Review Article

# Role of Ultrasound in Estimation of Palatine Tonsil Volume in Obstructive Sleep Apnea Patients

Ayesha Mehwish, Ambreen Usmani

**ABSTRACT:**

Sleep constitutes one-third of our life and a good sleep affects the physical, mental and behavioral aspects of an individual. Disturbance in the normal biological rhythm of an individual can disrupt one's performance. Sleep disorders are many but the type that could take one's life is obstructive sleep apnea. Therefore it is important to know the anatomy of involved structures that are responsible for the pathophysiology of the above-mentioned condition. Obstructive sleep apnea-OSA is evolving as a worldwide health epidemic and is confronting an increasing prevalence especially due to the obesity pandemic. Though extensive global prevalence facts and figures are still missing, and worldwide OSA research in standings of activity, value, and socio-economic features has not yet been revealed. Ultrasound of palatine tonsil is an emerging and novel technique, as it is noninvasive and safest modality that can be used to determine severity of OSA. High frequency ultrasound is an impeccable diagnostic tool for assessment of tonsils in children and adults. It is cost effective, portable, noninvasive, painless, quick and easily accessible as compare to CT and MRI imaging.

**Keywords:** grading, obstructive sleep apnea, palatine tonsil, ultrasound, snoring

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## INTRODUCTION:

Sleep is a vital attribute of life as one-third of our lives are devoted to sleep.[1] A normal healthy individual sleeps for 7-8hours.[2] Disturbances of normal biological processes manifests in form of individual's poor performance at work, daily routine affecting his or her physiological processes of entire life. Population-based investigations have shown that people who have extensive and reduced sleep have lesser life span.[1, 2] Obstructive sleep apnea (OSA) is also termed as OSA-hypopnea syndrome is featured by recurrent complete or partial blockage of upper airway leading to recurrent oxyhemoglobin desaturation and altered sleep. Another known type is central sleep apnea that involves the failure of central control to initiate respirations by sending signals to muscles involved in breathing.OSA is a common sleep disorder and emerging as a "global health epidemic". It is increasingly documented to be an essential factor of medical morbidity and mortality.[3] Regarding global prevalence of obstructive sleep apnea reported that 936 million adults comprising age group from 30 to 69 years, men and women have this condition with mild to severe intensity, whereas 425 million adults having same age group have moderate to severe obstructive sleep apnea worldwide. The highest figure of people reported to be affected were in China and then in USA, Brazil and India.[4] It is 3-7% prevalent in the general population, [5]occurs in male and female and includes all ages with a predominant male predisposition .[6] Symptoms of the disease include snoring and apnea at night and day time restlessness, somnolence and lack of attentiveness and poor performance at home and office [3, 5], which in turn increases the risk of cardiovascular disease, hypertension, diabetes, infertility, reduced thinking and unexpected death. Increased neck circumference, weight gain, age above 40 years are the influencing factors for the disease.[5, 6]

Clinical evaluation of OSA requires detailed history which leads to early diagnosis of the condition. A close family member such as a spouse can give more trustworthy information than the person themselves as one is not aware of events during sleep. Careful assessment of symptoms must be included in the history like snoring, mouth breathing increased daytime sleepiness, breathlessness, choking, unrefreshing sleep, bad temper, sunrise headaches, memory loss, impotence, menopause, hormone replacement therapy, and use of alcohol, caffeine and tranquilizers.[3, 5, 6.] Primary anatomical site for OSA is pharynx and nearby related structures along the respiratory tract with most likely involvement of retroglossal and retropalatal regions. Other factors include hypertrophic tonsils, uvula, tongue, narrow oropharyngeal isthmus and mandibular retrognathia. Therefore, it is important to carefully inspect all the related anatomy which is involved in the development of the disease process by an otorhinolaryngologist or sleep specialist.[7]

There are various subjective tools invented in the past for the assessment of OSA. One of them is Berlin questionnaire which was invented in 1996 is an easy and authentic tool

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for the estimation of sleep apnea risk in general population.[8] This questionnaire gained an equal importance in China for anesthesiologists of Post Anesthesia Care Unit and accepted as a screening tool to recognize subjects who are more vulnerable to develop OSA and to establish the possible reason of developing postsurgical respiratory complications .Others include Epworth Sleepiness scale and STOP-BANG questionnaire but these tools facilitates the physician in reaching diagnosis and recommended to be used in addition to physical examination and laboratory evaluations[8, 9]

Physical examination should cover identification of risk factors such as weight gain with BMI = 28 kg/$m^2$, neck circumference, detailed upper respiratory examination along with Muller's maneuver in which supple endoscope is passed through nasal cavity and patient is instructed to inspire with mouth and nose closed. In this way collapse of soft tissues at tongue base, above soft palate and pharyngeal obstruction can be visualized. Similarly, the disease may go unnoticed and underdiagnosed when patients visit any clinic or hospital, they are inquired about systemic disorders but not screened for OSA symptoms. Radiographs should be taken to assess craniofacial malformation or occlusion.[10]

The "gold standard" test for the diagnosis of OSA is polysomnography, which include the accounts for various observations like electroencephalogram, electrocardiography, electrooculogram, electromyography, pulse oximetry, nasal and oral airflow, sleep posture, blood pressure and esophageal pressure. Another type is a split-night polysomnography which is conducted in two phases first usual polysomnography test is done followed by CPAP- Continuous positive airway pressures- titrations but these tests are very expensive and require a lot of investigations of physiological processes and a night stay which in our setup is not easy.[11] Ultrasound is emerging as an effective and beneficial technique in estimation of tonsil volume in adults and pediatric population. Palatine tonsil is simplyrecognized in the pharynx through physical examination but in certainconditions, the size and position of the tongue and its base may make necessary evaluation difficult. In routine examination, tonsil grading and lateral views of x-rays are utilized to judge the area occupied by tonsils. Clinical gradingof tonsils involve transverseextension of the lymphoid tissue towards the mid line. On theother hand, depth of this tissue in the oral aspect and medial marginspreading toward the pharynx are not evaluated.[12] Ultrasonography is frequently used to evaluatecranio-cervicalgrowths or masses.[13]However, for visualizationof tonsils, the usage of this modality is scant. Transcervical ultrasound was used to distinguishperitonsillar cellulitis from tonsillar abscess in adults.Its use has shown an outstanding sensitivity and specificity in order to differentiate between tonsillar infections.[14, 15]

Incorrect assessment of the disease condition may lead to inaccurate treatment and management that may end up in life threatening complications. Other imaging techniques such as CT-scan neck can be used for identification of pathology but with it there is an issue of harmful exposure of radiations. Consequently ultrasound has been increasingly used for imaging purposes due to its safety and easiness and should be considered for diagnostic and preoperative assessment. Therefore, it is evident from literature that transcervical ultrasound can be an acceptable imaging technique for the evaluation of tonsillar shape, size, appearance, perfusion, pathology and as well as severity of obstructive sleep apnea by identifying pathological changes of the anatomical structures that basically cause it.[16] It is imperative to review literature and gather authentic information from different researches conducted worldwide to helpphysicians, surgeons and health care providers by providing them evidence based outcome when ordering investigations to their patients, objective ultrasound findings of tonsillar size in OSA.

**METHODOLOGY:**

The literature was reviewed and systemically searched from international search engines for example pub med and Google scholar. This literature search was carried out from 2000-2020. The used key words were palatine tonsil, ultrasound, grading, snoring, oropharyngeal anatomy and obstructive sleep apnea. By exploring with these key words total 72 articles were retrieved and 47 articles were filtered by focusing on the topic.In addition to the mentioned topics, more articles were further explored from the references of the filtered articles to get more literature.

**LITERATURE REVIEW:**

The paired palatine tonsils are positioned at the junction of the gastrointestinal and respiratory tract in tonsillar fossa between palatoglossal and palatopharyngeal arches. These lymphoepithelial organs and are the sites for continuous lymphoid cell stimulation therefore are an important part of immune system.[17] Tonsils undergoes hypertrophy due to recurrent infections or as a part of generalized lymphoid hypertrophy. The first removal of the tonsils was explicated in the first century A.D. by Cornelius Celsus in Rome. He used his bare fingers to embrace the tonsil and remove it. If the tonsil was covered by a membrane, he used a scalpel to cut through it. Later vinegar and a layered medication were used to accomplish hemostasis.[18]

There are various pre- and post-operative methods for the determination of tonsil volume that how much they occupy oropharyngeal isthmus. Evaluation of its size and free pharyngeal airway is significant in clinical routine. The present valuation of palatine tonsils is made according to Brodsky's criteria for almost thirty years.[19] However, controversies are still present about the significance of such measured methods. In accordance with Gray's anatomy, itstates that "the size of the projection of the medial border of the tonsil into the pharynx is not a true indication of the size of the organ''.[20] Various other methods developed for

estimation of actual volume includes measurements of various parameters on excised specimens, these include Archimedes' Principle according to which water displaced by excised specimen measured as real volume. Ellipsoid formula in which total tonsil volume is calculated as product of length, width and depth of specimen , multiplied by 0.523, measured by sliding calipers and ruler.Cavalieri method involves physical sectioning of surgical specimen of equal thickness then addition of volumes of each section by incorporating values obtained in a certain formula for total volume of a specimen.[21] Other diagnostic measures include radiographic, ultrasonographic, CT scan and MRI images. All these modalities have certain limitations and restrictions, among them ultrasonographic assessment is the safest and innovative. It is eminent that the lateral view of skull radiograph is valuable for the assessment of adenoid hypertrophy or nasopharyngeal narrowing; on the other hand, tonsil shadow can also be seen in the skull lateral view. Furthermore this technique can be easily performed on pediatric patients in an out-patient department.[22-25]. Correlational analysis of tonsillar grading and tonsillar volume in a prospective cohort done in adults showed the mean post-operative tonsillar volume of grades 1,2,3 and 4 was 2.58±1.15, 4.33±1.99, 6.58±2.69 and 9.33±1.15ml, respectively as a significant relationship between them with $p<0.001$.[26]

Another study revealed the coherent correspondence between subjective and objective tonsillar dimensions and added that Brodsky grading was more effectively linked with OSA severity than palatine tonsillar volume.[27] It was documented in 2015 that size of tonsil does not influence the severity of OSA with p-value =0.32. The study was conducted on 70 children of ages between 1to18 years undergoing adeno-tonsillectomy, polysomnography was done before and after surgery. 40 % (28/70) Subjects who were categorized as grade 3+ and 4+, their symptoms resolved completely after surgery. Improvement in AHI also noted from the median of 11.8±21.7 to 2.0±6.1 events/h.[28]

In a recent review article, authors concluded that present available anatomical treatment strategies do not provide cure to all adults suffering from OSA whereas clinical diagnosis is limited to apnea hypopnea index severity which is also not a complete criteria. There is rising attention towards anatomical and physiological phenotyping which is related to syndrome identification. Clinical evaluation of a patient must include a detailed morphological evaluation of oropharynx with supportive physiological treatment which is evolving such as oxygen, sedatives, stimulation of hypoglossal nerve that will modify therapy options for an appropriately selected patient.[29] Pre-surgical evaluation of palatine tonsil volume helps physicians in appropriate diagnosis as this technique is safest,noninvasive and less painful. In adults, for over 30 yearstrans-cervical ultrasound has been used for the detection of peritonsillar infections. However, in the past few years use of this modality is highlighted to observe the tonsilsin pediatric population.[30]

Trans-cervical ultrasound imaging technique is considered generally safe as it is noninvasive, devoid of harmful radiations, valuable in detection of head and neck masses in young age group. In recent times, this imaging technique has been gaining significant value because of its ability to visualize the oral cavity and pharynx with meticulousness. Effectiveand successful use requires a thorough knowledge of airway anatomy and ultrasound experience [12, 31-33] Trans-cervical ultrasound of palatine tonsils as an adjunct to the assessment of upper airway is an alternative and complementary imaging method to magnetic resonance imaging and computed tomography which have certain limitations.Pre-surgical evaluation of tonsil anatomy with ultrasound is thought to be valuable for the estimated response to tonsillectomy and perioperative distresses .[34]

In the pediatric domain, Bandarkar et al reported first time use of tonsillar ultrasound of various tonsillar pathologies along with comprehensive photographic accounts. Authors of the study used this novel technique to differentiate tonsillitis, tonsillar abscess, peritonsillar cellulitis and infections. This technique determines palatine tonsils effectively and accurately as well as it is very practicable and noninvasivechoice. In spite of presenting great assertion for identifying different tonsillar pathologies, authors of this research reported that there are no studies in the literature that confirms precisionof this imaging technique in assessing volume of tonsil in different scopes.[35] An ultra-sonographic study, which is the first of its kind, performed on 26 children in which they have compared preoperative trans-cervical tonsillar ultrasound measurements with excised tonsils and volume assessment by water displacement method. The mean ± SD ultra-sonographic size was 3.6 ml (±2.5ml) and actual tonsillar size was 3.9ml (±2.1ml) having p-value 0.24 which is not significant but have correlation with real tonsillar size (r=0.89), these findings will help in further perioperative risk stratification of pediatric patients planned for surgery who could or not undergo obstructive sleep apnea syndrome. However, both measurement methods shows no distinction but compliance of sonographic measurements was proven.[36]

Kay-Rivest E et al;are the pioneers to affirm size of tonsil in threescopes can be exactly distinguished with ultrasound and relates with ex vivo specimens. In their prospective analysis they compare tonsillar ultrasound dimensions to actual pathology in 75 consecutive children going through surgery for various reasons. In general, ultrasound mildly underestimated tonsillar size. The right and left tonsils which were assessed exhibited dissimilarities between measured volumes of -0.075 and actual volume of -0.221 $cm^3$ along with confidence interval of 95%. They have concluded that high frequency ultrasound is an effective technique to evaluate acute and chronic tonsillar disease in

pediatric population.[37] In a study pre-surgical evaluation of subjective and actual volume after tonsillectomy were compared in which investigators of the studyestablished that tonsil sizes were higher in the subjects who were overweight and undergoing from Obstructive sleep apnea syndrome further objective volume and clinical volume estimation through grading correlates well..[38]

Obesity is one of the major influencing featurefor Obstructive sleep apnea. Development of this condition likely involves increase in appetite hormones triggered by disturbed sleep whereas might help mild condition but not the severe one.[39] A study which involves 277 pediatric cases relates pre surgical subjective grading via oral examination with post-surgical measurements of tonsil which includes width, length, height and volume. Volumewas the best correlated factor in the subjective classification and actual tonsil volume was described to differ from 2.17-4.7 ml.[40]

Children with advanced obstructive sleep apnea have high chances of getting postsurgical airway problems.[41] In pediatric populationthe occurrence of postoperative complications is nearly four times greater in children of age less than 3-years.[42]In tonsillar enlargement and severe OSAsubjects sonography may be used to identify and predict the severity of postsurgical complications after tonsillectomy.Anatomy ofhuman's upper respiratory tract is highly variable, and the pathological anatomy of sleep apnea patients is even more inconstant. Furthermore the upper airway anatomy of sleep apnea patient alters over time as the condition advance or recovers.[43]

In a prospective clinical research that includes both children and adults in which the investigators explore the achievement of ultrasonography in the precise estimation of palatine volume. In the sample of 50 children the mean actual tonsil volume ±SD was 3.5 ± 1.45 ml which was evaluated through water displacement method and ultrasonographic volume was3.67 ± 1.59 ml with high correlation. In this study the mean actual tonsil volume in 35 adult subjects ± SD was 5.15 ± 2.25 ml. Ultrasonographic volume which was evaluated was 5.71 ±2.98 ml with moderate correlation was found between both methods.[44] It is well identified that endophytic tonsil lead to misrepresentative of clinical grading as compared to actual volume in adults. Those subjects with lower grades were known to have greater tonsil volume than predicted during surgery. In these type of cases ultrasound is a better option to provide true estimation of tonsil volume that may enhance considerable importance and direction on clinical follow up or operation decisions.[45]

Another ultrasonographic Japanese study conducted in pediatric age group, in which authors reported that tonsil size increases significantly until 3-years of age but it does not increases between 3 to 12 years of age, they also reported that tonsil size was associated with anthropometric indices like age, weight, and height, with strongest correlation with height. Authors of the study concludes, usage of this modality in early assessment of tonsillar pathology, determination of its size and assistance in pre-surgical evaluation of its expansion in the oral cavity[46] Imaging, performed predominantly by physicians and research scientists, has been essential to evaluate the morphological basis of obstructive sleep apnea.Increased collapsibility of the upper airway due to increased nasal resistance and a narrowed, elongated oropharynx leads toapnea during sleep as there is reduction in tone of the pharyngeal dilator muscles. Imaging can strongly detect this condition. The value of imaging techniques has proven its importance in assessing site, degree and reasons of airway collapsibility, its length and location of the hyoid bone.[47] Understanding of radiological anatomy of the normal tonsillar tissue and various peritonsillar pathologies can help the radiologist and clinicians to make the appropriate diagnosis. Correct diagnosis of the condition helps in management of cases,taking decisions and care of patients. Imaging technique like ultrasound should be considered when managing or treating obstructive sleep apnea in order to assess the airway appropriately which will in turn help in better evaluation of a patient. Though it is not the standard in care of patients, there is significant potential for the incorporation of ultrasound technology into forthcoming care of upper airway assessment.

## CONCLUSION:

High frequency ultrasound is an impeccable diagnostic tool for assessment of tonsils in children and adults. It is cost effective, portable, noninvasive, painless, quick and easily accessible as compare to CT and MRI imaging. Also, it does not require sedation neither uses ionizing radiations. Use of this safest modality aids clinical classification and can be helpful in decisions for tonsillectomy.

**Author Contribution:**
Ayesha Mehwish: Conceiving the idea, data collection and analyzing data, literature search and writing of the article
Ambreen Usmani: Literature search, analyzing data and writing of the article

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