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Exploration of Ultrasound and Contrast Enhanced Ultrasound in the Diagnosis of Chest Wall Metastasis of Prostate Cancer

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Abstract: This article deeply explores the clinical characteristics of chest wall metastasis of prostate cancer, and the application value of ultrasound and contrast-enhanced ultrasound in its diagnosis. By analyzing a specific case in detail, the ultrasound and contrast-enhanced ultrasound manifestations of prostate cancer chest wall metastasis were revealed, and the role of these imaging methods in improving diagnostic accuracy, guiding clinical treatment, and evaluating prognosis was discussed. Research has found that ultrasound and contrast-enhanced ultrasound techniques can provide strong support for the diagnosis of chest wall metastasis in prostate cancer and provide important references for personalized treatment of patients.

1. Introduction

Prostate cancer, as a common male malignant tumor, has diverse modes of metastasis. Although chest wall metastasis is relatively rare, once it occurs, it often indicates that the disease has entered the advanced stage and the difficulty of treatment has significantly increased. Therefore, accurate diagnosis of prostate cancer chest wall metastasis is of great significance for developing effective treatment plans and evaluating patient prognosis. With the continuous development of ultrasound and contrast-enhanced ultrasound technology, these two non-invasive and convenient imaging examination methods have gradually demonstrated unique advantages in the diagnosis of prostate cancer chest wall metastasis. This article aims to explore the application value of ultrasound and contrast-enhanced ultrasound in the diagnosis of chest wall metastasis of prostate cancer through case reports and comprehensive analysis.

2. Clinical characteristics of chest wall metastasis in prostate cancer

Prostate cancer, as a major disease threatening men's health, often accompanies bone system metastasis in its late stages. Although bone metastasis of prostate cancer is more common in the spine, pelvis, and other areas, chest wall metastasis is also not uncommon. Early diagnosis of chest wall metastatic cancer is of great significance for developing treatment plans and evaluating prognosis. Ultrasound, as a non-invasive and convenient imaging examination method, plays an important role in the diagnosis of chest wall lesions[1]. The introduction of contrast-enhanced ultrasound technology

has further improved the diagnostic accuracy of ultrasound for chest wall metastatic cancer.

3. Case report

3.1 Patient Information

Male, 75 years old, seeking medical attention for a "right anterior chest wall mass with progressive enlargement for 2 months and 1 month". The patient has no history of trauma and lost 7kg in weight during the onset of the disease. Physical examination showed clear consciousness, no abnormalities in heart and lung auscultation, and no liver or spleen palpation. A tough mass of approximately 5cm × 3cm × 3cm was palpable on the right anterior chest wall, with regular shape, poor mobility, obvious tenderness, and no obvious swelling or rupture of the surface skin.

3.2 Ultrasonic manifestations

Conventional ultrasound shows a hypoechoic mass under the subcutaneous tissue of the right anterior chest wall, with a range of approximately 3.7cm ×3.0cm ×1.8cm, clear boundaries, irregular appearance, and alternating internal echogenicity. There is no attenuation behind the mass, and CDFI shows abundant blood flow signals within the mass. The poor continuity of the deep rib cortex suggests rib involvement. Elastic imaging shows that the mass has a soft texture, but this manifestation does not match the hardness characteristics of malignant tumors, indicating the need for further examination to clarify the diagnosis. (See Figure 1)

Figure 1 Ultrasound manifestation of right anterior chest wall mass

A conventional ultrasound with low echo, poor continuity of deep rib cortex, B abundant blood flow signal within the mass, C soft and elastic texture

3.3 Contrast enhanced ultrasound findings

Ultrasound contrast examination was performed, and 3.0ml of Sonovir was injected into the median vein mass of the left elbow. After injection of contrast agent, the arterial phase of the mass began to enter earlier than the surrounding tissue at 11s and reached its peak at 23s, showing uniform high enhancement and thick branching blood vessels visible inside. At 40s, the contrast agent began to fade, but still showed high enhancement. CEUS diagnosis: Solid mass in the right anterior chest wall, presenting as a blood rich lesion, highly suspected of malignant tumor metastasis. (See Figure 2)

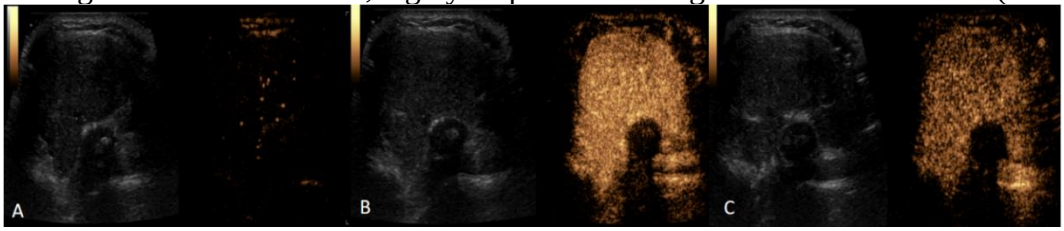

Figure 2 Contrast enhanced ultrasound imaging of right anterior chest wall mass

A11s enhances B23s before the surrounding tissue reaches its peak and shows high enhancement, while C40s begins to fade and show high enhancement

3.4 Pathologic diagnosis

Ultrasound guided coarse needle (18G) biopsy was performed, and pathology showed adenocarcinoma infiltration in the right chest wall tissue. Combined with immunohistochemical results (PSA+, 34 β E12-, CK broad+, P504s+, P63-, PSAP-), Complies with prostate adenocarcinoma metastasis. The serum immunological test showed a PSA level of 100.0ng/ml (normal range is 0-4ng/ml), which significantly increased. PET/CT examination showed enlargement of the prostate, uneven increase in glucose metabolism activity, involvement of the bladder and seminal vesicles, multiple metastatic lymph nodes near bilateral iliac vessels and pelvic cavity, and multiple bone destruction in bilateral ribs, thoracic vertebrae, and pelvis. The clinical stage is T4N1M1c, with a Gleason score of 9 and a WHO/ISUP grading of 5.

4. Application of ultrasound in chest wall metastasis of prostate cancer

4.1 Principles and advantages of ultrasound imaging

The essence of ultrasound imaging technology lies in utilizing the propagation characteristics of ultrasound in human tissues, and presenting the internal structure and details of the human body in the form of images by receiving and analyzing the reflected sound wave signals. Ultrasonic waves, an intangible wave, interact with substances of different densities when penetrating human tissue, resulting in phenomena such as reflection and scattering. These phenomena are captured by ultrasound probes and converted into electrical signals, which are then processed by complex algorithms to ultimately present the vivid and three-dimensional images before our eyes. These images not only reveal the microscopic world inside the human body, but also become an important basis for doctors to diagnose diseases and develop treatment plans. The advantages of ultrasound imaging lie in its non-invasive, real-time, and economical nature[2]. No need for ionizing radiation, patients do not need to bear additional physical burden; Real time imaging enables doctors to observe the dynamic changes of lesions in real time; And the relatively low cost makes this technology more popular, benefiting more patients. These advantages are particularly important in the diagnosis of chest wall metastasis of prostate cancer. Prostate cancer, a malignant tumor in the male urinary system, is often accompanied by the risk of bone metastasis in its late stages. As one of the important structures of the human body, once the chest wall is invaded by prostate cancer, it often means the deterioration of the disease and the challenge of treatment. Ultrasound imaging, with its unique advantages, has become an important tool for diagnosing chest wall metastasis of prostate cancer. It can not only clearly display the structure of the chest wall soft tissue, but also capture those small and hidden lesions, providing valuable diagnostic information for doctors.

4.2 Ultrasonic manifestations

The ultrasound manifestation of prostate cancer chest wall metastasis often presents an irregular shape, with blurred boundaries and unclear boundaries with surrounding tissues. These lesions are waiting for doctors to discover and interpret. On ultrasound images, these "reefs" often exhibit low echo or mixed echo characteristics, forming a sharp contrast with the echoes of surrounding normal tissues. In addition to its morphological and echogenic characteristics, ultrasound can also capture the blood flow inside the lesion. In cases of prostate cancer chest wall metastasis, rich blood flow signals can often be seen inside the lesion nourishing these 'unwelcome guests'. The presence of these blood

flow signals not only provides important clues to the activity of lesions for doctors, but also provides important reference for subsequent treatment. Ultrasound can also observe the interrelationships between lesions and surrounding tissues[3]. In cases of prostate cancer chest wall metastasis, the lesions often cause compression or infiltration of surrounding tissues, leading to changes in chest wall structure. These changes are manifested on ultrasound images as thickening of soft tissue in the chest wall, destruction of ribs, or thickening of the pleura.

5. Application of contrast-enhanced ultrasound in chest wall metastasis of prostate cancer

5.1 Principles and significance of contrast-enhanced ultrasound

The core of ultrasound contrast technology lies in injecting microbubble contrast agents into the patient's body. These microbubbles undergo nonlinear vibrations under the action of ultrasound, significantly enhancing the intensity and contrast of ultrasound signals. The significance of contrast-enhanced ultrasound technology in the diagnosis of chest wall metastasis of prostate cancer is profound. It can reveal tiny vascular structures that are difficult to capture with traditional ultrasound, providing doctors with an unprecedented microscopic view. The morphology, distribution, and blood flow velocity of these tiny blood vessels are key indicators for evaluating the activity and malignancy of lesions [4]. By using contrast-enhanced ultrasound, doctors can more accurately determine whether prostate cancer has invaded the chest wall and the severity of metastasis. Ultrasound contrast technology has real-time and dynamic characteristics, which can capture subtle features of lesions that change over time. This is of great significance for evaluating treatment efficacy and monitoring disease progression. Contrast enhanced ultrasound can serve as a non-invasive and convenient monitoring tool in the treatment of prostate cancer chest wall metastasis, helping doctors adjust treatment plans in a timely manner and ensuring optimal treatment outcomes for patients. Ultrasound contrast technology also has high safety and economy. Compared with imaging examinations such as CT and MRI, contrast-enhanced ultrasound does not require the use of ionizing radiation, avoiding potential radiation damage risks. Its examination cost is relatively low and more easily accepted by a large number of patients. This makes contrast-enhanced ultrasound technology more widely used and practical in the diagnosis of prostate cancer chest wall metastasis.

5.2 Contrast enhanced ultrasound findings

From a morphological perspective, the contrast-enhanced ultrasound images of prostate cancer chest wall metastasis often present an irregular and blurred mass morphology. These lumps vary in shape, size, and location, but they all emit an ominous aura. Under the enhancement of contrast-enhanced ultrasound, the internal structure of these masses can be clearly presented, and doctors can observe key information such as the distribution of blood vessels, blood flow velocity, and the presence of necrotic areas inside. From the perspective of hemodynamic characteristics, the contrast-enhanced ultrasound manifestations of prostate cancer chest wall metastasis exhibit a high degree of heterogeneity. This heterogeneity is not only reflected among different patients, but also among lesions in different parts of the same patient. Some lesions may exhibit rich blood flow signals; And other lesions have a lack of blood flow. This hemodynamic difference provides important clues for doctors to evaluate the malignancy and prognosis of lesions. Contrast enhanced ultrasound can also capture the dynamic characteristics of lesions over time. During the treatment of prostate cancer chest wall metastasis, doctors can regularly monitor contrast-enhanced ultrasound images to observe whether the size, shape, and blood flow signals of the lesion have changed. These changes record the life and death, progression and regression of lesions. By comparing the contrast-enhanced ultrasound images at different time points, doctors can evaluate the treatment effect, adjust the treatment plan in

a timely manner, and ensure that patients achieve the best treatment results. It is worth noting that contrast-enhanced ultrasound technology is not omnipotent in the diagnosis of chest wall metastasis of prostate cancer. Due to the complexity and diversity of lesions, as well as individual differences, there are certain difficulties in interpreting contrast-enhanced ultrasound images. Therefore, when interpreting contrast-enhanced ultrasound images, doctors need to make a comprehensive judgment based on the patient's clinical manifestations, laboratory tests, and other imaging examination data. Only in this way can the accuracy and reliability of diagnosis be ensured.

6. The value of ultrasound and contrast-enhanced ultrasound in the diagnosis of chest wall metastasis of prostate cancer

6.1 Improve diagnostic accuracy

Ultrasound technology, as one of the cornerstones of medical imaging, plays an irreplaceable role in the diagnosis of chest wall metastasis of prostate cancer due to its non-invasive, convenient, and real-time imaging characteristics. Through the propagation and reflection of ultrasound in human tissues, ultrasound technology can clearly outline the structure and morphology of chest wall soft tissues, providing doctors with intuitive visual information. Traditional ultrasound technology often falls short when dealing with small lesions or complex anatomical structures. At this time, the introduction of contrast-enhanced ultrasound technology has brought unprecedented breakthroughs in the diagnosis of prostate cancer chest wall metastasis. Ultrasound contrast technology significantly enhances the contrast and resolution of ultrasound signals by injecting microbubble contrast agents into the patient's body and utilizing the interaction between ultrasound and contrast agent microbubbles [5]. This technology can not only clearly display the tiny vascular structures in the soft tissue of the chest wall, but also capture the hemodynamic characteristics of the lesion area in real time, providing doctors with richer and more accurate diagnostic information. In the diagnosis of chest wall metastasis of prostate cancer, contrast-enhanced ultrasound technology can accurately distinguish tumor tissue from normal tissue, reveal the boundaries, morphology, and internal structure of the lesion, thereby improving the accuracy of diagnosis. The combination of ultrasound and contrast-enhanced ultrasound technology has pushed the diagnosis of prostate cancer chest wall metastasis to a new height. By comprehensively analyzing ultrasound images and contrast-enhanced ultrasound images, doctors can more accurately determine the nature, size, and location of lesions, providing strong support for subsequent treatment. The non-invasive, real-time, and economical nature of ultrasound and contrast-enhanced ultrasound technology has also made it the preferred method for diagnosing chest wall metastasis of prostate cancer.

6.2 Guide clinical treatment

The formulation and adjustment of treatment plans in the clinical treatment of prostate cancer chest wall metastasis often rely on accurate diagnostic information. Ultrasound and contrast-enhanced ultrasound technology provide precise decision-making basis for clinical treatment with their unique imaging advantages. Ultrasound and contrast-enhanced ultrasound techniques before surgical treatment can help doctors clarify the location, size, and shape of lesions, providing important references for planning surgical paths. By accurately locating the lesion area, doctors can more accurately remove tumor tissue while reducing damage to surrounding normal tissue, improving the safety and success rate of surgery. In non-surgical treatments such as radiotherapy and chemotherapy, ultrasound and contrast-enhanced ultrasound technology can monitor changes in lesions in real time, providing timely feedback for adjusting treatment plans. By regularly monitoring ultrasound images and contrast-enhanced ultrasound images, doctors can

evaluate treatment effectiveness, timely detect the progression or recurrence of lesions, adjust treatment plans, and ensure that patients receive the best treatment results. Ultrasound and contrast-enhanced ultrasound technology can also provide strong support for personalized treatment of prostate cancer chest wall metastasis patients. By comprehensively analyzing patients' clinical manifestations, ultrasound images, and contrast-enhanced ultrasound images, doctors can develop more personalized and accurate treatment plans for patients, improving the targeting and effectiveness of treatment.

6.3 Evaluate prognosis

The evaluation of prognosis is equally crucial in the diagnosis and treatment of prostate cancer chest wall metastasis. Ultrasound and contrast-enhanced ultrasound technology, with their unique imaging advantages, provide strong support for prognosis evaluation. Ultrasound and contrast-enhanced ultrasound techniques can accurately determine the malignancy and invasiveness of lesions. By comprehensively analyzing the morphology, size, internal structure, and hemodynamic characteristics of the lesion, doctors can assess the malignancy of the lesion and predict the prognosis of the patient. Diseases with higher malignancy often indicate poorer prognosis and require more aggressive treatment strategies. Ultrasound and contrast-enhanced ultrasound technology can monitor changes in lesions in real time, providing the possibility for dynamic evaluation of prognosis. By regularly monitoring ultrasound images and contrast-enhanced ultrasound images, doctors can observe the growth rate, morphological changes, and changes in hemodynamic characteristics of lesions, thereby evaluating treatment effectiveness and prognosis. If the lesion shows a stable or shrinking trend, it indicates a better prognosis; If the lesion continues to enlarge or new metastases appear, it indicates a poor prognosis and requires adjustment of the treatment plan. Ultrasound and contrast-enhanced ultrasound technology can also provide strong support for long-term follow-up of patients with prostate cancer chest wall metastasis. By regularly monitoring patients' ultrasound images and contrast-enhanced ultrasound images, doctors can promptly detect the recurrence or progression of lesions, provide timely intervention and treatment for patients, thereby prolonging their survival and improving their quality of life. It is worth noting that the value of ultrasound and contrast-enhanced ultrasound technology in the diagnosis of prostate cancer chest wall metastasis is not isolated, but complementary and mutually reinforcing. By comprehensively analyzing ultrasound images and contrast-enhanced ultrasound images, doctors can gain a more comprehensive understanding of the condition of the lesion and provide patients with more accurate and personalized diagnosis and treatment services.

7. Conclusion

This article analyzes the clinical characteristics, case reports, and the application of ultrasound and contrast-enhanced ultrasound in the diagnosis of prostate cancer chest wall metastasis, revealing the unique value of these two imaging methods in the diagnosis of prostate cancer chest wall metastasis. Ultrasound and contrast-enhanced ultrasound can not only improve diagnostic accuracy, but also guide clinical treatment and evaluate prognosis, providing strong support for personalized treatment of prostate cancer chest wall metastasis patients.

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