes in sleep.. It is observed that snoring is worse in slow wave sleep and during the early part of the night, while it is relatively rare during REM sleep.

Muller manouvre is the reverse of Valsalva manouvre.

> 50% obstruction is considered significant.

TYPES OF AIRWAY ANATOMY IN OSA PATIENTS:

classified into 3 types based on upper airway anatomical findings

1) TYPE 1 :

airway narrowing predominantly involves the **oropharynx** and the palatal arch is positioned normally .

2)TYPE II :

palatal arch is in a low position and the tongue is relatively large divided into two subgroups depending on the level of predominant airway narrowing .

IIa : predominantly involves the oropharynx, and the larynx and hypopharynx are easily seen with mirror .

IIb : involves both the oro - and hypopharynx

3). TYPE III :

airway compromise is limited to the **hypopharyngeal airway**

CEPHALOMETRICS

1.Patients who respond poor to UPPP have the following characteristics in cephalometry:

1.Low lying hyoid bone in relation to the mandibular plane.

2. Posterior airway space < 7mm (measured from the tongue base to the posterior pharyngeal wall)

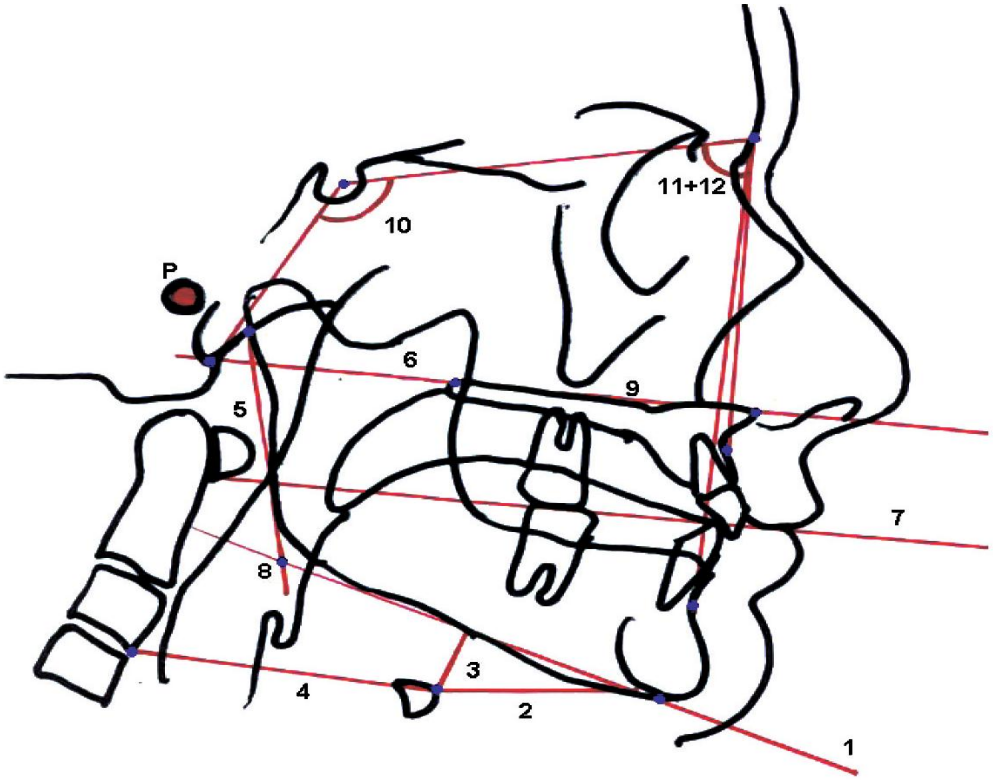
3.distance from the mandible upto the hyoid > 20 mm.

2.Patients with obstructive sleep apnoea were subjected to cephalometric analysis at Scottish sleep centre , Edinburgh for assessing the cranio – cervico facial morphology and analysed twelve variables and measurements.

The results of the study showed that

- the most significant difference Between OSA ansd non OSA patients lay in the hyoid-mandibular plane distance
- and the mandibular corpus height was significantly greater in OSA patients particularly those above the age of 50 years

The cephalometric analysis and the measurements done are outlined in the picture below :



Cephalometric Planes and Angles

1 = gonion-gnathion; 2 = hyoid to retrognathion;

3 = hyoid to mandibular

4 = cervical vertebra 3 to hyoid; 5 = gonion to articulare;

6 =posterior nasal spine to basion; 7 = internal maxillary length

8 =gonion; 9 = anterior nasal spine to posterior nasal spine

10 = sellanasion-basion angle; 11 = sella-nasion-point A angle

12 = sellanasion-point B angle; P = porion

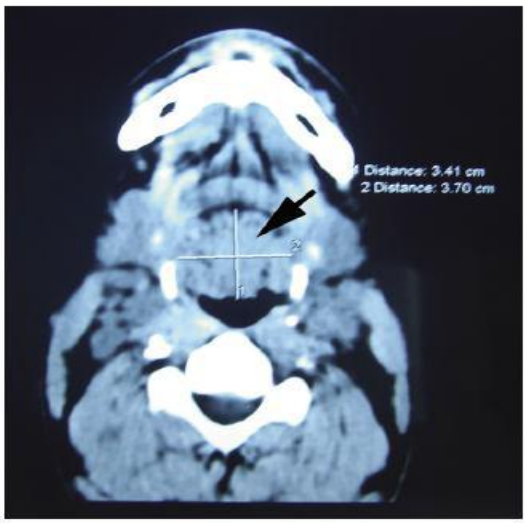
ROLE OF COMPUTED TOMOGRAPHY:

1.The much popular cephalometry cannot successfully evaluate the three dimensional structure such as pharynx as it can provide only a 2 Dimensional image rather than cross sectional images as such its value in diagnosing and treatment of OSA is on the decline and additional imaging modalities are required .

2.CT is done in the supine position and done in different phases of respiration and It can provide information about the cross sectional airway and the site of collapse

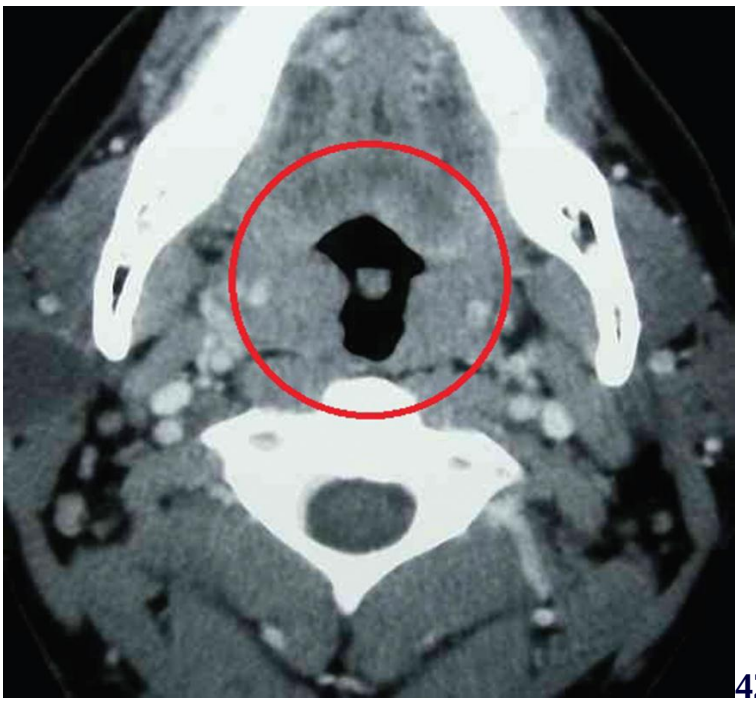
3.CT can provide additional information such as adenoid size, lingual tonsillar hypertrophy, glossoptosis , size of the velum .

4.some of the airway pathologies demonstrated below :



LINGUAL TONSILLAR HYPERTROPHY

PHYSIOLOGICAL PATTERN OF AIRWAY- LATEROLATERAL DIMENSION BEING THE LONGEST



PATHOLOGICAL PATTERN OF AIRWAY

TREATMENT OPTIONS :

Treatment options for OSA fall under three categories :

1. Behavioural Modification

2. Devices that can be worn

3. Surgery

1.BEHAVIOURAL MODIFICATION :

WEIGHT REDUCTION :

Weight reduction leads to improvement in lung volumes thereby reducing pharyngeal resistance and improves nocturnal hemoglobin saturation (11)

SLEEP POSTURE THERAPY :

The patient sleeps on their side or stomach as opposed to on the back, as most patients obstruct more in the supine position.

Pillows or positioners can be helpful to assist in this type of postural therapy.

MITIGATION OF ALCOHOL INTAKE :

Alcohol precipitates and / or aggravates sleep - disordered breathing by depressing

hypoglossal nerve activity which innervates the dilator muscles of the upper airway that stabilize the pharynx against collapse. Reduction or avoidance of alcohol will reduce the frequency and severity .

AVIODANCE OF TRANQUILISERS AND SEDATIVES

AVIODANCE OF HIGH CALORIE OR LARGE FATTY MEAL

9. DEVICES THAT CAN BE WORN :

- **Positive airway pressure:**

  Most effective treatment in moderate to severe grades of OSA in tolerant patients.

  It is available in many forms such as CPAP, bi level positive airway pressure, automatically titrating positive airway pressure and demand positive airway pressure .(12)

  Each delivers positive pressure through a device worn on the face, and serves as an internal pneumatic splint for the airway.

CPAP, the most commonly used form of PAP, typically uses between 5 and 15 cm of water pressure to maintain airway patency.

- **Oral appliances :**

1. **Mandibular repositioning devices**

advance the mandible anteriorly, which brings forward the tongue and other muscles of the oropharynx and hypopharynx.The position of the palate is also changed with the mandibular repositioning device through action of the palatoglossus muscle. It is used for patients with simple snoring and mild apnea. Patients with pre-existing disorders of the temporomandibular joint and edentulous patients are not considered to be good candidates for this device. As with PAP, no training of the airway occurs, therefore nightly use is necessary for treatment effect.(13)

2.Tongue - Retaining Device (TRD)

It increases pharyngeal patency by pulling the superior aspect of the tongue forward, away from the posterior wall of the pharynx .

TYPES OF ANATOMY IN OBSTRUCTIVE SLEEP APNOEA :

There are many classification systems proposed for the anatomy of upper airway

some of which are worth mentioning :

1.Friedman classification

2.Ikematsu classification

3.Fujita classification

IKEMATSU CLASSIFICATION

Ikematsu associated snoring with obesity ,mouth breathing oropharyngeal or hypopharyngeal masses, enlarged uvula, redundant pillar mucosa, macroglossia, retroganthia, supine sleeping posture.(15)

He described a scheme to classify oropharyngeal anatomy using six features :

1. soft palate length (+_ 50mm)

2. uvula length (11mm)

3. wide uvula(10mm)

4. pillar arch morphology(parallel, webbed, embedded, emerging)

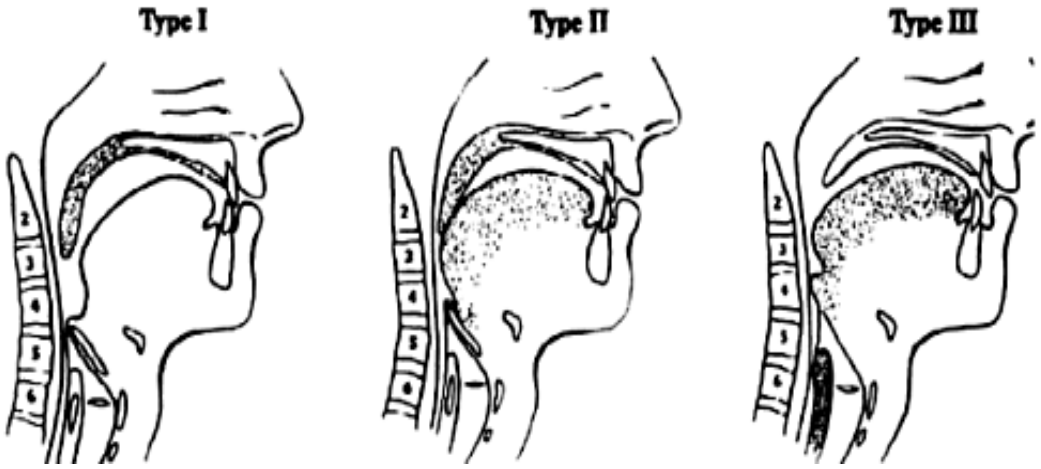
5. oropharyngeal narrowing (anterior arch >2cm , posterior arch >1.5cm , shallow oropharynx <5mm)

6. enlarged dorsum of the tongue (oropharynx not seen with phonation)

FUJITA CLASSIFICATION

- Type 1- abnormalities at the level of upper oropharynx abnormal uvula, palate , tonsils and upper pharynx
- Type 2- patients with oropharyngeal and hypopahryngeal obstruction
- Type 3- hypopharyngeal obstruction alone from tissues of tongue base lingual tonsils, supraglottis and hypopharynx (16)

FUJITA CLASSIFICATION



FRIEDMANN CLASSIFICATION

- It is used for the prediction of outcome of uvulopalatopharyngoplasty (UPPP) in the surgical management of Obstructive Sleep Apnoea .
- Classification is based on

1. Mallampatti classification

2. Body mass index (BMI)

3. Tonsil size

- Stage 1 – tonsils graded 3+ or 4+

  Mallampatti 1 or 2

  BMI < 40 kg/ m2

- Stage 2- intermediate between the extremes

- Stage 3 – tonsils graded 1+or 2 +

  Mallampatti 3/4 BMI > 40 kg/m2

MOORE CLASSIFICATION

Lower pharynx is classified according to the lateral cephalometric X rays based on upper tongue base, lower tongue base, retroepiglottic obstruction.(17)

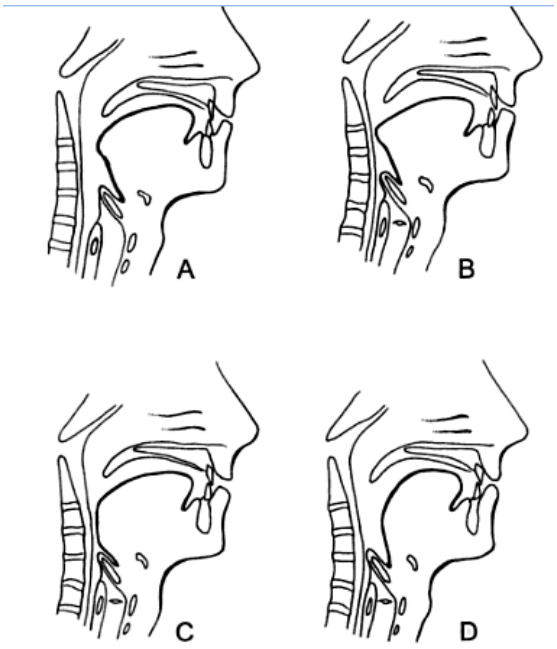
Type A – upper tongue base obstruction with normal lower tongue base and epiglottis

Type B –

Type B1 -combined upper tongue base and epiglottic obstruction

Type B 2 – combined upper, lower tongue base and epiglottic obstruction

Type C- epiglottic obstruction



SURGICAL MANAGEMENT OF OSA :

Surgical procedures to improve PAP use:

In selected patients with elevated pressures, surgery on the upper airway (tonsillectomy , adenoidectomy , nasal surgery)can reduce PAP pressures and improve compliance.

Non-upper airway surgery for OSA

UTILITY OF SURGERY IN OSA :

1. bypassing the obstructive area by tracheostomy
2. eliminating the obstructive lesion in order to prevent soft palate collapse in the upper airway during an apneic episode

Tracheotomy is used on a temporary basis in the perioperative period for patients undergoing upper airway surgery for OSA. (14) Indications include:

1. Morbidly obese patients unable to tolerate PAP
2. Morbidly obese patients with Pickwickian syndrome who require upper airway bypass and nocturnal ventilation
3. Patients Who are unable to tolerate PAP
4. Other Treatment options have failed.

Bariatric surgery is considered when

1. BMI > 40 or
2. BMI > 35 with significant co-morbidities.

UPPER AIRWAY SURGERY IN OSA PATIENTS

INDICATIONS:

1. AHI >20 events / hour.

2.’ Oxygen desaturation nadir’>90%

3. ‘Esophageal pressure more negative’ ‘> -10cm H2O’

4. ‘Cardiovascular derangements’ (arryhtmias, elevated blood pressure)

5. ‘Neurobehavioural symptoms’ (excessive daytime sleepiness)

6. Failure of medical management

7. ‘Anatomical sites of obstruction’ (nose, tongue, softpalate)

CONTRAINDICATIONS:

1. severe pulmonary disease

2.morbid obesity

3.unstable cardiovascular disease

4.alcohol or drug abuse

5.psychiatric instability

CURRENTLY AVAILABLE SURGICAL PROCEDURES

‘’POWELL RILEY TWO PHASE SURGICAL PROTOCOL’’(20)

‘’PHASE 1’’:

- ‘nasal surgery’ (septoplasty , turbinate reduction , nasal valve grafting) (21)
- uvulopalatopharyngoplasty
- ‘tonsillectomy’
- ‘mandibular osteotomy with genioglossus advancement’
- ‘hyoid myotomy and suspension’
- ‘temperature controlled radiofrequency’ (TCRF)- turbinates , palate, tongue base

‘’PHASE 2’’ :

- ‘Maxillomandibular Advanced Osteotomy’
- ‘Temperature controlled radiofrequency (TCRF)’- tongue base

UTILITY OF ‘’ POWELL RILEY SURGICAL PROTOCOL’’

- Offers a tailor made approach for each patient
- Procedures are focused towards specific pathology
- Reduces risk of over operating
- Limited pain and reduced time for regaining well being
- Acceptable for many
- Improved cure rates for phase 2 surgery

‘’RATIONALE FOR SURGICAL PROCEDURES’’

1. ‘Nasal reconstruction ‘
2. ‘Uvulopalatopharyngoplasty’
3. ‘Mandibular osteotomy with genioglossus advancement’
4. ‘Maxillomandibular advancement osteotomy’

NASAL RECONSTRUCTION :

- Nasal obstruction can occur due to turbinate hypertrophy, septal deviation , nasal valve incompetence.
- Main aim of the surgery is to keep the nasal valve open and to reduce mouth breathing(22.23)
- Mouth opening leads to glossoptosis (abnormal posterior motion of tongue)which can occlude the hypopharynx and narrows the air passage
- Surgery consists of septoplasty, turbinate reduction and alar grafting
- Treatment of the nasal obstruction also improves the response to CPAP

UPPP (UVULOPALATOPHARYNGOPLASTY)

Most frequently used for the treatment of OSA and snoring.

- It causes enlargement of the oropharynx pathway and reduces recurrent collapses and thereby number of events of nocturnal hypoxia encountered
- It includes excision of the excess oropharyngeal tissues from the free margin of the uvulae, pillars of tonsil and velum
- Post incision, reconstruction of the oropharynx done by pulling the posterolateral margins of the pharynx and suturing the bilateral palatoglossus muscle

''MANDIBULAR OSTEOTOMY WITH GENIOGLOSSUS ADVANCEMENT''

- The main utility is reduction in the number of episodes of glossoptosis and hypopharyngeal occlusion during sleep
- The mandible is osteotomised rectangularly thereby leading to forward displacement of the genial tubercle , genioglossi and glossum
- Sole surgery that do not alter the dental occlusion or jaw position
- Disadvantage is that not much alteration is done to the glossum when compared to the ‘maxilla mandibular advancement ‘(23)

''HYOID MYOTOMY WITH SUSPENSION ''

- The genioglossi, genio-hyoid and constrictors of the pharynx at the mid neck get inserted to hyoid
- These muscles contributes much to maintain the hypopharynx patent.
- The utility of the procedure is to reduce the collapse of the hypopharynx by anterior advancement of the hyoid
- It can be a separate procedure or in combo with genioglossus advancement for the tongue base

MAXILLOMANDIBULAR ADVANCEMENT OSTEOTOMY

- It is a phase 2 procedure and is the sole procedure that paves more space for the glossum in the mouth (25,26)
- The main aim is to alleviate the rigid obstruction of the hypopharynx by expansion of the maxillary and mandibular frameworks
- Combination of a Le-fort 1 osteotomy with mandibular sagittal split osteotomy
- Success rate of maxillomandibular advancement is improve when used in conjunction with phase 1 procedures

PREPOPERATIVE MANAGEMENT

- ‘’Upper airway surgery in sleep apnea patients can temporarily worsen the sleep apnea and lead to serious and potentially fatal complications, including acute upper airway obstruction, hypoxemia, hypercarbia, myocardial infarction, cardiac arrhythmias, stroke and death’’
- To prevent these complications the impending airway problems should be detected earlier
- It becomes a must to carefully monitor these patients in the postoperative period due to the impending complications.
- Though tere is paucity of published data regarding this , it can be considered that the severity of OSA correlated positively with increased risk of complications
- Considerate decision has to be made regarding the probability of performing the procedure without admitting the patient and later shifting the patient in a vehicle to another hospital or observing the patient for recovering , or the entire monitoring under intensive care .

‘’USE OF CPAP (CONTINUOUS POSITIVE AIRWAY PRESSURE)’’

- In OSA patients there is altered sleep cycle with disruptions which added on to the anxiety caused by sleepless nights can be a hindrance for the surgeon.(29)

- After the completion of surgery , the patient may enter into a deep snoring and this may further account for the recurrence of the disorder nad increased severity
- Thus improving the nocturnal sleep disturbances before and after surgery may prove very beneficial for the patient
- So these patients may be advocated with the use of CPAP for months before surgery and may also carry their device with them in the time before and after surgery (30)
- Most of the patients finally decide to go under the knife after the untiring use of CPAP and not tolerating it so even little utility of the device will grossly improve the outcome

''USE OF NARCOTICS AND SEDATIVES''

- OSA should never be advocated the use of 'narcotics' and 'sedative' 'hypnotics' 'anxiolytics' as they may cause sudden mortality in these patients.
- They depress respiratory drive , cause blunting of the arousal response and leads to fatal hypoxia.
- Benzodiazepine agonists reduce upper airway muscle tone and worsens the disease progression
- Flurazepam increases Apnea Hypopnoea Index

- triazolam increases the threshold level of obstructed passage above which the patient awakens , apnea and hypopnea duration and hypoxic events.(34)
- Besides these when patient with OSA needs these drugs, unrelenting monitoring with pulse oximeter becomes mandatory , and supplemental oxygen may be added upon whenever required (32,33)

''REFLUX AND ASPIRATION PRECAUTIONS'':

- Obesity , a common association in patients suffering from'sleep disordered breathing', can lead to excess fat deposition intraabdominally which leads to increased pressure intraabdominally and thus in turn elevated events of gastroesophageal reflux and increased chances for hiatal hernia.(35)
- Most of the obese patients have excess residual resting gastric fluid > 25 ml preoperatively , acidic pH < 2.5 and escalation in aspiration during induction or extubation. (36)
- Obese patients should be advised with the use of either a 'hydrogen pump antagonist', 'proton pump inhibitor' or 'esophageal motility stimulant' in the preoperative period.(37)

''ALTERNATE METHODS FOR DIFFICULT VENTILATION''

- 'Oral airway'
- 'Long nasopharyngeal airway'
- 'Laryngeal mask airway'

- ‘ Oesophago tracheal combitube’
- ‘Rigid ventilating bronchoscope’
- ‘Intratracheal jet stylet’
- ‘Transtracheal jet ventilation’

‘’ALTERNATE METHODS FOR DIFFICULT INTUBATION’’

- ‘Awake intubation’
- ‘ Light wand’
- ‘Fiberoptic intubation’
- ‘Videolaryngoscope’
- ‘Intubation thro laryngeal mask airway’
- ‘Retrograde intubation’
- ‘Blind nasal intubation’

‘’EXTUBATION ‘’

- ‘’Extubation is another critical time due to potential airway obstruction. The patient should have purposeful movement, recovery of neuromuscular activity, sustainable head lift for at least 5 seconds, and an adequate voluntary tidal volume.’’ (39)
- Verification whether the patient has been fully reversed from the blockade neuromuscular junction to be done before extubating
- patient may be positioned semi-upright or lateral.

- Patients must be extubated awake .(40)

  Many anesthetists prefer not to extubate ‘ deep ’ as the airway may obstruct.
- ‘’ if extubated light or awake, the patient may cough or buck on the tube and cause bleeding into the airway. ‘’
- many ‘medical and surgical contra-indications’ exist for extubating the patient awake
- Children may develop ‘post obstructive pulmonary edema’ when extubated deep because of the negative pressure breathing on an obstructed airway (41)
- As a rule if intubation is easy, extubation also becomes easier.so prior idea can be generated about the possibilities of risks occurring during extubation and anticipation leads to reduced complications
- ‘’The patient should only be extubated with appropriate personnel and equipment present so as to be able to replace the tube if necessary.’’
- The role of additional use of local anaesthetics for improving ‘operative safety’ is still doubtful.(42)
- ‘’ Use of long-acting local anesthetics at the conclusion of surgery may reduce the need for narcotic analgesics but may worsen apnea due to blockage of airway mechanoreceptors that contribute to the arousal stimulus and apnea termination. ‘’

- In short the use of narcotics should be avoided during surgery as there is persistence of their effect in the postoperative period and increased incidence of complications
- The radiologist should be aware of all these hardships in connection with dealing of obstructive sleep apnoea patients since these may also happen when these patients are sedated for the dynamic MR imaging

MATERIALS AND METHODS

METHODOLOGY :

INCLUSION CRITERIA:

This is a prospective study that involved adult patients with no previous history of upper airway surgery or adenoidectomy or tonsillectomy presenting with symptoms of snoring, excessive daytime sleepiness , to the otorhinolaryngology department of Rajiv Gandhi Government General Hospital from March2014-June 2015. The diagnosis of Obstructive sleep Apnoea was made on the basis of clinical history and questionnaires , and apnoea hypopnoea index measured by overnight polysomnography and Drug Induced Sleep Endoscopy (DISE).

Those patients with moderate to severe grades of Obstructive sleep apnoea were selected and subjected to dynamic MR imaging of the upper airway .

The study protocol was approved by the institutional ethical committee and the departmant review board and institutional informed guidelines were observed .

EXCLUSION CRITERIA :

- History of prior surgery such as tonsillectomy and adenoidectomy or upper airway surgery .
- Uncooperative patients
- Patients with contraindications to MRI such as claustrophobia, MR incompatible metal implants , pacemakers, cochlear implants and other devices.

DATA ACQUISITION :

Initial clinical assessment:

Informed consent was obtained from each participating patient and the protocol was approved by the institutional ethical committee. A total of 50 cases were studied . Apnoea Hypopnoea Index (AHI) was determined for each patient with the help of otorhinolaryngologist . Total duration of the complaints were recorded for each patient .

Imaging procedure:

- MR imaging for all the patients were performed using a 3.0 Tesla MRI (SIEMENS – SKYRA). The technique is based on cine MR imaging where 128 consecutive images are done over 2 minutes during episodes of airway obstruction oxygen desaturation, each image approx 1 second.

- The images, done within seconds of each other, can then be presented in a "cine" or movie format.
- The patient lies supine with the neck in a neutral position with the head and neck vascular coil (32 channel)
- Images were acquired in three sets :

    1.awake

    2. muller's manouvre

    3.asleep

- Each set consists of

    1. sagittal image
    2. axial images planned at three levels :

        i.e a.velopharynx,

        b. oropharynx,

        c. laryngopharynx

- The technical parameters is as follows

MR UNIT	3 TESLA SIEMENS SKYRA

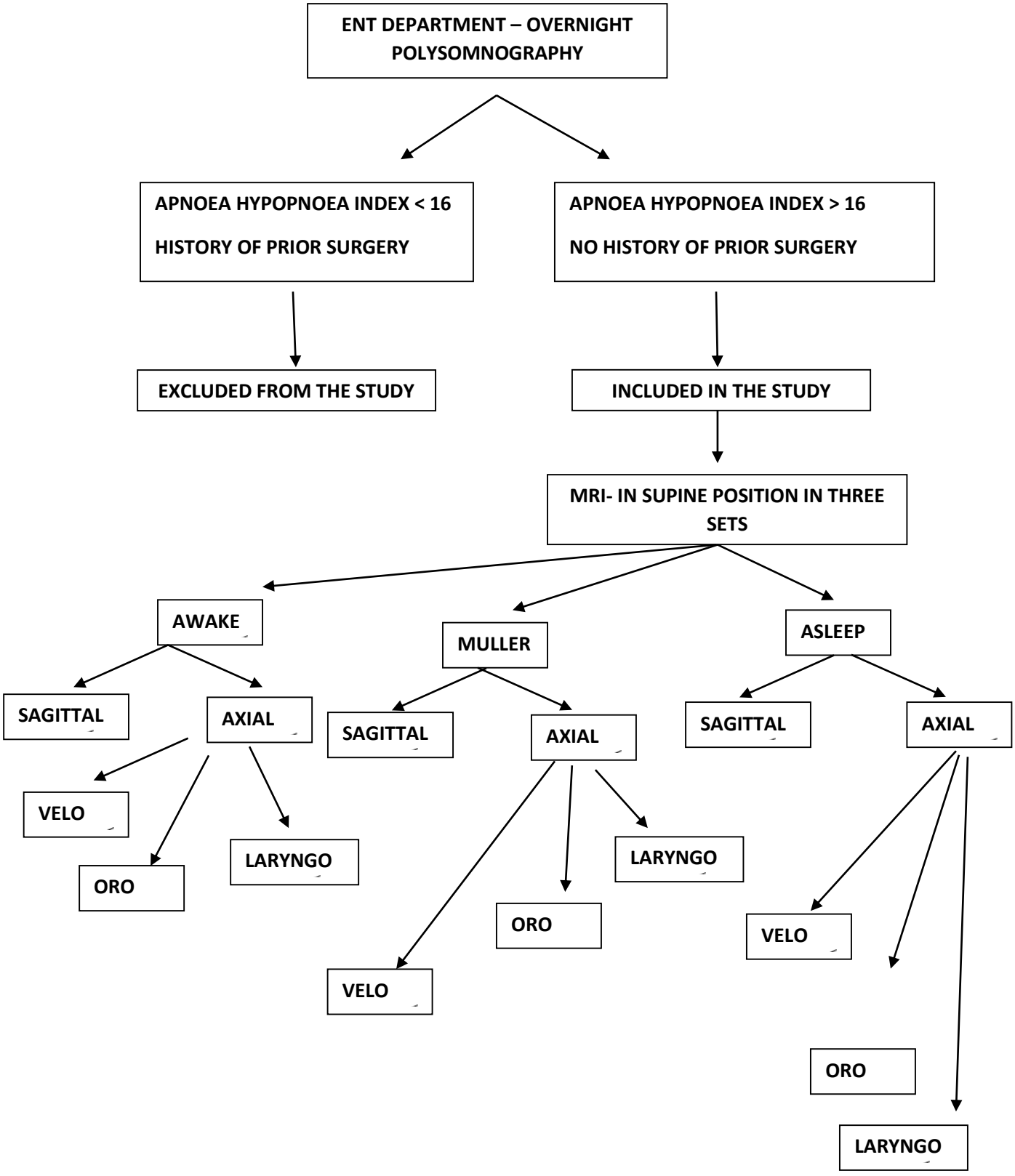
SEQUENCE	T2 FLASH ULTRAFAST CINE SAGITTAL& AXIAL
TR/TE	54.8/2.9
FLIP ANGLE	12
SLICE THICKNESS	4mm
FIELD OF VIEW	20 CM

IMAGE INTERPRETATION :

- We classified a patient as having obstruction at one particular level if there is more than 50% reduction in the cross sectional airway diameter either anteroposterior or lateral or both when copmared to the images acquired in the awake state.
- Images were interpreted under the guidance of an experienced radiologist .
- After analysis of the sagittal and axial images separately i.e awake , muller and asleep . the images are compared with each other to determine the level of obstruction and cause of obstruction
- In addition to the above said measurements of airway dimensions , length and thickness of softpalate was also measured and noted .

- Then the level of obstruction and the cause of obstruction as determined with the muller's manouvre and asleep images were compared with each other and statistical analysis was performed .
- Thus to sum up, parameters studied were
    1. Presence or absence of obstruction
    2. Obtrsuction if present , level of obstruction
    3. Cause of obstruction
    4. Dimensions of soft palate – length and thickness
    5. Airway dimensions – anteroposterior and lateral diameter
- Our protocol differs only with the use of muller 's manouvre in between awake and asleep image acquisition . we confirmed the utility of muller's manouvre by comparing it with the images acquired during sleep.

SYNOPSIS OF IMAGE ACQUISITION



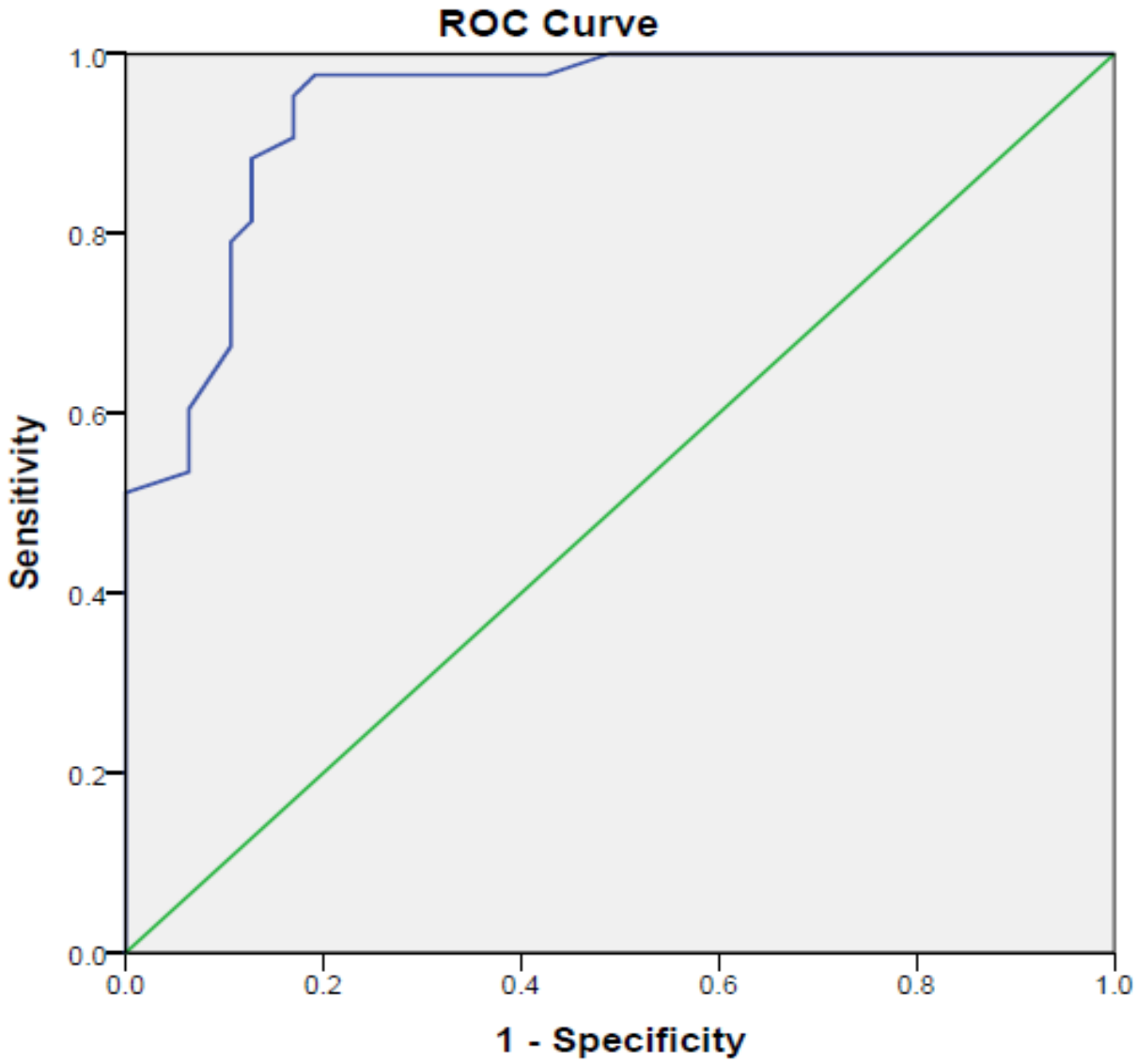
STATISTICAL ANALYSIS

MODALITIES USED

- Receiver operating characteristics (ROC) – to determine the cutoff ratio or threshold relative value of different parameters which had the maximum sensitivity and specificity .
- ROC curves assess the performance of Muller's Manouver in predicting the presence of obstruction in OSA patients . ROC curves have two axis- X and Y. X axis denotes 1-specificity and Y axis denotes sensitivity. Different threshold values were tested and the best obtained. Area Under The Curve (AUC) predicted the best relative value. Cut off values were calculated so as to achieve the highest sensitivity and specificity .
- To find the significant differences between the bivariate samples in paired groups (awake , muller, asleep) paired sample 't' test was used.
- To describe about the data ,descriptive statistics, frequency distribution and percentage analysis were used for categorical variables and for continuous Variables mean and Standard Deviation (S.D) were used.

ROC CURVE FOR MULLER AP DIAMETER :

- ROC curve was calculated between the percentage of positive cases detected by dynamic MR imaging during muller manouvre which correlated with the gold standard investigation , and the percentage of positive cases detected by dynamic MR imaging during sleep which correlated with the gold standard investigation



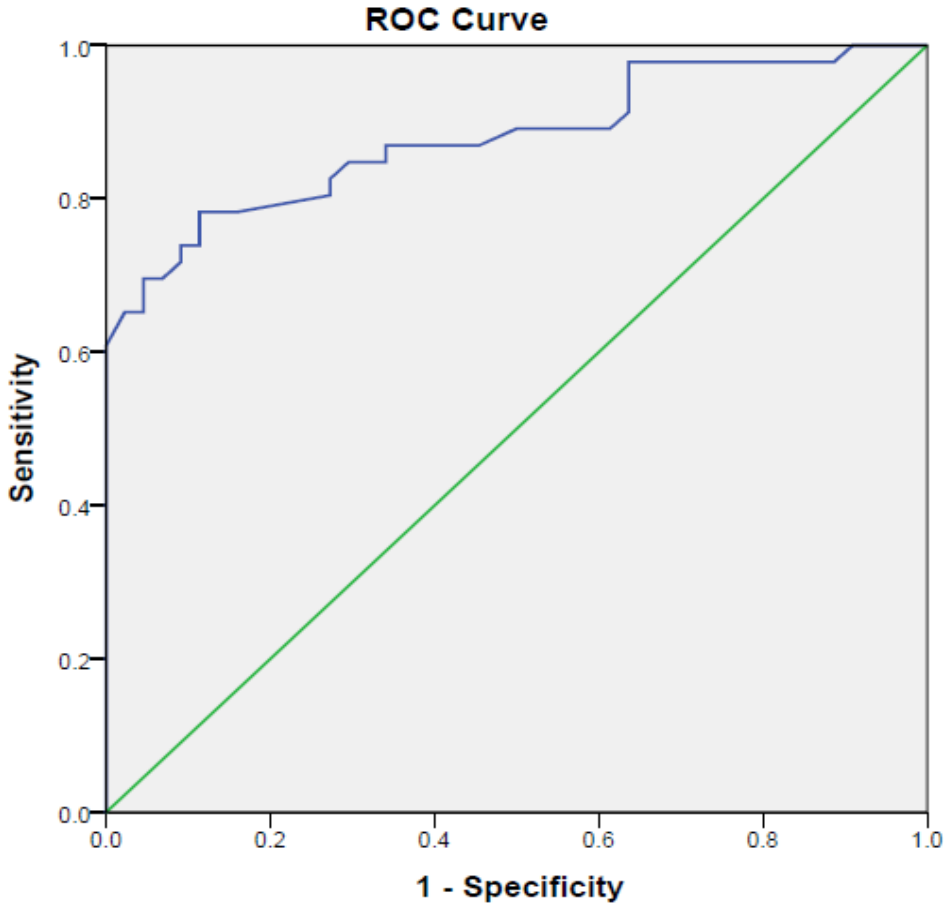
Area under the curve	0.939
Standard error	0.024
Significant p value	0.0001
95% confidence interval	0.892-0.985

- ROC Curve for Muller manouvre with anteroposterior diameter as the criteria for diagnosing obstruction with 1-specificity in the x axis and sensitivity in the Y axis shows the curve to lie in the superior right end of the reference line with sensitivity of 88.4% and specificity of 87.2% with a cutoff value of 6.4. Area under the curve is 0.939 which indicates significant accuracy to indicate obstruction with a p value of less than 0.0001

ROC CURVE FOR MULLER LATERAL DIAMETER :

- ROC curve was calculated between the percentage of positive cases detected by dynamic MR imaging during muller manouvre which correlated with the gold standard investigation , and the percentage of positive cases detected by dynamic MR imaging during sleep which correlated with the gold standard investigation.
- ROC Curve for Muller manouvre with anteroposterior diameter as the criteria for diagnosing obstruction with 1-specificity in the x axis and sensitivity in the Y axis shows the curve to lie in the superior right end of the reference line with sensitivity

of 78.3% and specificity of 84.1% with a cutoff value of 7.35. Area under the curve is 0.88 which indicates significant accuracy to indicate obstruction with a p value of less than 0.0001



Area under the curve	0.880
Standard error	0.037
Significant p value	0.0001
95% confidence interval	0.808-0.952

AIRWAY DIMENSIONS AT THE VELOPHARYNGEAL LEVEL:

- Airway dimensions i.e anteroposterior and lateral dimensions were measured at the axial images during awake state, during muller's maneuver, and during asleep states . comparison between these were made using ''**paired T Test''** comparing in a pair of 6 .

Paired Samples Test[a]

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	AWAKE AP - MULLER AP	5.7300	5.3171	.9708	3.7446	7.7154	5.903	29	.000
Pair 2	AWAKE AP - ASLEEP AP	4.5967	5.2320	.9552	2.6430	6.5503	4.812	29	.000
Pair 3	MULLER AP - ASLEEP AP	-1.1333	.9007	.1644	-1.4697	-.7970	-6.892	29	**.213**
Pair 4	AWAKE LATERAL - MULLER LATERAL	8.8100	6.9887	1.2760	6.2004	11.4196	6.905	29	.000
Pair 5	AWAKE LATERAL - ASLEEP LATERAL	8.0667	6.9118	1.2619	5.4857	10.6476	6.392	29	.000
Pair 6	MULLER LATERAL - ASLEEP LATERAL	-.7433	.8966	.1637	-1.0781	-.4085	-4.541	29	**.133**

In the above paired "t"test for the velopharyngeal level there was

1. Significant difference between the airway dimensions during awake and muller manouvre in both anteroposterior and lateral diameters with p value less than 0.0001

2. Significant difference between the airway dimensions during awake and asleep in both anteroposterior and lateral diameters with p value less than 0.0001

3. No significant difference between the airway dimensions during muller's and asleep in both anteroposterior and lateral diameters with p value of about **0.213** and **0.133** respectively.

AIRWAY DIMENSIONS AT THE OROPHARYNGEAL LEVEL

- Airway dimensions i.e anteroposterior and lateral dimensions were measured at the axial images during awake state, during muller's maneuver, and during asleep states . comparison between these were made using ''**paired T Test''** comparing in a pair of 6 .

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	AWAKE AP - MULLER AP	5.4700	5.0919	.9297	3.5686	7.3714	5.884	29	.000
Pair 2	AWAKE AP - ASLEEP AP	5.3133	4.6987	.8579	3.5588	7.0679	6.194	29	.000
Pair 3	MULLER AP - ASLEEP AP	-.1567	1.0944	.1998	-.5653	.2520	-.784	29	.439
Pair 4	AWAKE LATERAL - MULLER LATERAL	5.1733	3.8918	.7105	3.7201	6.6266	7.281	29	.000
Pair 5	AWAKE LATERAL - ASLEEP LATERAL	4.8200	3.9677	.7244	3.3384	6.3016	6.654	29	.000
Pair 6	MULLER LATERAL - ASLEEP LATERAL	-.3533	1.0523	.1921	-.7463	.0396	-1.839	29	.076

In the above paired “t”test for the oropharyngeal level there was

1. Significant difference between the airway dimensions during awake and muller manouvre in both anteroposterior and lateral diameters with p value less than 0.0001

2. Significant difference between the airway dimensions during awake and asleep in both anteroposterior and lateral diameters with p value less than 0.0001

3. No significant difference between the airway dimensions during muller’s and asleep in both anteroposterior and lateral diameters with p value of about **0.439**and **0.076** respectively.

AIRWAY DIMENSIONS AT THE HYPOPHARYNGEAL LEVEL

- Airway dimensions i.e anteroposterior and lateral dimensions were measured at the axial images during awake state, during muller’s maneuver, and during asleep states . comparison between these were made using ‘’**paired T Test’’** comparing in a pair of 6 .
- In the paired “t”test for the oropharyngeal level there was
- 1. Significant difference between the airway dimensions during awake and muller manouvre in both anteroposterior and lateral diameters with p value less than 0.0001

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	AWAKE AP - MULLER AP	5.0700	5.1429	.9390	3.1496	6.9904	5.400	29	.000
Pair 2	AWAKE AP - ASLEEP AP	5.6167	4.3687	.7976	3.9854	7.2480	7.042	29	.000
Pair 3	MULLER AP - ASLEEP AP	.5467	2.3117	.4221	-.3165	1.4099	1.295	29	.205
Pair 4	AWAKE LATERAL - MULLER LATERAL	6.6700	6.9779	1.2740	4.0644	9.2756	5.236	29	.000
Pair 5	AWAKE LATERAL - ASLEEP LATERAL	7.5467	6.5515	1.1961	5.1003	9.9930	6.309	29	.000
Pair 6	MULLER LATERAL - ASLEEP LATERAL	.8767	3.3331	.6085	-.3679	2.1213	1.441	29	.160

2. Significant difference between the airway dimensions during awake and asleep in both anteroposterior and lateral diameters with p value less than 0.0001

3. No significant difference between the airway dimensions during muller's and asleep in both anteroposterior and lateral diameters with p value of about **0.205** and **0.160** respectively.

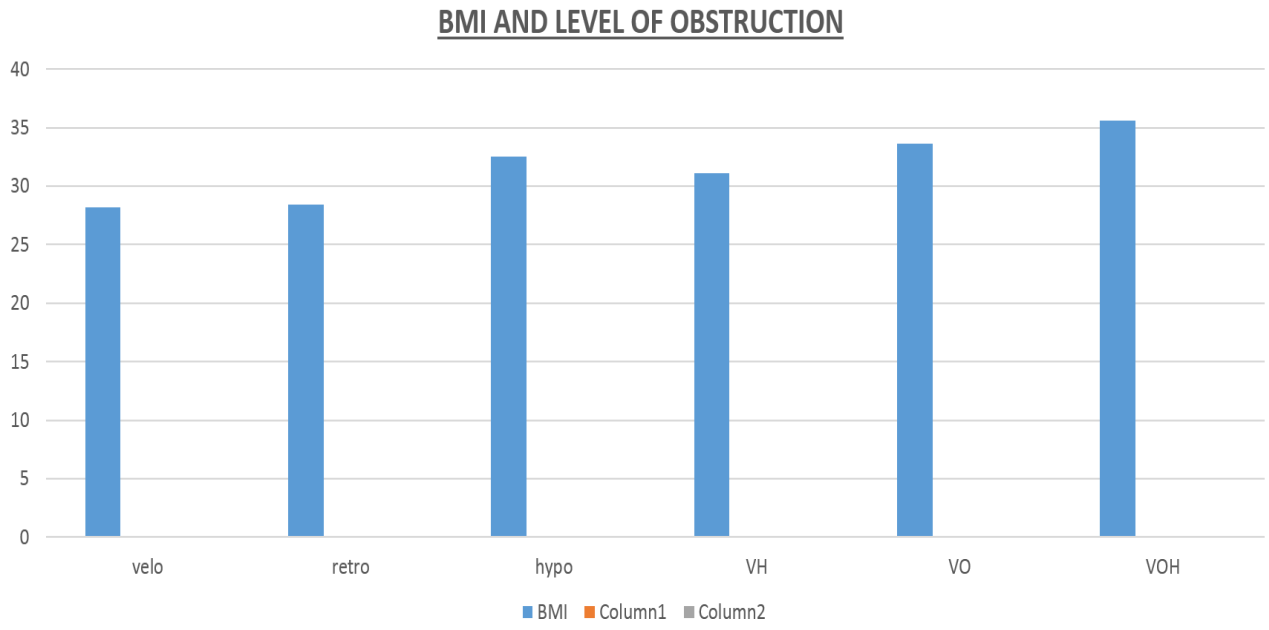
OBSERVATION AND RESULTS

OBSERVATION :

In this study, 50 patients were enrolled who were diagnosed to have Obstructive Sleep Apnoea (OSA) with overnight polysomnography and then subjected dynamic MR imaging of the upper airway.

BMI DISTRIBUTION:

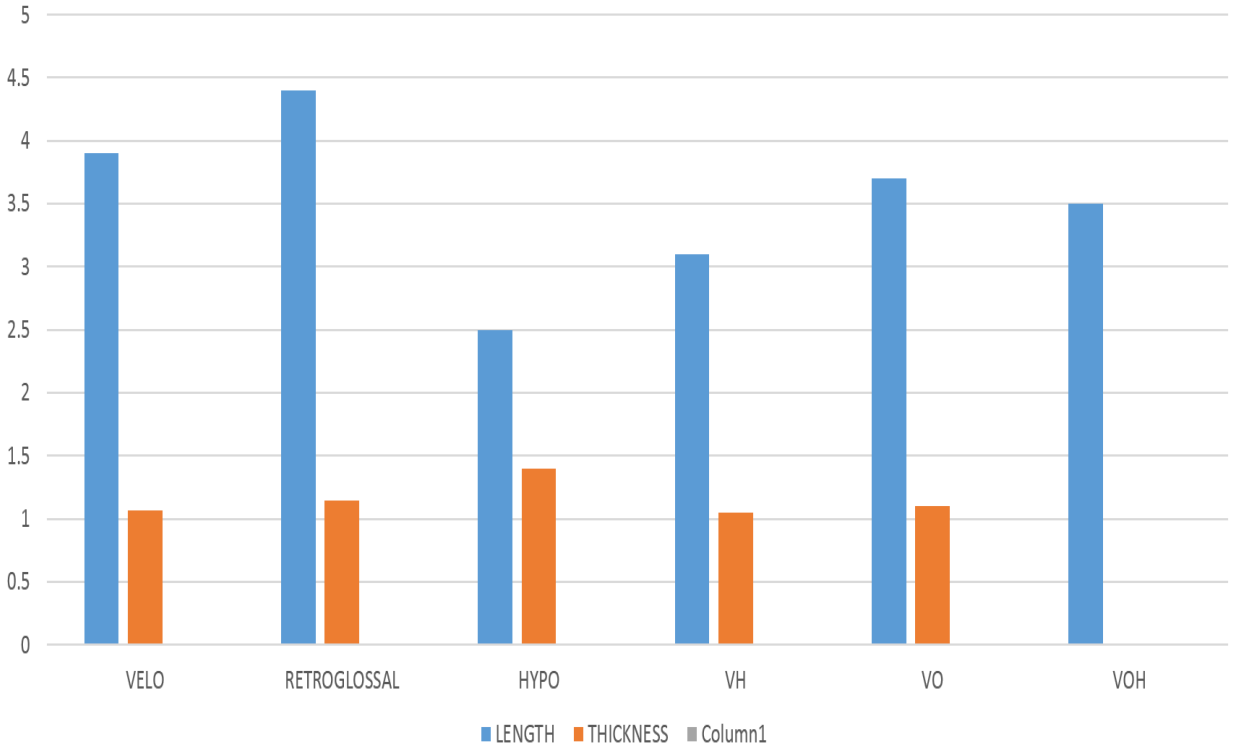
In this study out of 50 patients , 3 patients were diagnosed with no obvious obstruction and those [patients with demonstrable obstruction had their BMI on the higher side (Figure 6.1)



Patients with level of obstruction at the velopharynx, retroglossal, hypopharyngeal,combined levels of velopharynx and hypopharynx, velopharynx and oropahrynx , velopharynx,oropharynx and hypopharynxhad their mean BMI of around 28.2, 28.4,32.5,31.1,33.6,35.6 respectively.

DIMENSIONS OF THE VELUM :

Length and thickness of soft palate were measured in 47 patients with level of obstruction at various levels (figure 6.2)



LEVEL OF OBSTRUCTION	LENGTH OF SOFTPALATE(cm)	THICKNESS OF SOFT PALATE(cm)
velopharynx	3.9	1.07

retroglossal	4.4	1.15
hypopharyngeal	2.5	1.4
Velo-hypopharynx	3.15	1.05
Velo-oropharynx	3.7	1.1
Velo-oro-hypo	3.5	0.9

CORRELATION BETWEEN LEVEL OF OBSTRUCTION BMI AND DIMENSIONS OF VELUM:

Following are tables of descriptive statistics of level of obstruction and BMI and dimensions i.e length and thickness of velum .

LEVEL OF OBSTRUCTION – VELOPHARYNX :

	MINIMUM	MAXIMUM	MEAN	S.D
BMI	23.5	38	28.25	4.6
LENGTH	2.6cm	5.2 cm	3.9 cm	0.75
THICKNESS	0.8 cm	1.4 cm	1.076 cm	0.19

It was observed that in patients with velopharyngeal obstruction , mean BMI was around 28.2 with a standard deviation of about 4.6. The mean length of soft palate

was around 3.9 cm with a standard devaition of about 0.75 and the mean thickness of softpalate was around 1.076 cm with a standard deviation of about 0.19

LEVEL OF OBSTRUCTION – OROPHARYNX :

	MINIMUM	MAXIMUM	MEAN	S.D
BMI	24.3	32.5	28.4	5.7
LENGTH	3.8 cm	5.0 cm	4.4 cm	0.84
THICKNESS	1 cm	1.3 cm	1.15 cm	0.2121

It was observed that in patients with oropharyngeal obstruction , mean BMI was around 28.4 with a standard deviation of about 5.7. The mean length of soft palate was around 4.4 cm with a standard deviation of about 0.84 and the mean thickness of softpalate was around 1.15 cm with a standard deviation of about 0.21.

LEVEL OF OBSTRUCTION – HYPOPHARYNX :

	MINIMUM	MAXIMUM	MEAN
BMI	32.5	32.5	32.5
LENGTH	2.5 cm	2.5 cm	2.5 cm
THICKNESS	1.4 cm	1.4 cm	1.4 cm

It was observed that in patients with hypoopharyngeal obstruction , mean BMI was around 32.5. The mean length of soft palate was around 2.5 cm and the mean thickness of softpalate was around 1.4 cm .

LEVEL OF OBSTRUCTION –NONE:

	MINIMUM	MAXIMUM	MEAN	S.D
BMI	17	20.5	19.16	1.89
LENGTH	2.5 cm	4.0 cm	3 cm	0.866
THICKNESS	0.4 cm	1.2 cm	0.8 cm	0.400

It was observed that in patients with no obstruction , mean BMI was around 19.16 with a standard deviation of about 1.89. The mean length of soft palate was around 3.0 cm with a standard deviation of about 0.86 and the mean thickness of softpalate was around 0.8 cm with a standard deviation of about 0.4

LEVEL OF OBSTRUCTION – VELO & HYPOPHARYNX :

	MINIMUM	MAXIMUM	MEAN	S.D
BMI	25.7	36.5	31.1	7.6
LENGTH	2.7 cm	3.6 cm	3.15 cm	0.6
THICKNESS	0.9 cm	1.2 cm	1.05 cm	0.2121

It was observed that in patients with multilevel obstruction at velopharynx and hypopharynx , mean BMI was around 31.1 with a standard deviation of about 7.6. The mean length of soft palate was around 3.15 cm with a standard deviation of about 0.6 and the mean thickness of softpalate was around 1.05 cm with a standard deviation of about 0.2121.

LEVEL OF OBSTRUCTION – VELO & OROPHARYNX :

	MINIMUM	MAXIMUM	MEAN	S.D
BMI	24.6	40	33.656	5.107
LENGTH	2.4 cm	4.5 cm	3.789 cm	0.66
THICKNESS	0.8 cm	1.5 cm	1.14 cm	0.2160

It was observed that in patients with multilevel obstruction at velopharynx and oropharynx, mean BMI was around 33.656 with a standard deviation of about 5.1. The mean length of soft palate was around 3.789 cm with a standard devaition of about 0.66 and the mean thickness of softpalate was around 1.14 cm with a standard deviation of about 0.216.

LEVEL OF OBSTRUCTION – VELO & ORO & HYPOPHARYNX

	MINIMUM	MAXIMUM	MEAN	S.D
BMI	34.7	37.5	35.66	1.5
LENGTH	3.0 cm	3.9 cm	3.5 cm	0.48
THICKNESS	0.9 cm	1.1 cm	0.99 cm	0.0833

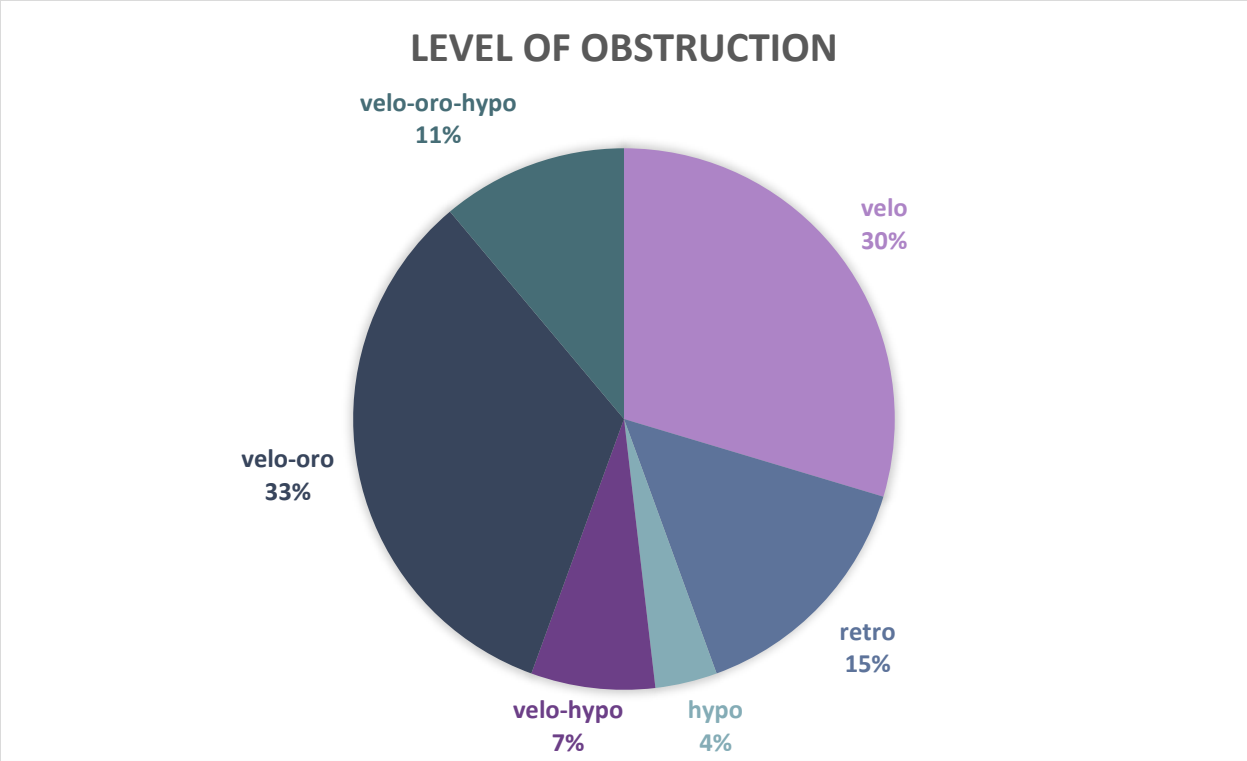
It was observed that in patients with with multilevel obstruction at velopharynx oropharynx and hypopharynx, mean BMI was around 35.66 with a standard deviation of about 1.5. The mean length of soft palate was around 3.5 cm with a standard devaition of about 0.48 and the mean thickness of softpalate was around 0.99 cm with a standard deviation of about 0.0833.

LEVEL OF OBSTRUCTION

Of the 50 patients investigated, 47 patients demonstrated

airway obstruction at single or multiple levels as illustrated in (Figure 6.3).

the most common level of obstruction was found to be combinedat the level of velopharynx and oropharynx (33%) followed by single at the level of velopharynx (30%) , retroglossal contributing about 15%, triple level obstruction of velo- oro- hypopharynx (11%).with the least common level in combined is velo and hypopharynx (7%) and in single level is hypopharynx (4%)



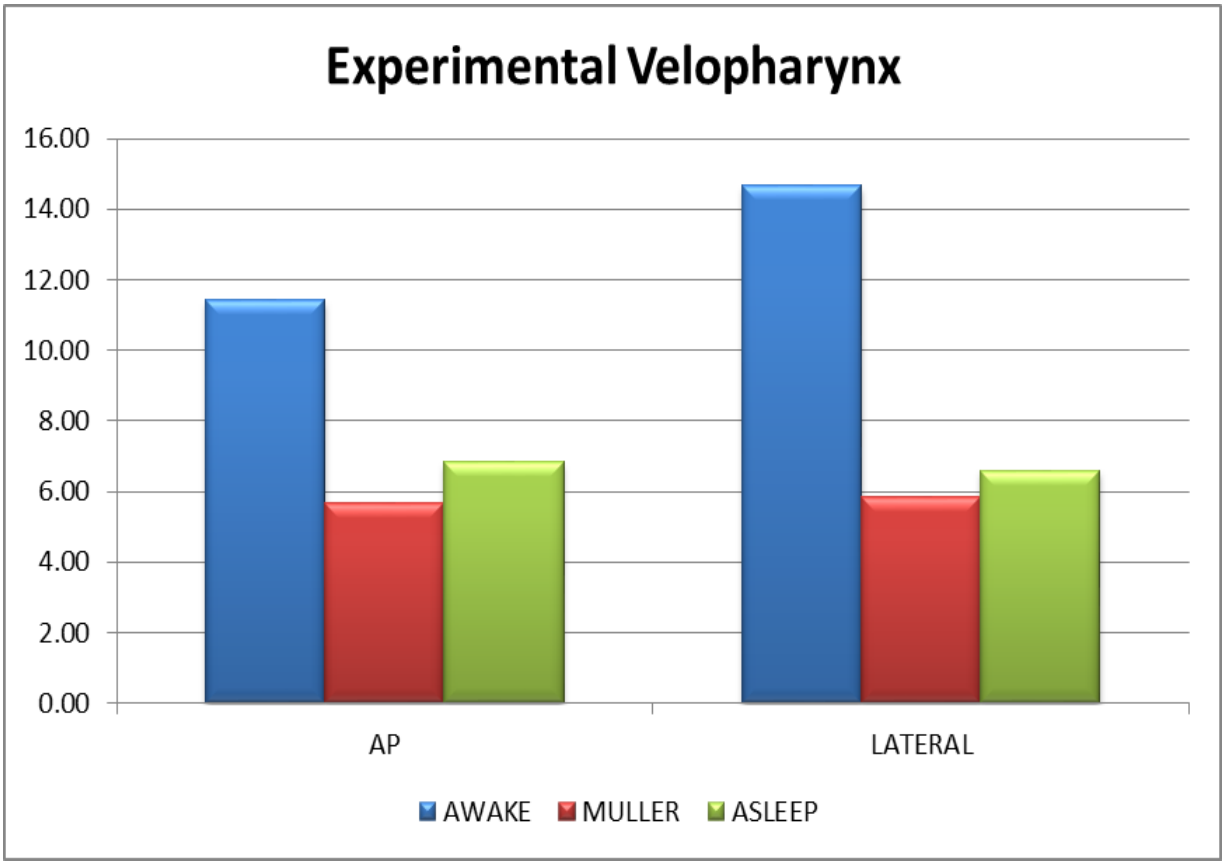
AIRWAY DIMENSIONS

- Airway dimensions were measured in the axial images at velopharynx, oropharynx, hypopharynx and more than 50 % reduction in the diameter either anteroposterior or lateral or both was considered significant obstruction both in muller's manouvre and during sleep .

AT VELOPHARYNGEAL LEVEL:

- At the level of velopharynx , mean anteroposterior diameter during awake, muller, asleep states were 11.4mm, 5.4mm. 6.6mm respectively.
- The mean lateral diameter during awake, muller, and asleep states were 14.6 mm, 5.8 mm , 6.6mm respectively.

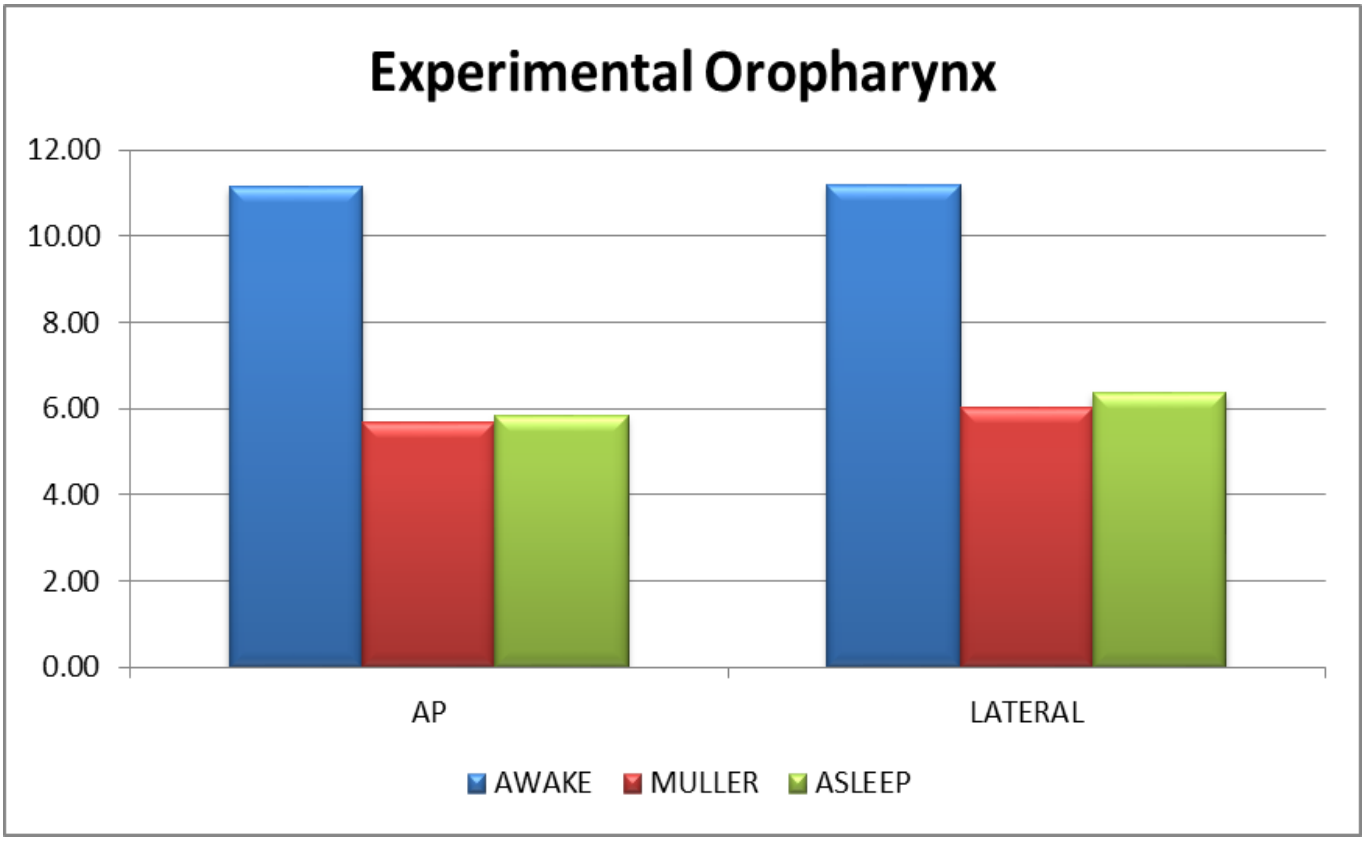
- It is observed that there is considerable reduction in the airway diameters in muller as well as sleep when compared to awake state
- If there is >50% reduction in the airway diameter, it is considered as significant obstruction



AT THE LEVEL OF OROPHARYNX :

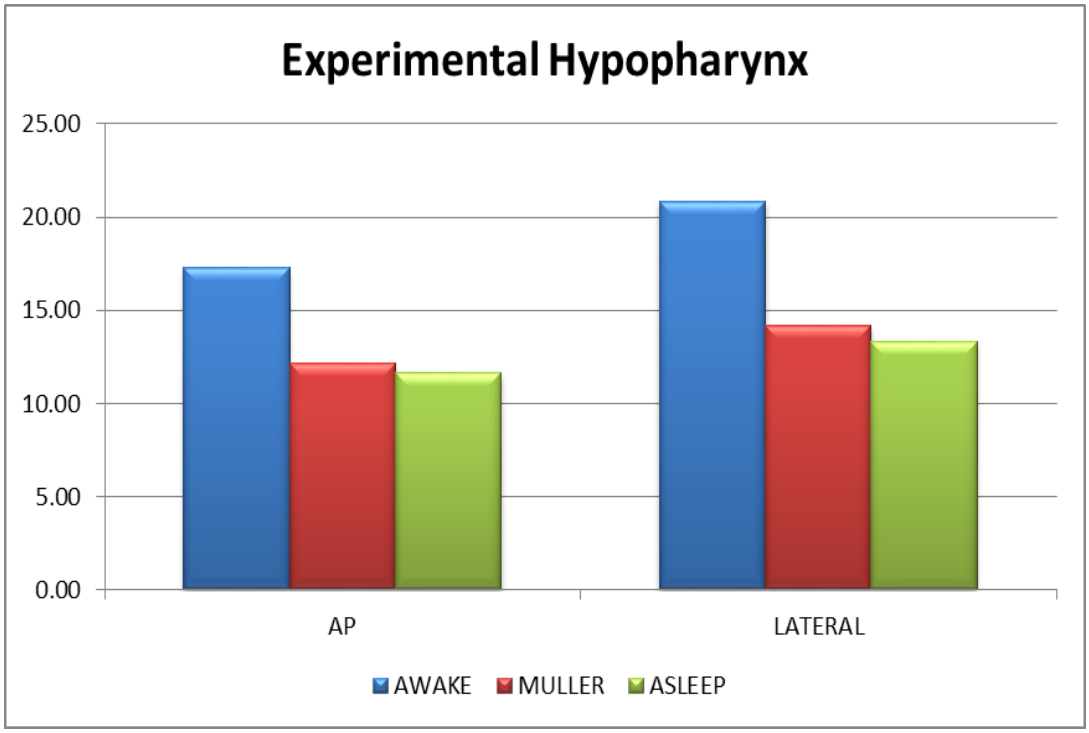
- At the level of oropharynx , mean anteroposterior diameter during awake, muller, asleep states were 11.16mm, 5.6mm. 5.8mm respectively.

- The mean lateral diameter during awake, muller, and asleep states were 11.2 mm, 6.03 mm , 6.38 mm respectively.
- It is observed that there is considerable reduction in the airway diameters in muller as well as sleep when compared to awake state
- If there is >50% reduction in the airway diameter, it is considered as significant obstruction



AT THE LEVEL OF HYPOPHARYNX :

- At the level of hypopharynx , mean anteroposterior diameter during awake, muller, asleep states were17.26mm, 12.2mm. 11.65mm respectively.
- The mean lateral diameter during awake, muller, and asleep states were 20.8mm, 14.2 mm , 13.3 mm respectively.
- It is observed that there is considerable reduction in the airway diameters in muller as well as sleep when compared to awake state
- If there is >50% reduction in the airway diameter, it is considered as significant obstruction



RESULTS

- Of the 50 patients investigated , 3 patients diagnosed with no obvious obstruction and were excluded from the statistical analysis
- Of the 47 patients diagnosed with obstruction the most common level of obstruction was combined multilevel obstruction followed by single level of obstruction at the level of velopharynx .
- It was observed that in patients with velopharyngeal obstruction , mean BMI was around 28.2 with a standard deviation of about 4.6. The mean length of soft palate was around 3.9 with a standard deviation of about 0.75 and the mean thickness of softpalate was around 1.076 with a standard deviation of about 0.19
- It was observed that in patients with oropharyngeal obstruction , mean BMI was around 28.4 with a standard deviation of about 5.7. The mean length of soft palate was around 4.4 with a standard deviation of about 0.84 and the mean thickness of softpalate was around 1.15 with a standard deviation of about 0.21.
- It was observed that in patients with hypoopharyngeal obstruction , mean BMI was around 32.5. The mean length of soft palate was around 2.5 and the mean thickness of softpalate was around 1.4 .

- The mean lateral diameter during awake, muller, and asleep states were 14.6 mm, 5.8 mm , 6.6mm respectively.
- It is observed that there is considerable reduction in the airway diameters in muller as well as sleep when compared to awake state
- The mean lateral diameter during awake, muller, and asleep states were 11.2 mm, 6.03 mm , 6.38 mm respectively.
- The mean lateral diameter during awake, muller, and asleep states were 20.8mm, 14.2 mm , 13.3 mm respectively.
- ROC Curve for Muller manouvre with anteroposterior diameter as the criteria for diagnosing obstruction with 1-specificity in the x axis and sensitivity in the Y axis shows the curve to lie in the superior right end of the reference line with sensitivity of 88.4% and specificity of 87.2% with a cutoff value of 6.4. Area under the curve is 0.939 which indicates significant accuracy to indicate obstruction with a p value of less than 0.0001
- ROC Curve for Muller manouvre with anteroposterior diameter as the criteria for diagnosing obstruction with 1-specificity in the x axis and sensitivity in the Y axis shows the curve to lie in the superior right end of the reference line with sensitivity

of 78.3% and specificity of 84.1% with a cutoff value of 7.35. Area under the curve is 0.88 which indicates significant accuracy to indicate obstruction with a p value of less than 0.0001

- Muller's manouvre can be an excellent alternative for the dynamic MR imaging done during sleep

CONCLUSION

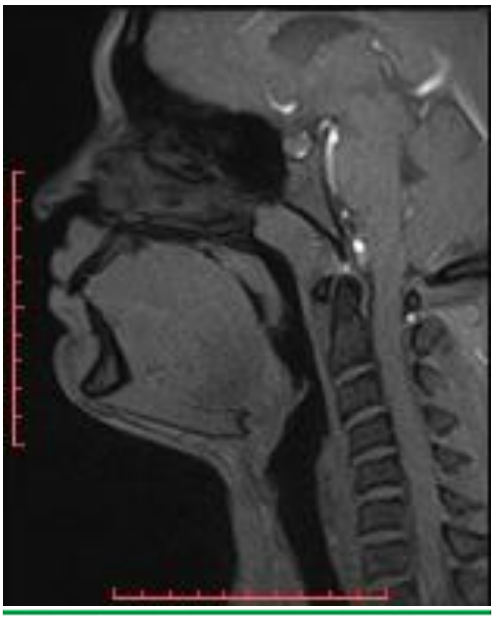
- We found a positive correlation between obesity and Obstructive sleep apnoea
- There was increased length and thickness of softpalate in patients with multilevel obstruction at the velopharynx and hypopharynx
- Most common level of obstruction was found to be at the level of velopharynx
- There was significant reduction in the airway diameter in both asleep and Muller's manouvre images when compared to those acquired during awake states
- It was also observed that Muller's maneuver could depict the airway pathologies accurately at par with the images acquired during sleep
- So in conclusion, sleep MRI which was a cumbersome procedure till now, because of the requirements for the patient to fall asleep either spontaneously or induced with the help of anaesthetic agents can now be done easily utilizing the Muller's manouvre which is nothing but a simulation of snoring

- Limitation of the study included subjective variation in the performance of Muller’s manouvre

REPRESENTATIVE CASES

CASE 1

AWAKE

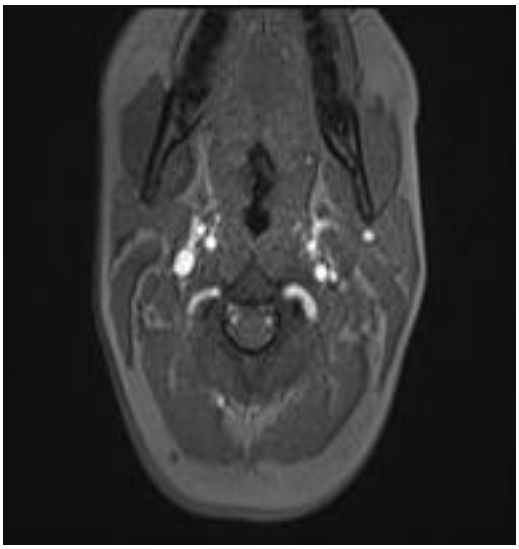


ASLEEP

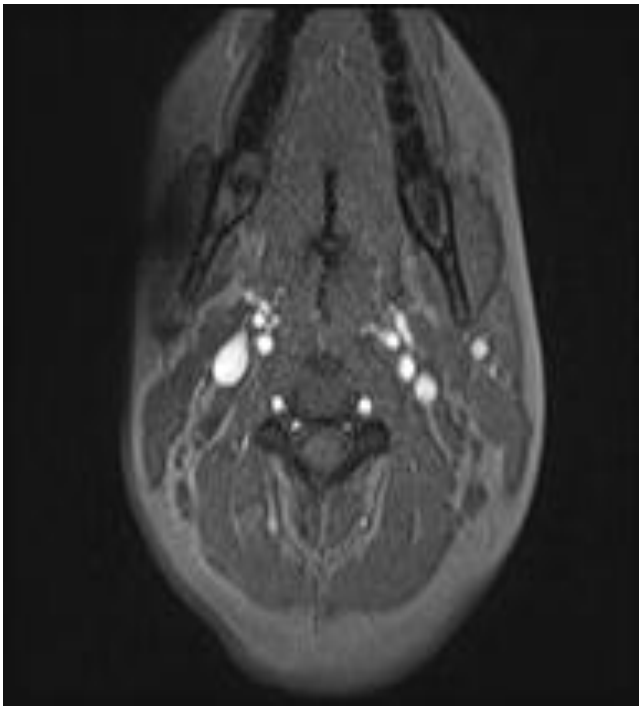
36 YR OLD PATIENT WITH BMI OF ABOUT 45 KG/M2 WITH CHRONIC HISTORY OF SNORING . SAGITTAL DYNAMIC MR IMAGES SHOW **OBSTRUCTION AT THE LEVEL OF VELOPHARYNX** DUE TO BULKY AND THICK VELUM AND POSTERIOR PHARYNGEAL WALL COLLAPSE .

CASE 2

AWAKE



ASLEEP

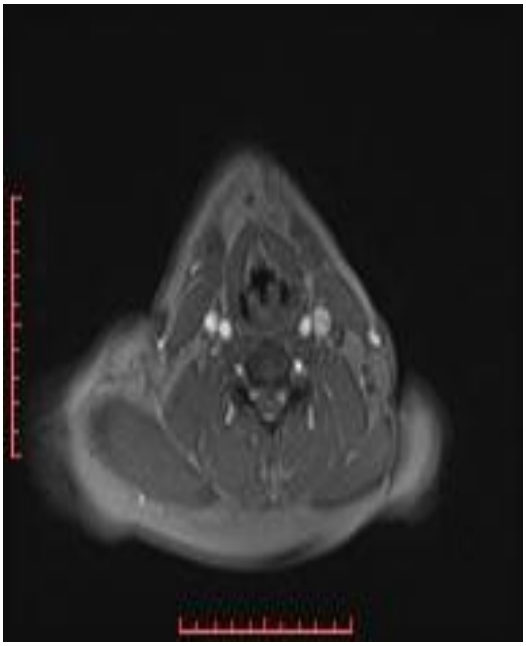


35 YR OLD MORBIDLY OBESE PATIENT (WITH BMI OF ABOUT 40 KG/M2) .

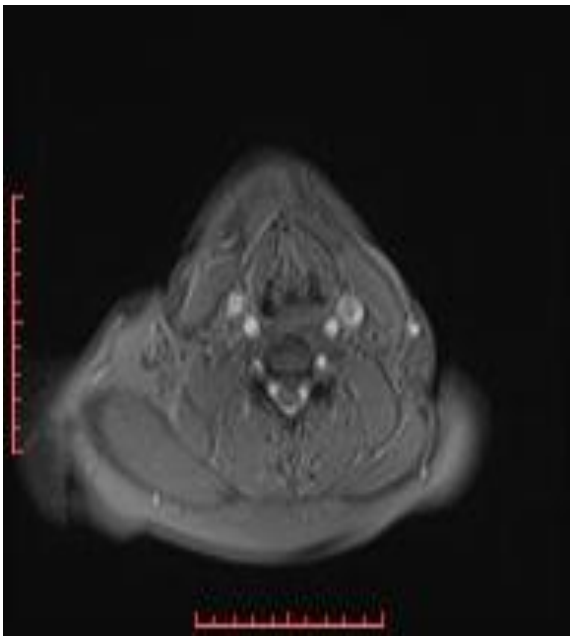
AXIAL IMAGES AT **THE RETROGLOSSAL LEVEL SHOWED OBSTRUCTION** AND COLLAPSE OF THE AIRWAY AND MORE THAN 50% REDUCTION IN THE LATERAL AND AP DIAMETERS OF THE AIRWAY AT THIS LEVEL AND THE CHANGES ARE OBVIOUS IN BOTH THE SLEEP AND MULLER'S MANOUVER IMAGES

CASE 3

AWAKE



ASLEEP



48 YR OLD MALE PATIENT PRESENTED WITH HISTORY OF SNORING. HIS BMI VALUES WERE NORMAL . AXIAL IMAGES AT THE LEVEL OF HYPOPHARYNX SHOWED FLOPPY EPIGLOTTIS AND **OBSTRUCTION AT THE HYPOPHAYRNGEAL LEVEL**

SOFT PALATE DIMENSIONS MEASUREMENT

LENGTH OF SOFT PALATE

THICKNESS OF SOFT PALATE

COMPARISON OF MULLER'S MANOUVRE VERSUS SLEEP IMAGES-SAGITTAL

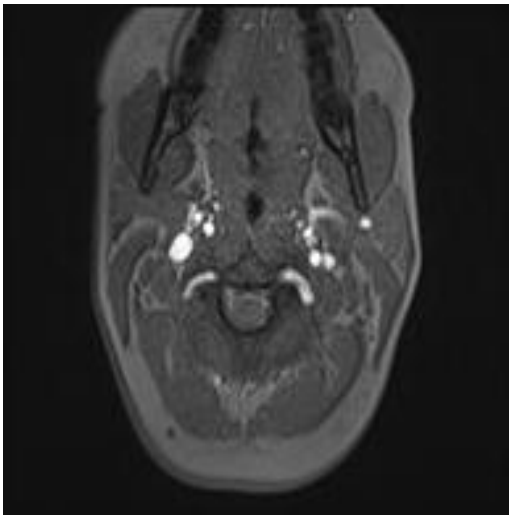
MULLER'S MANOUVRE

SLEEP

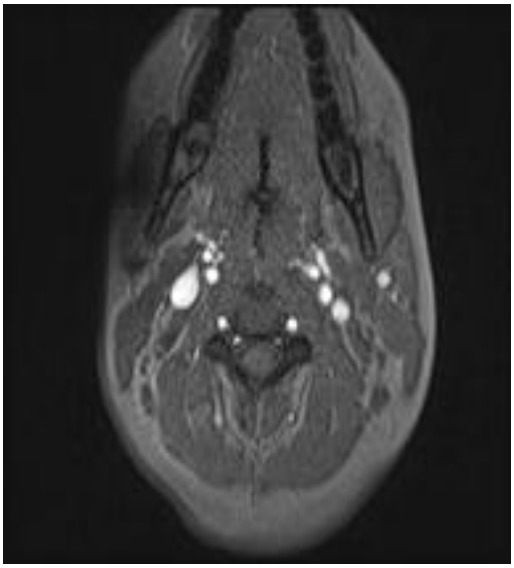
35 YEAR OLD OBESE PATIENT WITH DOCUMENTED APNOEA HYPOPNOEA INDEX OF MORE THAN 20/SEC .IN OVERNIGHT POLYSOMNOGRAPHY DYNAMIC MR IMAGING SHOWED MULTILEVEL OBSTRUCTION AT THE LEVEL OF RETROPALATAL AND RETROGLOSSAL LEVELS WITH BULKY AND THICK VELUM AND GLOSSOPTOSIS AND THE CHANGES ARE DEMONSTRATED WITH BOTH MULLER'S MANOUVRE AND DURING SNORING

COMPARISON OF MULLER'S MANOUVRE VERSUS SLEEP IMAGES- AXIAL (RETROGLOSSAL)

MULLER'S MANOUVRE



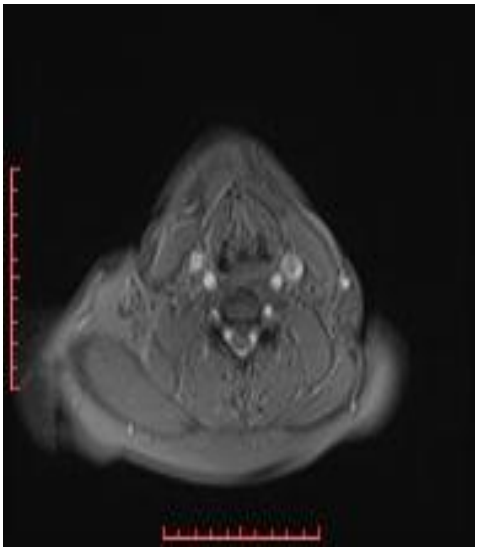
SLEEP



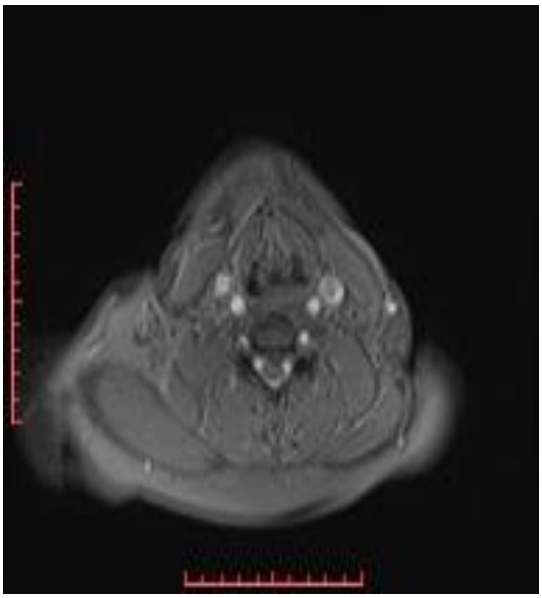
38 YEAR OLD OBESE PATIENT WITH DOCUMENTED APNOEA HYPOPNOEA INDEX OF MORE THAN 20/SEC .IN OVERNIGHT POLYSOMNOGRAPHY DYNAMIC MR IMAGING SHOWED MULTILEVEL OBSTRUCTION AT THE LEVEL OF RETROPALATAL AND RETROGLOSSAL LEVELS WITH BULKY AND THICK VELUM AND GLOSSOPTOSIS AND THE CHANGES ARE DEMONSTRATED WITH BOTH MULLER'S MANOUVRE AND DURING SNORING IN THE AXIAL IMAGES PLANNED AT THE RETROGLOSSAL LEVEL

COMPARISON OF MULLER'S MANOUVRE VERSUS SLEEP IMAGES- AXIAL (HYPOPHARYNGEAL)

MULLER'S MANOUVRE



SLEEP



48 YR OLD MALE PATIENT PRESENTED WITH HISTORY OF SNORING. HIS BMI VALUES WERE NORMAL . AXIAL IMAGES AT THE LEVEL OF HYPOPHARYNX SHOWED FLOPPY EPIGLOTTIS AND **OBSTRUCTION AT THE HYPOPHAYRNGEAL LEVEL**

STATIC PATENT TYPE OF AIRWAY

AWAKE

SLEEP

NO MEASURABLE CHANGE IN THE AIRWAY DIAMETER COULD BE OBSERVED BETWEEN THE AWAKE AND ASLEEP STATES – STATIC PATENT TYPE OF AIRWAY

STATIC COLLAPSED TYPE OF AIRWAY

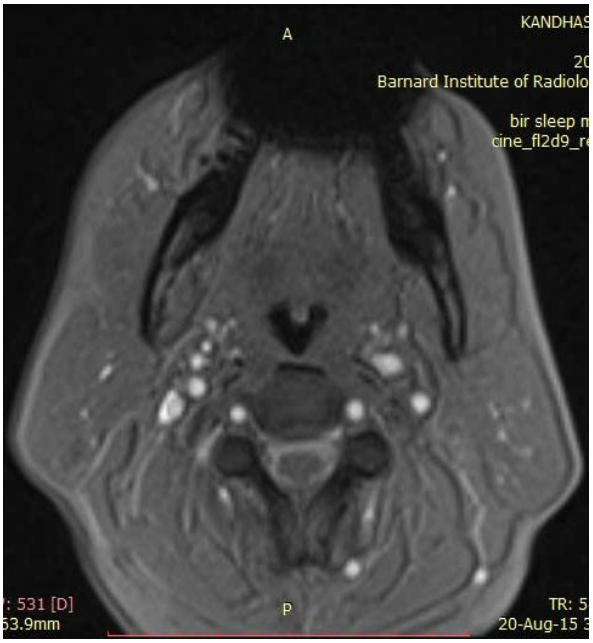
AWAKE

AIRWAY REMIANS COLLAPSED IN BOTH AWAKE AND ASLEEP STATES – STATIC COLLAPSED TYPE OF AIRWAY

SLEEP

DYNAMIC PATENT TYPE OF AIRWAY

AWAKE



SLEEP

OBVIOUS REDUCTION IN THE AIRWAY DIAMETER WAS OBSERVED BETWEEN AWAKE AND ASLEEP STATES BUT THE AIRWAY REMAINS PATENT – DYNAMIC PATENT TYPE OF AIRWAY

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ANNEXURES

@EJL 1284.4
@EJL

INSTITUTIONAL ETHICS COMMITTEE
MADRAS MEDICAL COLLEGE, CHENNAI 600 003

EC Reg.No.ECR/270/Inst./TN/2013
Telephone No.044 25305301
Fax: 011 25363970

CERTIFICATE OF APPROVAL

To
Dr.Mubarak Sazira.S.
PG in MD (Radio-Diagnosis)
Madras Medical College
Chennai 600 003

Dear Dr.Mubarak Sazira.S.

The Institutional Ethics Committee has considered your request and approved your study titled **"DYNAMIC MR IMAGING OF THE UPPER AIRWAY DURING MULLER'S MANOUVRE AND DURING SLEEP IN PATIENTS WITH OBSTRUCTIVE SLEEP APNOEA " NO.15022015**

The following members of Ethics Committee were present in the meeting held on 03.02.2015 conducted at Madras Medical College, Chennai 3.

1. Dr.C.Rajendran, MD	:Chairperson
2. Dr.R.Vimala,MD.,Dean,MMC,Ch-3	: Deputy Chairperson
3. Dr.B.Kalaiselvi,MD.,Vice Principal,MMC,Ch-3	: Member Secretary
4. Dr..R.Nandhini,MD.,Inst.of Pharmacology,MMC	: Member
5. Dr..P.Ragumani, MS., Professor, Inst.of Surgery,MMC	: Member
6. Dr..K.Ramadevi, Director , Inst.of Bio-Chem.MMC	: Member
7. Dr..Saraswathy,MD.,Director,Pathology, MMC	: Member
8. Dr.Md.Ali, MD., DM.,Prof.&HOD of Medl.GE,MD.MMC	: Member
9. Dr.S.G.Sivachidambaram,Director I/c, Inst.of Internal Medicine	: Member
10. Thiru S.Rameshkumar	: Lay Person
11.Thiru S.Govindasamy, BA., BL.,	: Lawyer
12.Tmt.Arnold Saulina, MA., MSW.,	: Social Scientist

We approve the proposal to be conducted in its presented form.

The Institutional Ethics Committee expects to be informed about the progress of the study and SAE occurring in the course of the study, any changes in the protocol and patients information/informed consent and asks to be provided a copy of the final report.

Member Secretary, Ethics Committee

MEMBER SECRETARY
INSTITUTIONAL ETHICS COMMITTEE
MADRAS MEDICAL COLLEGE
CHENNAI-600 003

Sys 2

PROFORMA

TITLE:

"***DYNAMIC MR IMAGING OF THE UPPER AIRWAY DURING MULLER'S MANOUVRE & DURING SLEEP IN PATIENTS WITH OBSTRUCTIVE SLEEP APNOEA*''**

Sl.No:

Name :

Age/Sex :

Occupation :

Address :

Presenting Complaints

Past History:

H/O Diabetis mellitus, hypertension, cardiac disease

Vital signs:

Pulse :

BP :

Respiratory rate :

Investigations:

indirect laryngoscopy

overnight polysomnography

INTERPRETATION:

PATIENT CONSENT FORM

STUDY TITLE :

"***DYNAMIC MR IMAGING OF THE UPPER AIRWAY DURING MULLER'S MANOUVRE & DURING SLEEP IN PATIENTS WITH OBSTRUCTIVE SLEEP APNOEA***"

Patient may check (✓) these boxes.

PARTICIPANT NAME : DATE:

AGE: SEX: I.P.NO. :

The details of the study have been provided to me in writing and explained to me in my own language. ☐

I confirm that I have understood the purpose of the above study. I had the opportunity to ask the question and all my questions and doubts have been answered. ☐

I understand that my participation in the study is voluntary and that I am free to withdraw at any time without giving any reason. ☐

I understand that investigator, the institution, regulatory authorities and the ethical committee will not need my permission to look at my health records both in respect to the current study and any further research that may be conducted in relation to it, even if I withdraw from the study. I understand that my identity will not be revealed . I agree not to restrict the use of any data or results that arise from this study. ☐

I HEREBY CONSENT TO UNDERGO COMPLETE PHYSICAL EXAMINATION,BIOCHEMICAL AND RADIOLOGICAL INVESTIGATION PERTAINING TO THE STUDY. ☐

I have been given an information sheet giving details of the study . ☐

I hereby consent to participate in the above study .

Signature of the Participant

PATIENT INFORMATION SHEET

We are conducting a study on "***DYNAMIC MR IMAGING OF THE UPPER AIRWAY DURING MULLER'S MANOUVRE & DURING SLEEP IN PATIENTS WITH OBSTRUCTIVE SLEEP APNOEA''***

- Your co-operation would be valuable to us for the same.
- The privacy of patients in the research will be maintained throughout the study. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared.
- Taking part in this study is voluntary. You are free to decide whether to participate in this study or to withdraw at any time: your decision will not result in any loss of benefits to which you are otherwise entitled.
- The result of the special study may be intimated to you at the end of the study period or during the study if anything is found abnormal which may aid in the management or treatment.

Signature of the Investigator Signature of participant

(Dr.S.MubarakSazira)

Date:

ஆராய்ச்சித் தகவல் தாள்

குறட்டை விடுவது ஒரு ஆபத்தான நோய்.நம்மில் பலர் இதை அலட்சியப்படடுத்துவதால் இரத்தக்கொதிப்பு , நீரிழிவு நோய், இருதயநோய் போன்றவற்றால் பாதிக்கப்படக்கூடிய அபாயநிலை அதிகரித்து வருகிறது.இந்நோயைக் குணப்படுத்தப் பல அறுவைசிகிச்சைகள் நமது மருத்துமனையில் நடத்தப்பட்டு வருகின்றன.அறுவை சிகிச்சைக்கு முன்னால் எம்.ஆர்.ஐ எடுப்பது அவசியம்.

பொதுவாக இந்த எம்.ஆர்.ஐ தூங்கும் போது எடுக்கப்படும்.இந்த ஆராய்ச்சியில் மூச்சைப் பிடித்துக் கொண்டு எடுக்கும் போதும் அத்தசை மாற்றங்கள் நன்றாகத் தெரியுமா என்பதை காணப் போகிறோம்.அதனால் முதலில் நீங்கள் மூச்சைப் பிடித்துக் கொள்ளும் போதும் பின்னர் தூங்கும் போதும் இந்த பரிசோசதனை மேற்கொள்ளப்படும்.

ஏனெனில் அதை வைத்துதான் என்ன முறையில் அறுவை சிகிச்சை செய்வது என தீர்மானிக்கப்படும்.என்னென்ன மாதிரியான தசைமாற்றங்களால் இத்தொந்தரவு ஏற்படுகிறது என்பதைக் கண்டறிய இந்த ஆராய்ச்சி நடத்தப்பட உள்ளது.

நீங்களும் இந்த ஆராய்ச்சியில் பங்கேற்க நாங்கள் விரும்புகிறோம்.

முடிவுகளை மற்றும் கருத்துக்களை வெளியிடும்போது தங்கள் பெயரையோ அல்லது அடையாளத்தையோ வெளியிடமாட்டோம் என்பதையும் தெரிவித்துக்கொள்கிறோம்.

இந்த சிறப்புப் பரிசோதனையின் முடிவுகளை ஆராய்ச்சியின் போது அல்லது முடிந்த பின்னர் தங்களுக்கு அறிவிப்போம் என்பதையும் தெரிவித்துக்கொள்கிறோம்.

ஆராய்ச்சியாளர் கையொப்பம் பங்கேற்பாளர் கையொப்பம்

தேதி:

ஆராய்ச்சி ஒப்புதல் படிவம்

ஆராய்ச்சி தலைப்பு

பெயர் :

வயது :

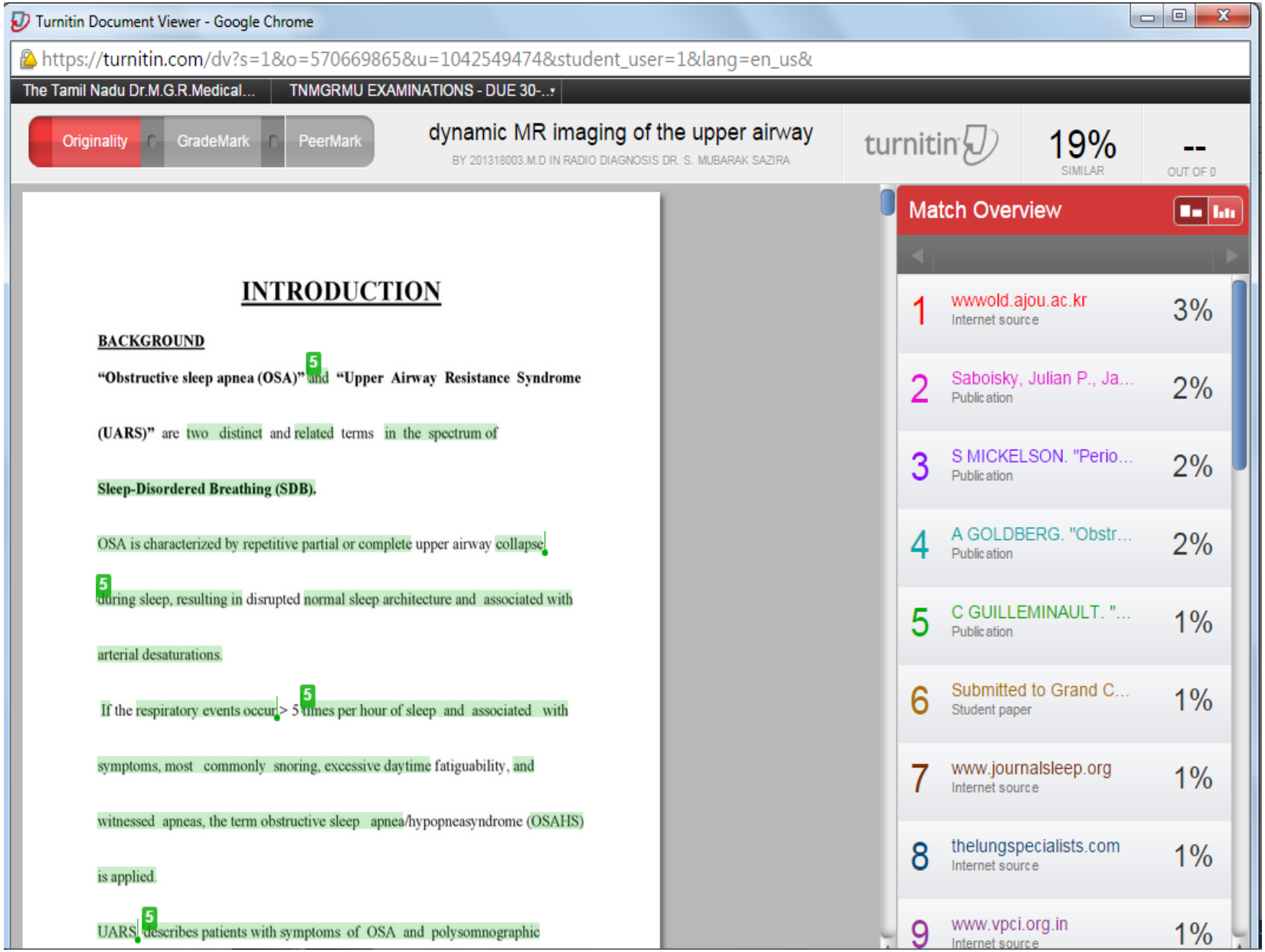
பால் :

இந்த ஆராய்ச்சியின் விவரங்களும் அதன் நோக்கங்களும் முழுமையாக விளக்கப்பட்டது .எனக்கு விளக்கப்பட்ட விபரங்களைப் புரிந்துகொண்டு நான் என் சம்மதத்தைத் தெரிவிக்கிறேன்.

இந்த ஆராய்ச்சியில் பிறரின் நிர்ப்பந்தமின்றி என் சொந்த விருப்பத்தின் பேரில் தான் நான் பங்கு பெறுகிறேன்.எனக்கு நான் தூங்கும் போது ம் மூச்சைப் பிடித்துக் கொண்டும் இப்பரிசோதனை செய்து கொள்ள சம்மதம்.

நான் என்னுடைய சுயநினைவோடு மற்றும் முழு சுதந்திரத்துடன் இந்த மருத்துவ ஆராய்ச்சியில் என்னை சேர்த்துக்கொள்ள சம்மதிக்கிறேன்.

பங்கேற்பாளர் கையொப்பம்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INTRODUCTION
BACKGROUND
"Obstructive sleep apnea (OSA)" and "Upper Airway Resistance Syndrome (UARS)" are two distinct and related terms in the spectrum of Sleep-Disordered Breathing (SDB).
OSA is characterized by repetitive partial or complete upper airway collapse during sleep, resulting in disrupted normal sleep architecture and associated with arterial desaturations.
If the respiratory events occur > 5 times per hour of sleep and associated with symptoms, most commonly snoring, excessive daytime fatiguability, and witnessed apneas, the term obstructive sleep apnea/hypopneasyndrome (OSAHS) is applied.
UARS describes patients with symptoms of OSA and polysomnographic
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ABBREVIATIONS

OSA : Obstructive Sleep Apnoea

UARS: Upper Airway Resistance Syndrome

SDB: Sleep Disordered Breathing

PSG : PolySomnoGraphy

DISE: Drug Induced Sleep Endoscopy

CPAP: Continuous Positive Airway Pressure

MRI : Magnetic Resonance Imaging

AHI : Apnoea Hypopnoea Index

RDI : Respiratory Disturbance Index

RERA : Respiratory Event Related Arousals

EEG: electroencephalogram

EMG : electromyogram

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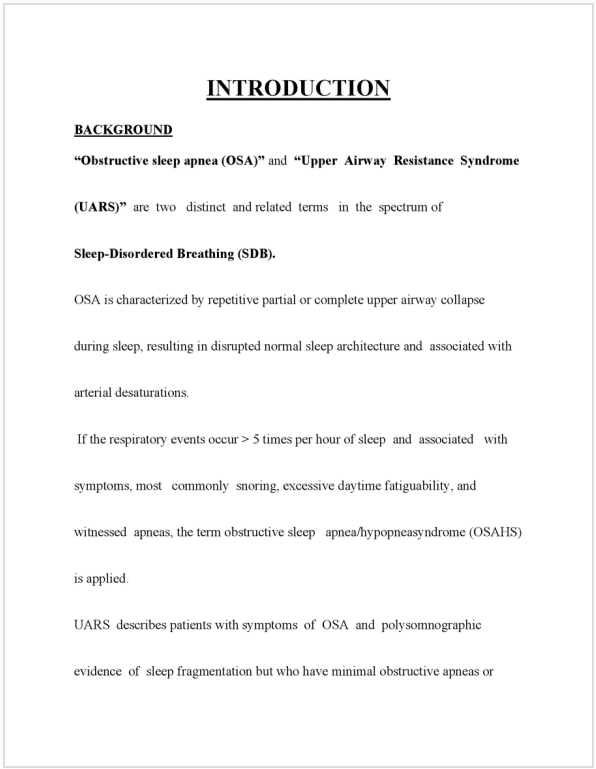

INTRODUCTION

BACKGROUND

"Obstructive sleep apnea (OSA)" and **"Upper Airway Resistance Syndrome (UARS)"** are two distinct and related terms in the spectrum of **Sleep-Disordered Breathing (SDB).**

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If the respiratory events occur > 5 times per hour of sleep and associated with symptoms, most commonly snoring, excessive daytime fatiguability, and witnessed apneas, the term obstructive sleep apnea/hypopneasyndrome (OSAHS) is applied.

UARS describes patients with symptoms of OSA and polysomnographic evidence of sleep fragmentation but who have minimal obstructive apneas or

SNO	NAME	AIRWAY DIMENSIONS(IN MM)									SOFT PALATE DIMENSIONS	
		AWAKE		MULLER		ASLEEP		BMI	**LEVEL OF OBSTRUCTION**	**CAUSE OF OBSTRUCTION**		
		AP	LATERAL	AP	LATERAL	AP	LATERAL				LENGTH	THICKNESS
1	MAHALAKSHMI	13.9	8.9	6.8	0.7	12.1	3.5	40	MULTIPLE – V AND O	BV, GP, MG	4.5	1.2
		14.7	14.3	5.6	4.3	6.7	5.4					
		14.5	12.4	11.4	13.5	11.3	12.5					
2	SHANKAR	10.9	7.8	3.8	2.6	4.5	3.5	35	SINGLE - VELO	BV,	4	1.01
		8.9	14.3	4.5	7.8	5.4	8.6					
		13.5	12.7	6.8	4.5	7.5	5.4					
3	SRINIVASAN	17.4	14	13.3	6.5	14.5	7.6	30	MULTIPLE – V AND O	BV, GP, MG	3.5	1.09
		14.5	12.3	7.6	4.5	8.7	6.6					
		13.5	13.4	8.6	6.5	9.6	5.8					
4	MASTHAN BASHA	10.1	16.3	12.4	15.5	13.4	16.7	25	SINGLE- ORO	TONSILS	2.9	0.9
		8.3	13.4	4.5	6.7	6.7	4.5					
		13	24	17.8	23.4	7.8	11.5					
5	PALANIVEL	4.5	7.8	0	0	1	0.5	28	SINGLE- VELO	BV	3.4	0.8
		5.8	8.9	3.4	7.5	3.5	7.8					
		28	29	18.8	14.6	17.4	12.3					
6	MUTHUSAMY	8.3	10.6	3.8	2.8	4.2	3.5	27.9	MULTIPLE – V AND O	BV, GP, MG	3.5	1.2
		12.5	4,6	0	0	0	0					
		19.6	14.8	17.4	10.2	14.8	11.2					
7	MANI	4.5	9.8	0.3	0.2	1.2	0.6	23.7	SINGLE- VELO	BV, PP	4.2	1.1
		4.2	9.7	7.6	5.6	4.5	4.6					
		24	22	18.3	14.4	17.8	12.9					
8	RAJAMMAL	8.1	10	4.5	3.8	4.7	3.9	37.8	MULTIPLE – V AND O	BV, GP, MG	5.6	1
		11	3.5	0	0	0	0					
		19	14	17	10	14	11.2					
9	SHANKAR	3.9	8.5	0	0	1.2	0.5	24.7	SINGLE- VELO	BV,PP	4	1.2
		3.9	8.2	3.4	7.5	3.5	7.8					
		24	22	18.8	14.2	17.9	12.3					
10	NASRIN	3.7	8.9	0	0	1	0.9	25.6	SINGLE- VELO	BVPP	4.8	1.38
		3.9	8.2	3.4	7.5	3.5	7.8					
		24	22	18	14	17	12					
11	BARI	13.7	11.7	5	9.7	6.4	8.6	34.8	MULTIPLE – V , ORO, HYPO	BV,PP,MG,FE	3.8	1.4
		8.3	13.2	6.8	6.8	7.6	8.8					
		14.6	9.8	1.3	1.5	1.9	2.4					
12	SARBUDEEN	9.7	10.1	9.6	7.5	9.5	8.5	25.8	SINGLE- ORO	MG	3.5	1.5
		7.9	13.4	5.6	7.7	4.5	6.6					
		14	26	9.8	22.4	8.8	21.3					
13	SURESH	10.1	16.3	12.4	15.5	13.4	16.7	20	NO OBSTRUCTION	BV,GP	3.5	1.6
		10	13.9	12.6	8.9	11.5	9.7					
		13	24	17.8	23.4	16.9	21.9					
14	RAMASAMY	8.1	10	4.5	3.8	4.7	3.9	34.7	MULTIPLE – V AND O	BV	3.8	1.8
		11	3.5	0	0	0	0					
		19	14	17	10	14	11.2					
15	LATHA	13.2	17.4	12.3	15.4	13.1	16.3	20.5	NO OBSTRUCTION			
		14.4	10.5	12.6	8.8	11.2	9.5					
		18.4	25.6	17.7	23.8	16.3	21.2					
16	RAJESH	3.7	8.9	0	0	1	0.9	23.5	SINGLE - VELO	GP,MG	4	1.4
		3.9	8.2	3.4	7.5	3.5	7.8					
		24	22	18	14	17	12					
17	RAMMOHAN	21	22	20.3	21.6	21.1	23.4	24.3	SINGLE- RETRO	BV,PP,MG,FE	4.5	1.5
		17.4	19.8	9.4	7.8	10.2	6.4					
		19.8	24.3	17.6	22.3	16.7	21.6					
18	RAMALINGAM	13.2	13.5	5	5.5	6.5	7.2	36.5	MULTIPLE- VELO AND HYPO	MG,GP	3.6	1.6
		12.1	12.1	4.9	8.5	5.2	7.8					
		14.7	15.8	1.2	1.3	2.3	3.5					
19	MOHD.ALI	16	24	14	16	15	15.4	32.5	SINGLE- ORO	BV,PP,MG,GP	3.8	1.8
		9.1	13.6	0	0	1.3	1.2					
		21	38	7	35	9.8	24					
20	DEVI	23	21	12	7	13.4	8	24.6	MULTIPLE – V AND O	BV, MG	3.9	1.9
		12	19	5.4	8.6	6.8	9.7					
		16	15	11	12	10.5	11.6					
21	ALBERT	12	13	0	0	1.3	1.2	25.7	MULTIPLE - V AND O	BV,PP,MG,FE	4.2	1.6
		14.6	17.7	3.1	5.6	3.2	6.6					
		16	25.7	15.4	24.3	14.5	22.5					
22	BABU	12	19	5.5	10	6.2	9.8	17	MULTIPLE- V,O,H	BV,PP,MG,FE	4.5	1.5
		20	7	0	0	1.5	1.3					
		18	17	6	0	5	0.5					

23	RAMESH	12	21	0.3	0.7	1.2	1	34.5	MULTIPLE- V,O,H	FE	4.8	1.4
		8	14	4	3	3.5	3					
		12	9	6	4.5	5.4	6					
24	KOKILA	10.5	11.6	11	9	13.2	10	32	MULTIPLE- V AND O	BV,PP,MG,GP	4.9	1.5
		14	6.9	13	5.8	14	7					
		14	24	3	2	5	6.3					
25	RAMANATHAN	17	28	0	0	1.3	1.2	33.5	MULTIPLE- V,O,H	BV,PPFE	3.8	1.6
		19	15.8	6.9	11.5	7.4	13.5					
		15.3	34	14	31	16	34					
26	DAMODARAN	13	18	0	0	1.3	1.2	34.7	MULTIPLE- V,O,H	BV,GP,MG	3.5	1.7
		13	9	9	9	10.5	10.3					
		16	31	0	0	1.2	1.4					
27	ELANCHERAL	13	17	12	15	13	16	36.7	MULTIPLE- V,O,H	BV,PP	3.3	1.8
		14	10	12	8	11	9					
		18	25	17	23	16	21					
28	VIGNESH	5.4	12	2	7	3	5	34.2	MULTIPLE- V,O,H	BV,PP	3.2	1.9
		9.9	13	4.5	7.5	3.8	6.8					
		12	17.7	10	13	11	12.3					
29	VADIVELU	12.9	20.4	0	0	1.2	1.4	33.5	MULTIPLE- V,O,H	BV,PPFE	3	2
		12.9	9	6	7.2	5.4	6.5					
		14	22.8	11.1	21.7	12	21.4					
30	VIJAY	17.9	22.6	0	0	1.2	1.2	32.6	MULTIPLE- V,O,H	BV,GP,MG	4.8	1.6
		15.3	9	11.2	7.2	10.5	6.8					
		15	19	12	15.4	14	16.4					
31	RAMAN	18.6	16.5	13.5	14.3	17	15.7	33.8	MULTIPLE- V,O,H	BV,PP	5.2	1.5
		15.4	14.6	14.5	13.2	12.4	11.5					
		34	25	20	22	21	18					
32	MURUGAN	17.5	15.4	15.6	13.2	16.7	13.5	37.6	MULTIPLE- V,O,H	BV,PP	4.6	1.4
		15.6	13.5	14.3	12.4	14.6	12.8					
		33	22	30	20	28	21					
33	MURUGESWARI	16.3	15.4	13.5	14.3	12.3	12.5	37.8	MULTIPLE- V,O,H	BV,GP,MG	4.8	1.2
		17.6	16.5	15.6	14.8	13.2	13.5					
		32.4	33.2	31.5	31.6	30.7	30.4					
34	LAKSHMANAN	19	18.7	17.6	16.5	15.6	14.3	32.9	MULTIPLE- V,O,H	BV,GP,MG	4.5	1.1
		23.3	21.1	22.1	19.7	21.4	17.6					
		33.5	35.4	32.6	31.6	31.7	30.7					
35	MAYILVANAN	20	17.6	18.6	15.4	17.5	13.5	35.8	MULTIPLE- V,O,H	BV,PP	3.5	1.3
		22	21.8	21.5	21.4	20.7	19.8					
		33.2	33.5	32.6	31.5	31.8	31.7					
36	MULLAINATHAN	17.8	14.6	15.8	14.3	16.7	13.5	35.9	MULTIPLE- V,O,H	BV,GP,MG	4	1.4
		15.4	14.6	14.2	11.5	14.6	12.8					
		33.4	22.45	28.7	19.8	28	21					
37	PANDIYAN	15.4	14.3	14.5	13.5	14.7	12.5	34.7	MULTIPLE- V,O,H	BV,GP,MG	4.2	1.6
		18.7	15.6	17.6	14.5	17.8	15.7					
		32.4	33.2	31.5	31.6	30.7	30.4					
38	ANNAMALAI	17.8	14.6	15.8	14.3	16.7	13.5	35.9	MULTIPLE- V,O,H	BV,GP,MG	4.4	1.8
		15.4	14.6	14.2	11.5	14.6	12.8					
		33.4	22.45	28.7	19.8	28	21					
39	INDUMATHY	20.6	18.6	19.7	15.6	15.7	18.7	35.9	MULTIPLE- V,O,H	BV,PP	4.8	1.2
		21.6	22.4	20.7	21.4	20.7	19.8					
		33.2	33.5	32.6	31.5	31.8	31.7					
40	SAKTHIVEL	16.7	15.4	13.5	14.3	12.3	12.5	35.7	MULTIPLE- V,O,H	BV,GP,MG	4.6	1.5
		17.8	16.5	15.6	14.8	13.2	13.5					
		33.6	32.7	31.5	31.6	30.7	30.4					
41	UNNAMALAI	17.6	16.5	16.7	15.7	16.6	15.8	35.9	MULTIPLE- V,O,H	BV,GP,MG	4.5	1.8
		14.6	12.8	13.8	11.8	14.6	12.8					
		33	22	30	20	28	21					
42	MARIYAPPAN	16.3	15.4	13.5	14.3	12.3	12.5	35.9	MULTIPLE- V,O,H	BV,PP	3.8	1.9
		17.6	16.5	15.6	14.8	13.2	13.5					
		32.4	33.2	31.5	31.6	30.7	30.4					
43	MANIMARAN	18.7	16.4	17.5	15.4	17.5	14.3	35.9	MULTIPLE- V,O,H	BV,GP,MG	3.6	1.6
		16.7	15.7	14.6	13.5	15.8	14.8					
		31.4	33.6	30.8	32.7	29.9	31.7					
44	MUTHUSAMY	21.5	17.6	19.7	15.6	15.7	18.7	35.9	MULTIPLE- V,O,H	BV,GP,MG	3.5	1.7
		22.6	22.8	20.7	21.4	20.7	19.8					
		33.2	33.5	32.6	31.5	31.8	31.7					
45	RAMASAMY	17.4	16.8	15.6	15.2	15.8	14.6	35.9	MULTIPLE- V,O,H	BV,PP	3.4	1.8
		18.9	15.4	15.6	16.5	15.3	17.6					
		32.1	34.2	31.5	30.9	30.7	30.4					
46	GOPAL	15.6	16.5	13.4	14.3	12.4	11.5	35.9	MULTIPLE- V,O,H	BV,GP,MG	3.2	1.9
		16.7	17.6	15.4	16.5	15.6	16.8					
		32.5	33.5	30.9	31.8	30.7	31.5					
47	GOMATHY	17.8	16.7	15.4	14.3	17.4	16.4	35.9	MULTIPLE- V,O,H	BV,GP,MG	3.1	1.2
		14.9	12.6	13.5	11.8	12.4	11.3					
		34.5	24.3	32.6	31.5	30.5	20.5					

48	NALINI	16.4	15.6	17.6	14.8	17.4	14.55	35.9	MULTIPLE- V,O,H	BV,GP,MG	4	1.3
		17.6	14.5	16.7	13.8	16.5	12.8					
		33.7	31.9	30.9	31.9	30.7	31.2					
49	RAMARAJAN	20.6	16.4	18.5	14.6	18.4	14.9	35.9	MULTIPLE- V,O,H	BV,GP,MG	4.2	1.4
		21.7	20.8	21.5	16.7	20.5	17.5					
		33.2	33.5	32.6	31.5	31.8	31.7					
50	MALATHY	18.6	17.4	18.3	16.7	17.5	15.6	35.9	MULTIPLE- V,O,H	BV,PP	4.3	1.5
		22.4	21.6	20.6	20.5	21.4	20.8					
		33.2	34.2	32.6	31.6	31.5	30.6					