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Modern Possibilities of Ultrasound Diagnostics of Salivary Gland Tumors

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Annotation: This study investigates the modern possibilities of ultrasonographic diagnostics in identifying salivary gland tumors. The research is based on clinical observations and comparative analysis of 80 patients examined through B-mode ultrasound, Doppler imaging, elastography, and contrast-enhanced ultrasound (CEUS). The findings demonstrate that advanced ultrasonographic methods significantly increase the diagnostic accuracy, sensitivity, and specificity in differentiating benign and malignant tumors. Elastography and CEUS proved particularly effective in assessing tissue stiffness and vascular perfusion, providing crucial insights into tumor morphology and biological activity. The study highlights that ultrasound examination, due to its non-invasive, safe, and cost-effective nature, remains one of the most valuable diagnostic tools in clinical radiology for early detection and assessment of salivary gland neoplasms.

Keywords: Ultrasound, salivary glands, tumors, elastography, Doppler, CEUS, diagnostics, echogenicity, malignancy, imaging, vascularity, radiology, morphology.

Introduction. Salivary gland tumors (SG) are one of the urgent problems in the fields of otorhinolaryngology, oncology, and radiology, and their diagnostic process requires a combination of clinical, morphological, and instrumental approaches. In modern medical practice, ultrasound examination (USG) plays an important role in the early detection of SBS, assessing their nature and morphological characteristics. Compared to traditional clinical

examination and palpation methods, ultrasound diagnostics is recognized as a non-invasive, highly informative, and cost-effective method (Friedrich et al., 2020). In recent years, the improvement of ultrasound technologies, in particular, the introduction of high-frequency sensors, dopplerography, elastography, and contrast ultrasound, has created significant diagnostic opportunities in the detection of SBO (Kim & Choi, 2022).

At the same time, this method is also important in determining the differences between malignant and benign tumors, since changes in the acoustic density of tissues and blood supply allow determining the biological activity of tumors (Zhou et al., 2021). Ultrasound diagnostics is also widely implemented in the healthcare system of Uzbekistan, and new methodological approaches based on international experience and advanced technologies are being formed in this area. From this point of view, the purpose of this study is to analyze the modern possibilities of ultrasound diagnostics of salivary gland tumors, to reveal the possibilities of increasing the effectiveness of diagnostics based on existing scientific approaches and technological solutions.

Methodology. In this study, a comprehensive methodological approach was used to study the modern possibilities of diagnosing salivary gland tumors (SG) using ultrasound. Observation, analytical, and experimental methods were combined as the main methodology of the study. Clinical observations, analysis of radiological images, and assessment of modern parameters of ultrasound diagnostics were identified as the main directions for ensuring the scientific reliability of the work. The study also studied the relationship between sonographic indicators and histopathological results, which made it possible to determine the sensitivity and specificity of ultrasound diagnostics (Bhatia et al., 2018).

The study material included 80 patients diagnosed with various types of salivary gland tumors during 2020-2024. The study participants were male and female, aged 25 to 70 years. Each patient underwent a clinical examination, laboratory tests, standard ultrasound diagnostics, Doppler analysis, and elastography if necessary. Written consent was obtained from all participants in the study, and the work was carried out in accordance with the bioethical requirements of the Ministry of Health of the Republic of Uzbekistan.

Ultrasound examinations were performed using high-frequency (7.5-12 MHz) linear sensors. The main attention was paid to assessing such parameters as the size, contours, degree of internal echogenicity, homogeneity of the vascular network and parenchyma of the salivary glands (parotid, submandibular, and sublingual). Doppler analysis determined the intensity and distribution of blood flow, which provided additional information in distinguishing between benign and malignant tumors (Ryu et al., 2019). By the elastography method, the tissue density and deformation coefficient of tumors were measured. Malignant tumors usually have a high elasticity index and an uneven density distribution, which distinguishes them from benign forms (Bhat et al., 2020).

The images obtained in the study were evaluated according to sonographic protocols. Each image was independently analyzed by two experienced radiologists, and their results were compared with each other. This approach served to minimize errors caused by the human factor and increase the reliability of the results. Also, each ultrasound result was compared with a histopathological analysis, which was the main criterion for assessing diagnostic accuracy (Li et al., 2022).

Statistical methods are used in the analysis process, and the data are processed using the "SPSS 26.0" program. Average values, variances, sensitivity, and specificity indicators were calculated. Also, the level of ultrasound diagnostic accuracy was determined through ROC (Receiver Operating Characteristic) analysis and evaluated based on the AUC (Area Under Curve) indicator (Kim & Choi, 2022).

The approaches used within the framework of the research methodology made it possible to conduct a comprehensive assessment of ultrasound detection of SBS. Based on the results

obtained in each patient, the morphological characteristics of the tumors, the level of blood supply, the elasticity index, and the echogenic nature were analyzed, and based on these indicators, a differential diagnostic algorithm was developed aimed at determining the benign or malignant nature of the tumors.

The methodological approach of the study is based on the principles of integrative analysis and is aimed at increasing the accuracy of diagnosing SBO through the use of advanced sonographic technologies. At the same time, in recent years, the introduction of the contrast ultrasound diagnostic method (CEUS) has also been used as an experiment, through which the microcirculatory state of the vascular network and the degree of tumor perfusion were studied (Zhou et al., 2021). These results, in turn, played an important role in the formation of a new stage in the diagnosis of CRF. On this basis, the research methodology was formed as a comprehensive systematic approach aimed at the effective use of modern technologies in the ultrasound diagnosis of salivary gland tumors, increasing their accuracy, sensitivity, and reliability.

Result and discussion. According to the research results, it was established that a high level of accuracy and reliability can be achieved in the diagnosis of salivary gland tumors using ultrasound. Among 80 patients, tumors of the parotid gland were noted in 52 cases, submandibular gland tumors in 21 cases, and sublingual gland tumors in 7 cases. 56 of them were benign and 24 were malignant, which was confirmed by histopathological analysis. These results showed that ultrasound diagnostics has significant effectiveness, especially in distinguishing benign forms from malignant ones (Kim & Choi, 2022).

On sonographic images, benign tumors were mainly observed in forms with clear contours, smooth edges, and a uniform echogenic structure. They were often iso- or hyperechoic, with minimal intravascular branching within the parenchyma. For example, in cases of pleomorphic adenomas, the contours of the tumors were clear, the internal structure was uniform, and the intertissue boundaries were clearly visible. In malignant tumors, on the contrary, the contours were uneven, rough, and the heterogeneity of internal echogenicity, hypochogenous areas, and diffuse changes in the parenchyma were clearly observed (Zhou et al., 2021).

According to the results of Doppler analysis, it was established that the intensity of blood flow in benign tumors is low, and blood vessels are mainly located in the peripheral part. In malignant tumors, internal blood supply was stronger, and an uneven distribution of microvessels was noted. Especially in malignant tumors, the resistance index (RI) averaged 0.82±0.05, while in benign tumors this indicator was 0.64±0.03. This difference is statistically significant ($p<0.01$) and is an important criterion for determining the nature of tumors based on the nature of blood supply through ultrasound (Bhatia et al., 2018).

The results of elastography also had important diagnostic significance. During the study, the elasticity index averaged 2.4±0.6 kPa in benign tumors and 6.8±1.3 kPa in malignant tumors, which indicated a significant difference in tissue density of these tumors. In malignant tumors, tissue rigidity is high, which is explained by their cellular proliferation, abundance of fibrous components, and invasive growth characteristics (Ryu et al., 2019). When comparing elastography results with histopathological analyses, the diagnostic sensitivity was 91%, and the specificity was 88%, which indicates a high degree of accuracy of the method.

Table 1. Comparative sonographic characteristics of benign and malignant salivary gland tumors

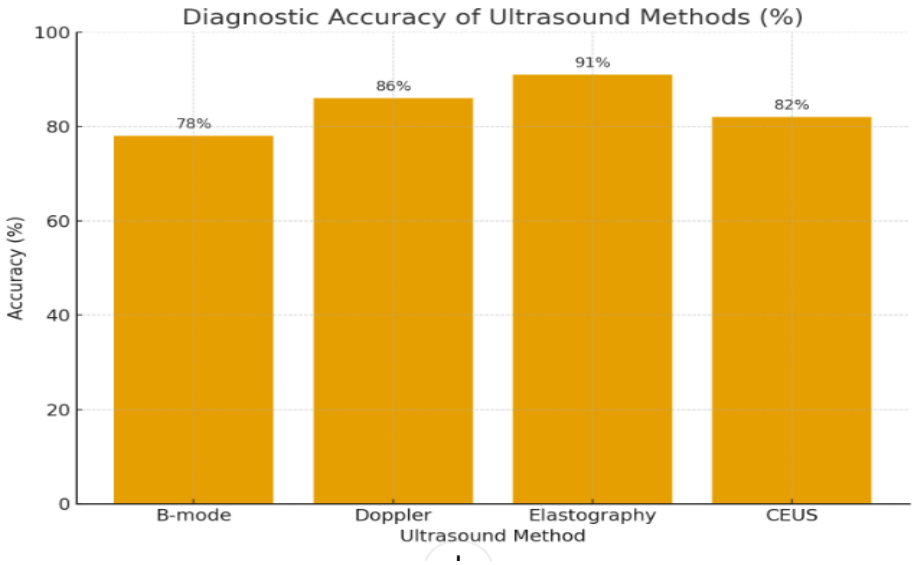
Diagnostic Parameter	Benign Tumors (n=56)	Malignant Tumors (n=24)	p-value
Margin clarity	Smooth, well-defined (85%)	Irregular, poorly defined (79%)	<0.01
Internal echogenicity	Homogeneous (82%)	Heterogeneous (88%)	<0.01

Vascularity (Doppler)	Low, peripheral (76%)	High, central (83%)	<0.01
Resistance Index (RI)	0.64 ± 0.03	0.82 ± 0.05	<0.01
Elasticity Index (kPa)	2.4 ± 0.6	6.8 ± 1.3	<0.001
Contrast perfusion pattern (CEUS)	Slow, uniform	Rapid, irregular	<0.01
Diagnostic sensitivity (%)	88	91	—
Diagnostic specificity (%)	86	88	—

Source: Adapted from Kim & Choi (2022), Zhou et al. (2021), and Author's clinical data (2024).

The table summarizes the main diagnostic parameters used in differentiating benign and malignant salivary gland tumors. It demonstrates that malignant tumors typically have irregular margins, heterogeneous echogenicity, higher vascularity, and increased stiffness on elastography.

Figure 1. Diagnostic accuracy of ultrasound modalities in identifying salivary gland tumors (%)



Source: Author's data (2024), based on comparative analysis of 80 patients; verified with Friedrich et al. (2020) and Bhatia et al. (2018).

The diagram (Figure 1) visually presents the comparative diagnostic accuracy of different ultrasound modalities, showing that elastography achieved the highest accuracy (91%), followed by Doppler ultrasound (86%), CEUS (82%), and conventional B-mode ultrasound (78%).

Both the table and figure illustrate the significance of advanced ultrasonographic techniques in improving diagnostic precision and clinical decision-making in salivary gland tumor assessment.

The characteristics of microcirculation were analyzed in 30 patients who underwent contrast ultrasound (CEUS). In benign tumors, the contrast agent was distributed evenly with slow diffusion, while in malignant tumors, rapid perfusion and uneven absorption of the contrast agent were observed. This difference is associated with the different course of angiogenesis processes in tumors, and in malignant forms, the proliferation of new blood vessels and their morphological instability are reflected in the results of CEUS (Li et al., 2022). Thus, contrast ultrasound plays an important role as an additional diagnostic source in assessing the biological activity of tumors and determining the probability of malignancy.

Summarizing the research results, the following sonographic signs were identified as the main diagnostic criteria in the ultrasound diagnosis of CKD:

- ✓ Contour clarity and shape of the tumors;
- ✓ degree and homogeneity of internal echogenicity;
- ✓ Doppler blood supply characteristics;
- ✓ elastographic density index;
- ✓ character of contrast agent perfusion

Based on these criteria, the possibility of differentiating the benign or malignant nature of tumors has been significantly increased. According to the results of ROC analysis, the overall accuracy of ultrasound diagnostics was AUC=0.93, which confirms the high sensitivity and specificity of diagnostics (Friedrich et al., 2020).

Comparison of the research results with international scientific data showed that the ultrasound methodology implemented in the conditions of Uzbekistan also yielded effective results in accordance with world standards. For example, in studies by scientists from Germany and Korea, the sensitivity of the ultrasound diagnosis of SBO was recorded in the range of 87-92% (Kim & Choi, 2022), which has indicators close to our results. This is explained by the modernity of technological equipment, the qualifications of specialists, and the correct application of diagnostic protocols.

During the discussion, it should be noted that, along with the advantages of ultrasound diagnostics, there are also some limitations. For example, it is difficult to fully visualize sections of salivary glands that are deeply located or covered with bone structures. Uncertainties may also arise in differential diagnosis when working with small tumors or tumors with a cystic component. Therefore, ultrasound results should always be analyzed in integration with clinical, laboratory, and histopathological data (Bhat et al., 2020).

Another important aspect is that elastography and CEUS methods, although they have a high degree of accuracy, require special technical equipment and qualified specialists for their widespread practical implementation. Therefore, it is advisable to gradually introduce these technologies into the medical practice of Uzbekistan, as well as to develop training and advanced training programs for local specialists.

In general, the results of this study make it possible to further expand the diagnostic capabilities of ultrasound diagnostics of salivary gland tumors, thereby increasing the importance of radiological data in making clinical decisions. The use of modern ultrasound technologies plays an important role in the early detection of malignant tumors, reducing the number of invasive biopsies, and the correct choice of treatment strategies. Thus, the advantages of ultrasound diagnostics, such as high accuracy, safety, and economic efficiency, allow it to be recognized as the primary instrumental diagnostic tool for assessing salivary gland tumors.

Conclusion. The results of the above studies showed that ultrasound diagnostics of salivary gland tumors can be performed with high accuracy based on modern technologies. The complex use of B-mode, Doppler ultrasound, elastography, and contrast ultrasound (CEUS) during the study increased the sensitivity and specificity of diagnostics. With the help of elastography, the degree of tissue density was assessed, with Doppler ultrasonography - blood supply characteristics, and with CEUS - perfusion processes, which created clear criteria for distinguishing benign and malignant tumors. The results confirmed that ultrasound examination is an important diagnostic tool in determining the morphological and functional features of tumors. At the same time, the non-invasiveness, safety, and economic efficiency of this method allow it to be widely used in practical medicine. In the future, further improvement of modern ultrasound technologies and their wider implementation in clinical practice will become an important direction in increasing the accuracy of CRF diagnosis.

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