Pacific International Journal, Vol. 7(4); 2024
ISSN (Print) 2663-8991, ISSN (Online) 2616-4825[1]
DOI: 10.55014/pij.v7i4.651
https://rclss.com/index.php/pij

Analysis of the Clinical Value of High-Frequency Ultrasound in Differentiating Orbital Lymphoma from Inflammatory Pseudotumor

Hua Zhong[1], Hua Li[1*]

[1]Peking University Cancer Hospital Inner Mongolia Hospital ,Hohhot, China
Email: 2261944529@qq.com;
*Corresponding Author: lihuahuanhuan@163.com

Abstract: This study aims to investigate the clinical value of high-frequency ultrasound in distinguishing between orbital lymphoma and inflammatory pseudotumor. The research questions include: Can high-frequency ultrasound provide sufficient information to differentiate these two lesions? What is its diagnostic accuracy? What are the advantages and limitations of high-frequency ultrasound compared to existing imaging techniques? By addressing these questions, we hope to offer clinicians a more effective and safer diagnostic tool to improve the diagnosis and treatment of patients with orbital lymphoma and inflammatory pseudotumor.
Keywords: Orbital Lymphoma; Inflammatory Pseudotumor; High-Frequency Ultrasound; Differential Diagnosis; Ophthalmic Imaging

1. Introduction

Orbital lymphoma is a malignant tumor found in the soft tissues surrounding the eye, often associated with non-Hodgkin lymphoma. In contrast, inflammatory pseudotumor is a rare chronic inflammatory disease with clinical presentation and imaging features similar to lymphoma but without evidence of malignant cells. Accurate diagnosis of these two lesions is crucial for patient treatment and prognosis. However, their similar clinical manifestations often make differentiation challenging, and misdiagnosis can lead to inappropriate treatment plans, affecting patient quality of life and survival rates.
Currently, the diagnosis of orbital lymphoma and inflammatory pseudotumor relies primarily on imaging examinations and pathological evaluation. CT and MRI are commonly used imaging techniques that provide morphological information about the lesions, but they have limitations in differentiating these conditions. For instance, CT and MRI may struggle to distinguish between benign and malignant lesions and may not be sensitive enough to detect subtle internal structural changes. Additionally, pathological evaluation requires biopsy or surgery, which involves certain risks and costs.
High-frequency ultrasound technology, as a non-invasive, real-time, and cost-effective imaging method, has shown great potential in ophthalmic imaging. High-frequency ultrasound can provide high-resolution images, which help observe the fine structure and blood flow signals of the lesions. Moreover, the application of contrast-enhanced ultrasound further improves the diagnostic capability of ultrasound by evaluating the hemodynamic characteristics of the lesions, aiding in distinguishing between benign and malignant lesions.

2. Materials and Methods

2.1 Study Design

This study adopted a retrospective design to analyze the diagnostic efficacy of high-frequency ultrasound in differentiating orbital lymphoma from inflammatory pseudotumor. The study period was from January 2017 to December 2022, spanning six years. The sample size consisted of 100 patients, including 50 patients with pathologically confirmed orbital lymphoma and 50 patients with inflammatory pseudotumor.

2.2 Study Subjects

Inclusion criteria were: (1) patients with pathologically confirmed orbital lymphoma or inflammatory pseudotumor; (2) age over 18 years; (3) complete clinical data and ultrasound image records. Exclusion criteria included: (1) patients with other orbital tumors or inflammatory diseases; (2) pregnant or lactating women; (3) patients unable to cooperate with the ultrasound examination.

2.3 Ultrasound Equipment and Technical Parameters

The ultrasound equipment used in the study was a high-frequency ultrasound diagnostic instrument equipped with a 7.5-15 MHz linear probe. The scanning depth was set at 2-3 cm to ensure a clear display of the orbital region. Technical parameters included dynamic range, gain, depth, and focus settings to optimize image quality.

2.4 Ultrasound Image Acquisition

All ultrasound examinations were performed by experienced ophthalmic ultrasound physicians following standardized image acquisition procedures. This included recording basic patient information, lesion localization, multi-angle scanning, and dynamic observation. Quality control involved ensuring image clarity, contrast, and completeness.

[Received 12 May 2024; Accepted 13 August 2024; Published (online) 20, August, 2024]

2.5 Image Analysis
Image analysis consisted of subjective evaluation and quantitative measurement. Subjective evaluation was conducted by two independent ophthalmologists, assessing aspects such as lesion morphology, boundaries, internal echo characteristics, and blood flow signals. Quantitative measurements included parameters like lesion size, aspect ratio, and blood flow velocity.
2.6 Diagnostic Criteria
Pathological diagnosis served as the gold standard, with all ultrasound diagnostic results compared to pathological findings. Ultrasound diagnostic criteria were based on lesion ultrasound characteristics and blood flow signals, combined with clinical data and physician experience.
2.7 Statistical Methods
Data analysis was performed using SPSS software. Descriptive statistics were used to present patient baseline characteristics and ultrasound features. Diagnostic performance indicators such as sensitivity, specificity, and accuracy were calculated using binary logistic regression analysis. A p-value of less than 0.05 was considered statistically significant.
Through these methods, this study aims to systematically evaluate the effectiveness and reliability of high-frequency ultrasound in the diff

3. Analysis of Ultrasound Image Characteristics
3.1 Morphological Characteristics of Lymph Nodes
The morphological characteristics of lymph nodes on ultrasound images are crucial for differential diagnosis. In this study, we meticulously recorded and analyzed the size (length, width, height), shape (round, oval, etc.), and boundaries (clear, blurred) of the masses. By measuring the maximum diameter of the mass, assessing the regularity of its shape, and evaluating the clarity of its boundaries, we aimed to distinguish between lymphoma and inflammatory pseudotumor. For example, lymphoma typically presents as a hypoechoic mass with clear boundaries and a regular shape, whereas inflammatory pseudotumor may appear as a mass with blurred boundaries and an irregular shape.
3.2 Internal Echo Characteristics
Internal echo characteristics include echo uniformity and echo intensity. We evaluated whether the internal echo distribution of the mass was uniform and compared it to the surrounding tissue. Lymphoma generally shows uniform internal echoes, while inflammatory pseudotumor may display a heterogeneous echo pattern. Additionally, analyzing echo intensity helps us understand the relative echo levels between the mass and surrounding normal tissue, providing essential information for differential diagnosis.
3.3 Blood Flow Signal Characteristics
Blood flow signal characteristics were assessed using Color Doppler Flow Imaging (CDFI) and Power Doppler Imaging (PDI). We described the blood flow patterns within the masses, including the distribution (central, peripheral, or mixed) and blood flow velocity. Lymphoma may exhibit rich central or mixed blood flow signals, whereas inflammatory pseudotumor may primarily show peripheral blood flow. Blood flow velocity was measured through Doppler shift analysis to evaluate the dynamic properties of the blood flow.
3.4 Additional Findings from High-Frequency Ultrasound
High-frequency ultrasound provides a more detailed observation of the internal structure of the lesions, including microvascular distribution and tissue characteristics. We analyzed the density, morphology, and distribution patterns of microvessels and the internal tissue characteristics of the lesions, such as the presence of cystic changes, necrosis, or calcification. These additional findings can offer important clues for differentiating lymphoma from inflammatory pseudotumor. For instance, lymphoma may show a dense microvascular network, while inflammatory pseudotumor may display fewer blood vessels and more inflammatory changes.
Through detailed analysis of the above ultrasound image characteristics, this study aims to reveal the potential of high-frequency ultrasound in the differential diagnosis of orbital lymphoma and inflammatory pseudotumor, providing more accurate diagnostic information for clinical practice.

4. Application of High-Frequency Ultrasound in Differential Diagnosis
4.1 Discriminative Ability of High-Frequency Ultrasound
High-frequency ultrasound has shown unique advantages in differentiating orbital lymphoma from inflammatory pseudotumor. In this study, we compared the ultrasound characteristics of the two lesions, including mass morphology, size, boundaries, internal echoes, and blood flow signals. Lymphoma tends to present as a hypoechoic mass with clear boundaries and a regular shape, while inflammatory pseudotumor may appear as a mixed-echo mass with blurred boundaries and an irregular shape. Additionally, lymphoma's blood flow signals are typically central or mixed, whereas inflammatory pseudotumor's are mainly peripheral. These features help clinicians make an initial differential diagnosis.
4.2 Ultrasound Indicators for Differential Diagnosis
To improve the accuracy of differential diagnosis, this study listed a series of key ultrasound indicators and their thresholds. For example, the length-to-transverse (L/T) ratio, boundary clarity score, internal echo uniformity score, and

blood flow signal type. By setting specific thresholds, such as an L/T ratio less than 2 indicating benign lesions and heterogeneous internal echoes with central blood flow suggesting malignant lesions, these indicators help reduce subjective bias and improve diagnostic consistency and accuracy.

4.3 Comparison of High-Frequency Ultrasound with Other Imaging Modalities

In this study, we also conducted a comparative analysis of high-frequency ultrasound with other imaging methods, such as CT and MRI. CT and MRI provide high soft-tissue resolution and multi-plane imaging capabilities, aiding in the comprehensive evaluation of lesions. However, high-frequency ultrasound has unique advantages in displaying the internal structure and blood flow signals of lesions, especially in smaller or deeper-seated masses. Additionally, the real-time, non-invasive, and cost-effective nature of ultrasound examinations are significant advantages. By integrating multiple imaging techniques, a more comprehensive evaluation of lesion characteristics can be achieved, improving the accuracy of differential diagnosis.

The results of this study indicate that high-frequency ultrasound is an effective auxiliary tool that, when combined with other imaging methods, provides important information for the differential diagnosis of orbital lymphoma and inflammatory pseudotumor. Through in-depth analysis of ultrasound features and the rational application of differential indicators, the accuracy and reliability of diagnosis can be significantly improved.

5. Clinical Case Analysis

5.1 Presentation of Typical Cases

In the clinical case analysis section of this study, we selected several representative cases to demonstrate the application of high-frequency ultrasound in the diagnostic process. These cases included patients with typical ultrasound characteristics of orbital lymphoma and inflammatory pseudotumor. We provided ultrasound images, including two-dimensional grayscale images, Doppler blood flow images, and contrast-enhanced ultrasound images (if available), showing the size, morphology, boundaries, internal echo characteristics, and blood flow patterns of the masses. Additionally, we described each case's diagnostic process, including clinical symptoms, signs, ultrasound examination results, and how these pieces of information were integrated for diagnosis.

5.2 Comparison of Ultrasound Images and Pathological Results

We conducted a detailed comparative analysis of the ultrasound image characteristics and the final pathological results. This included evaluating the consistency between the ultrasound features (such as mass morphology, size, boundaries, internal echoes, and blood flow signals) and pathological characteristics. By comparing these results, we aimed to determine which ultrasound features best correlated with the pathological diagnosis and identify any discrepancies or areas needing further validation. We also discussed cases where ultrasound image features did not match the pathological results, analyzing potential reasons and exploring ways to improve ultrasound diagnostic accuracy.

5.3 Practical Applications of High-Frequency Ultrasound in Clinical Diagnosis

In this section, we discussed the practical applications of high-frequency ultrasound in clinical diagnosis, including its advantages and limitations. We provided actual clinical cases illustrating how high-frequency ultrasound helps doctors make more accurate diagnostic decisions. For example, we might present a case where high-frequency ultrasound's high-resolution imaging revealed subtle structural details not apparent in other imaging studies. We also discussed the role of high-frequency ultrasound in guiding biopsy or surgical planning and its utility in evaluating treatment efficacy and monitoring lesion progression.

Additionally, we explored the potential applications of high-frequency ultrasound in clinical practice, such as its use in resource-limited settings or as a supplementary method to other imaging techniques. We also discussed how to integrate ultrasound findings with other clinical information (e.g., patient history, laboratory test results) to provide a more comprehensive diagnosis.

Through clinical case analysis, this study aimed to demonstrate the practical value of high-frequency ultrasound in the differential diagnosis of orbital lymphoma and inflammatory pseudotumor, offering practical guidance and insights for clinicians.

6. Limitations and Prospects of High-Frequency Ultrasound

6.1 Analysis of Limitations

Despite the significant advantages of high-frequency ultrasound in differentiating orbital lymphoma and inflammatory pseudotumor, there are notable limitations and potential sources of error. First, the quality of ultrasound images can be influenced by the operator's technical skill, leading to variability in results due to differing experience and techniques among physicians. Second, anatomical differences in patients, such as obesity or tissue edema, may affect the penetration of ultrasound waves and the clarity of images. Additionally, some lesions may exhibit overlapping ultrasound characteristics, making it challenging to make a definitive diagnosis based solely on ultrasound images.

6.2 Technical Improvements

Future technological advancements are crucial to overcoming current limitations. Enhancements in probe technology, such as higher frequency probes and more advanced transducer designs, can provide clearer image resolution. Optimization of image processing algorithms, including the use of artificial intelligence for image analysis, can enhance diagnostic accuracy and consistency. Moreover, the application of contrast-enhanced ultrasound can improve the visualization of blood flow characteristics of lesions, aiding in the differentiation of benign and malignant lesions. Education and training should also be prioritized to enhance physicians' ability to recognize and interpret ultrasound image features.

6.3 Future Research Directions

Future research should focus on developing new ultrasound technologies, such as superb microvascular imaging (SMI) and elastography, which may provide more information on tissue characteristics and the hemodynamics of lesions. Additionally, multimodal imaging fusion techniques, combining the strengths of ultrasound, CT, and MRI, could offer new perspectives for comprehensive lesion evaluation. The development of artificial intelligence and machine learning algorithms for automatic ultrasound image analysis and diagnostic feature extraction will be a crucial direction to improve diagnostic efficiency and accuracy. Lastly, large-scale prospective studies will help validate the diagnostic efficacy and cost-effectiveness of high-frequency ultrasound in different clinical settings.

In summary, high-frequency ultrasound, as a non-invasive and cost-effective diagnostic tool, holds significant value in the differential diagnosis of orbital lymphoma and inflammatory pseudotumor. Despite some limitations, its application potential is expected to expand and optimize through technological advancements and future research.

7. Conclusion

7.1 Summary of Research Findings

This study, through a retrospective analysis of high-frequency ultrasound images of 50 patients with orbital lymphoma and 50 patients with inflammatory pseudotumor, confirmed the significant value of high-frequency ultrasound in differentiating these two lesions. The findings indicate that high-frequency ultrasound provides clear key information on mass morphology, boundaries, internal echo characteristics, and blood flow signals, which are crucial for distinguishing lymphoma from inflammatory pseudotumor. Detailed analysis of ultrasound image characteristics showed that lymphoma tends to present as a hypoechoic mass with clear boundaries, regular shape, and uniform internal echoes, while inflammatory pseudotumor appears as a mass with blurred boundaries, irregular shape, and heterogeneous internal echoes. Additionally, lymphoma's blood flow signals are predominantly central or mixed, whereas inflammatory pseudotumor mainly shows peripheral blood flow. These findings provide clinicians with a powerful auxiliary diagnostic tool.

7.2 Implications for Clinical Practice

The study results have significant implications for clinical practice. High-frequency ultrasound, as a non-invasive, real-time, and cost-effective imaging modality, can be the preferred method for initial screening and diagnosis of orbital masses. It helps clinicians identify lesions at an early stage, avoiding unnecessary invasive examinations and reducing patient risk and economic burden. Moreover, high-frequency ultrasound shows potential in monitoring lesion progression and evaluating treatment efficacy, aiding in the formulation of more personalized treatment plans.

7.3 Long-Term Impact of the Study

In the long term, the potential applications of high-frequency ultrasound in ophthalmic diagnosis are broad. With technological advancements, such as higher frequency probes, more advanced image processing algorithms, and the development of artificial intelligence-assisted diagnostic tools, the resolution and diagnostic accuracy of high-frequency ultrasound are expected to improve further. Additionally, the integration of high-frequency ultrasound with other imaging modalities, such as CT and MRI, will provide richer information for comprehensive lesion evaluation. In the future, high-frequency ultrasound may play a more important role in the early diagnosis, treatment monitoring, and prognosis assessment of ophthalmic diseases, offering more precise and personalized medical services to patients.

In conclusion, this study not only confirmed the effectiveness of high-frequency ultrasound in the differential diagnosis of orbital lymphoma and inflammatory pseudotumor but also provided valuable references for clinical diagnosis and treatment, and pointed the way for the future development of ophthalmic imaging.

References:

[1] Wang Xiang, Li Tao, Du Wenhua, et al. The value of high-frequency color Doppler ultrasound and MRI in diagnosing orbital tumors [J]. Compilation of Papers from the Fourth National Conference on Superficial Organ and Peripheral Vascular Ultrasound Medicine of the Chinese Ultrasound Medical Engineering Society, 2013(24): 261-261.

[2] Nong Meifen. Application of contrast-enhanced ultrasound in the diagnosis of orbital tumors. Minimally Invasive Medicine, 2008; 3(5): 488-490.

[3] Zhao Gang, Shi Xiaobao, Pan Shinong, et al. Comparative imaging analysis of orbital tumors with MR and ultrasound. Journal of Medical Imaging, 2013; 23(3): 384-388.

[4] Dai Junchen, Chen Qin, Wu Hao, et al. The value of conventional ultrasound and contrast-enhanced ultrasound in diagnosing anterior orbital space-occupying lesions. Chinese Journal of Ultrasonography, 2016; 25(2): 150-154.

[5] Wang Feng, Liang Dong. Advances in the application of optical coherence tomography angiography in neurodegenerative diseases [J]. Journal of Ophthalmology, 2021; 36(10): 804-809.

[6] Hu Yi, He Weimin. Clinical pathological analysis of ocular adnexal lymphoma [J]. International Journal of

Ophthalmology, 2019; 19(6): 1082-1085.
[7] Ren Jiliang, Wu Yingwei, Tao Xiaofeng. Differentiating orbital lymphoma from inflammatory pseudotumor using conventional MRI texture analysis [J]. Chinese Journal of Medical Imaging Technology, 2017; 33(7): 980-984.