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Research Article

Utility of tongue root Acoustic Radiation Force Impulse Ultrasound Elastography in Determination of Obstructive Sleep Apnea Risk

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Abstract

Objectives: The aim of this study is to evaluate the efficacy of tongue root Acoustic Radiation Force Impulse (ARFI) Ultrasound Elastography in obstructive sleep apnea syndrome (OSAS) risk.

Methods: Patients who were referred to our ultrasonography department for different reasons were asked to participate to the study. All subjects filled in a Berlin Sleep Questionnaire (BQ) after the tongue root ARFI elastography examination. The measurements were obtained via a 1.5x1.5 mm box, two valid measurements were recorded from the center of each quadrant of tongue root, both in axial and sagittal sections. Subjects with two or more positive categories according to BQ were regarded as high risk for OSAS.

Results: One hundred and thirty-two subjects (35 males and 97 females) were enrolled in the study. The mean age of the participants was 47.25±27.60 years (18-95), and the mean BMI was 27.60±5.05 kg/m^2 (17.71- 43.25). Forty-six subjects (34.8%) were normal weighted, 44 (33.3%) were overweight, and 42 (31.8%) were obese. According to BQ, 52 subjects (39.4%) were in high-risk group, and 80 (60.6%) were in low-risk group for OSAS. There was no statistically significant relationship between high risk and low risk participants regarding axial or sagittal ARFI velocities. There was a statistically significant correlation between obesity and axial mean ARFI velocities. The axial mean velocities were lower in obese participants than normal and overweight ones, and lower in overweight participants than normal ones (p=0.028). No significant difference was found between the sagittal ARFI Elastography measurements of obese and non-obese subjects in the high-risk group (p=0.165). Mean axial ARFI measurement of obese subjects was significantly lower than other individuals (p=0.039) irrespective of OSA risk category.

Conclusion: Tongue root ARFI Elastography results are different among BMI groups, axial ARFI Elastography measurements of obese subjects were found to be lower than other individuals, but it is not a useful tool to differentiate low and high risk OSAS groups.

Keywords: ARFI, elastography, sleep apnea, tongue

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Obstructive sleep apnea syndrome (OSAS) is a relatively common disease that its complications cause significant mortality and morbidity.[1,2] Polysomnography is the gold standard diagnostic tool; however, it requires overnight hospitalization and bed capacity is limited with prolonged wait times. Diagnostic delays may occur due to late appointment dates.[3] Some surveys or tests have been proposed for screening, so that polysomnography appointments can be

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prioritized according to their results.[4-7] Lesser time consuming and practical diagnostic tools or screening methods are needed in the diagnosis of OSAS. We aimed to evaluate the diagnostic utility of tongue root Acoustic Radiation Force Impulse (ARFI) Ultrasound Elastography in OSAS.

Methods

This prospective study was confirmed by institutional ethics committee (Date 18.06.2020, Number: 02), and conducted between July 2020 and February 2022, in a tertiary health center. All patients gave informed consent.

Patients referred for ultrasonographic evaluation due to various reasons were asked to participate in the study. Individuals younger than 18 years old, male volunteers who had a beard, patients who had a history of head or neck surgery, or irradiation were excluded.

All patients underwent ARFI elastography examination by a Siemens Acuson S 2000 device (Siemens, Erlangen, Germany), with a linear 9L4 probe. Vendor's preset thyroid program was used. Patients lied down on the examination couch comfortably with a pillow under their neck, as the same position as thyroid ultrasound exam. The ultrasound probe was placed firmly under the chin avoiding compression. Axial and sagittal ARFI measurements was obtained at the end of the expiration. Patients were not asked to hold their breath to avoid any possible contraction of tongue muscles. The measurements were obtained via a 1.5x1.5 mm box, two valid measurements were recorded from the center of each quadrant of tongue root, both in axial and sagittal sections (Figs. 1, 2).

All subjects filled in Berlin Sleep Questionnaire (BQ) after the tongue root ARFI elastography examination.[8-10] This questionnaire was used for evaluating OSAS risk in this study and consists of 3 categories and 10 questions involving snoring and apnea in the first category, tiredness, and daytime sleepiness in the second and presence of hypertension or obesity in the third category. Subjects with two or more positive categories are regarded as high risk

Figure 1. Axial position and corresponding ARFI Elastography image.

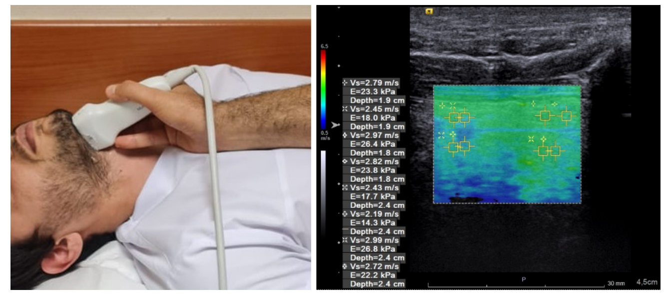

Figure 2. Sagittal position and corresponding ARFI Elastography image.

for OSAS.[11,12] Additionally, age, gender, body mass indices (BMI) of all patients were recorded.

Data were analyzed using SPSS (Statistical Package for Social Sciences) version 15.0. Continuous variables were reported as mean±SD. For the bivariable analysis, when the variables were parametric, the difference of averages test (Student's t-test) was used; in the case of variables with more than two categories, the one-way ANOVA test was carried out. Categorical variables were expressed as counts or percentages and compared using a χ^2 test. The $p<0.05$ was accepted as significant. Also, continuity-corrected chi-square test was used for qualitative data comparison, and independent groups t-test was used for two-group quantitative data comparison.

Results

One hundred and thirty-two subjects (35 males and 97 females) were enrolled in the study.

The mean age of the participants was 47.25±27.60 years (18-95); and the mean BMI was 27.60±5.05 kg/m^2 (17.71-43.25). Forty-six subjects (34.8%) were normal weight, 44 (33.3%) were overweight, and 42 (31.8%) were obese. According to BQ, 52 subjects (39.4%) were in the high-risk group, and 80 (60.6%) were in the low-risk group for OSAS. Results of the BQ is summarized in Table 1.

Table 1. Berlin Sleep Questionnaire results

	Number	%
Increased sleepiness		
Present	11	8.3
Not Present	121	91.7
Hypertension		
Present	31	23.5
Not Present	101	76.5
Body Mass Index		
Normal (18.51-24.99 kg/m^2)	46	34.8
Overweight (25-29.99 kg/m^2)	44	33.3
Obese (>30 kg/m^2)	42	31.8

There was a weak but statistically significant correlation between age and sagittal mean ARFI velocities. Sagittal mean ARFI velocities increased with age (r=0.22, p=0.010).

There was a weak but statistically significant correlation between age and axial mean ARFI velocities. The axial mean ARFI velocities decreased with increasing age (r=-0.21, p=0.018).

There was no significant relationship between high risk and low risk participants regarding axial or sagittal ARFI velocities (Table 2).

There was a statistically significant relationship between gender and axial mean ARFI velocities. The axial mean velocities were higher in females (p=0.021) (Table 3).

There was a statistically significant relationship between obesity and axial mean ARFI velocities. The axial mean velocities were lower in obese participants than normal and overweight ones, and lower in slightly obese participants than normal ones (p=0.028) (Table 4).

No significant difference was found in the comparison of sagittal ARFI Elastography measurements of obese and non-obese subjects in the high-risk group (p=0.165).

There was a significant difference in the comparison of axial ARFI Elastography measurements of obese and non-obese subjects in the high-risk group. Mean axial ARFI measurements of obese subjects was lower than other individuals (p=0.039).

Table 2. Comparison of sagittal and axial mean ARFI velocities of risk groups according to Berlin survey

	High risk (n=52) (Mean±SD)	Low risk (n=80) (Mean±SD)	p
Sagittal mean velocity (m/s)	2.09±0.28	2.38±2.56	0.410
Axial mean velocity (m/s)	2.22±0.37	2.31±0.41	0.142

SD: standard deviation.

Table 3. Comparison of sagittal and axial mean ARFI velocities by gender

	Male (n=35) (Mean±SD)	Female (n=97) (Mean±SD)	p
Sagittal mean velocity (m/s)	2.17±0.33	2.30±2.33	0.757
Axial mean velocity (m/s)	2.40±0.39	2.23±0.35	0.021

SD: standard deviation.

Discussion

The tongue, which includes the main dilator muscle of the upper airway genioglossus, has an important role in the development of OSAS.[11] The genioglossus muscle provides the forward movement of the tongue, and it has been reported that the backward displacement of the tongue has a significant contribution to the formation of apnea, especially in people who mouth breath during sleep.[12] In addition, increased fat infiltration in the soft tissues of the neck and decreased pharyngeal muscle tone in patients with OSAS have been reported to narrow the airway.[13]

In our study, which was planned in the light of this literature, we could not demonstrate significant correlation between OSA risk and axial or sagittal ARFI velocities.

It has been previously stated that Shear Wave Velocity (SWV) measured in 2-D Shear Wave Elastography (SWE) is sensitive to changes in muscle stiffness during active contractions and may be an indicator of muscle stiffness.[14] In addition, there are different studies evaluating muscle stiffness with sonoelastography.[15-20] Evaluation of tongue stiffness with imaging methods can provide information about the pathogenesis of OSAS and can be used in the follow-up of the response to the treatment applied in such patients.

Elastography measurements of the tongue in patients with OSAS have been the subject of only a few studies to date.[21-23] In a study conducted with the MR elastography (MRE) method, a lower tongue shear wave modulus was found in patients with OSAS compared to the control group.[21] In this study, a decrease in tongue stiffness was observed with a high apnea hypopnea index, but no significant correlation was observed with BMI or age.

Contrary to these findings, in another study using SWE, significantly higher tongue stiffness was found in OSAS patients compared to healthy controls.[22] The researchers stated that this inconsistency between the SWE and MRE findings may be due to the differences in the frequencies used in the methods. Besides, it has been suggested that this difference may be partially caused by the different par-

Table 4. Comparison of sagittal and axial mean ARFI velocities according to Body Mass Index

	Normal (Mean±SD)	Overweight (Mean±SD)	Obese (Mean±SD)	p
Sagittal mean velocity (m/s)	2.66±3.36	2.07±0.31	2.04±0.25	0.124
Axial mean velocity (m/s)	2.35±0.41	2.33±0.35	2.14±0.31	0.028

ticipant population. It is known that Asian patients with OSAS have a lower obesity rate and different distribution of body fat components.[24] The researchers speculated that a lower fat level in the tongue might result in higher cutting modulus in the participants in their study. With these findings, they concluded that the difference between OSAS patients in Asian and Western countries was caused by different physiopathologic processes.

In another study evaluating the tissue stiffness of the tongue muscles with SWE, significant changes in SWV were determined in the muscles next to the implanted stimulator.[23] Researchers were able to measure SWV values in genioglossus and geniohyoid muscles during relaxation and contraction caused by nerve stimulation with SWE, and they found an increase in muscle stiffness during stimulation. They stated that in hypoglossal stimulation therapy, it may be possible to distinguish those who respond to treatment from those who do not with sonoelastography.

In our study, although we found the axial mean SWV value to be lower in the high-risk group for OSAS, we did not find a significant difference between the risk groups in the sagittal plane. In the literature, significant differences in shear modulus values between different scan planes of muscles have been reported in animal[25] and human[26] studies. In a study using MRE, it was observed that differences in tongue stiffness in OSAS occur in the direction of muscle fibers.[21]

The factors that determine the stiffness of tongue tissues are classified in two groups: first, the constant "continuous" component of muscle and connective tissue, and secondly, the "active" contribution of muscle contraction caused by neural impulses that can change with the onset of sleep.[27] In the three-point Dixon MRI study, an increase in fat deposition at the base of the tongue was found in patients with OSAS.[24] In another study, the thickness of the tongue and soft palate was found to be higher in obese cases than in normal cases.[28] It has been reported that there is a significant correlation between the development of apnea and that OSAS symptoms may regress with weight loss.[12] We also found increased obesity in the high-risk group for OSAS in our study.

Limitations

Initially, our study was planned to compare the tongue ARFI elastography results with polysomnography, but due to the COVID 19 pandemic restrictions, our polysomnography unit was closed and turned into ICU. Our results may be compared with future studies targeting polysomnography reports.

Conclusion

Though tongue root axial ARFI Elastography measurements of obese subjects were found to be lower than other individuals, we report that tongue root ARFI Elastography is not a useful tool to differentiate low and high risk OSAS groups. To date, there are few studies evaluating muscle stiffness in OSAS patients with sonoelastography, and we think that our study will contribute to the literature despite its limitations.

Disclosures

Ethics Committee Approval: SANKO University Ethical Board Committee (Date 18.06.2020, Number: 02).

Peer-review: Externally peer-reviewed.

Conflict of Interest: None declared.

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