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PSMA PET/CT vs. MRI-DWI in Diagnosis of Early Metastasis of Prostate Cancer

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Abstract

Accurate staging is crucial in the management of prostate cancer. Advanced radiological technologies like PSMA PET-CT and whole-body MRI have proven to be more effective in detecting metastasis compared to traditional methods such as 99mTc-bone scintigraphy [1]. The effectiveness and diagnostic accuracy of these new technologies are still being evaluated.

Early detection of metastasis can significantly impact the treatment plan for patients. In the early stages, options like systematic therapy with androgen receptor targeted agents or metastatic ablative strategies can be considered.

Research is ongoing to determine the ideal medical imaging test with the highest diagnostic accuracy for prostate cancer staging.

Keywords: Prostate cancer (PCa); Prostate Specific Membrane Antigen (PSMA); Positron Emission Tomography Computed Tomography (PET/CT); Whole-Body Magnetic Resonance Imaging (WB-MRI); Cancer staging; Early metastatic disease.

Introduction

Prostate cancer (PCa) is the most prevalent cancer in men and the primary reason for cancer-related fatalities [2,3]. Over the past few decades, the significance of screening for early detection and treatment has been underscored. Unfortunately, the decrease in PSA screening has been linked to a rise in mortality rates [4]. Annually, over 2 million men receive a prostate cancer diagnosis, with more than 10 million individuals currently living with the disease, and approximately 700,000 individuals diagnosed with advanced stages such as metastatic lesions. Previous studies have been conducted on this topic [5].

Metastasis refers to the dissemination of cancer cells from the original tumor to various parts of the body. In cases of advanced prostate cancer, the bones are the most common sites for metastasis, affecting around 84% of patients and leading to symptoms like bone pain, fractures, and spinal cord compression. Apart from the bones, prostate cancer can also spread to distant lymph nodes (10.6%), the liver (10.2%), and the thorax (9.1%) [6]. The manifestation of symptoms varies depending on the affected organ when cancer cells metastasize to these areas.

Positron emission tomography (PET) imaging techniques using Prostate specific membrane antigen (PSMA) tracers have brought about a significant revolution in the field of prostate cancer. These techniques have not only improved the diagnosis and management of the disease but also played a crucial role in staging. PSMA, a glycoprotein found in the cell membrane, is

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expressed at minimal levels in primary prostate cancer cells. However, its expression significantly increases in advanced stages of the disease. PSMA PET/CT scans have shown a correlation with elevated tumor levels, disease stage, grade, and PSA levels [7]. As a result, there has been a growing interest in utilizing PSMA PET-CT in various research areas such as staging, recurrence detection, and treatment planning.

In addition to PSMA PET/CT, whole body Magnetic resonance imaging (WB-MRI) with diffusion-weighted imaging (DWI) sequence is another valuable imaging tool in the management of prostate cancer. WB-MRI helps in accurately identifying the location of the tumor, as well as assessing its invasion and the presence of metastatic lesions. [8] This comprehensive approach combining PSMA PET/CT imaging techniques and WB-MRI with DWI has significantly enhanced our ability to effectively manage prostate cancer.

The utilization of both PSMA PET/CT and WB-MRI DWI imaging techniques has demonstrated significant results in the field of medical imaging. Researchers and clinicians have successfully enhanced the accuracy and comprehensiveness of cancer imaging, specifically for prostate cancer, by utilizing the combined strengths of PSMA PET/CT and WB-MRI DWI. PSMA PET/CT offers high-resolution images of prostate cancer cells, facilitating precise disease localization and staging. On the other hand, WB-MRI DWI provides valuable insights into the cellular density and integrity of tissues across the entire body, enabling the identification of metastases or cancer spread beyond the prostate.

A 65-year-old gentleman has begun to express concerns about urinary incontinence. Subsequent radiological examinations, including WB-MRI and PET/CT, have successfully identified the presence of prostate cancer with early bone metastatic lesions in his case.

Case Presentation

A 65-year-old man with past medical history of morbid obesity, fatty liver, reflux esophagitis and cholelithiasis. This patient recently underwent laparoscopic Roux-En-Y-Gastric bypass. He presented to family physician with complaints of urinary incontinence.

Laboratory studies show elevated Prostate serum antigen (PSA) levels of 29 ng/ml. Subsequent prostate magnetic resonance prostate (MRP) revealed an enlarged prostate with a volume of 87cc, with dimensions of 3.1cm, 3.4 cm axial & sagittal plane respectively. lesion on right anterior-posterior part of right peripheral zone, which did not invade the capsule and showed no signs of enlarged lymph nodes or bone lesions (Figure 1). A Transrectal ultrasound (TRUS) fusion biopsy was performed, and histopathological results confirm the presence of acinar prostate adenocarcinoma with a Gleason score of 6, grade group (GG) 1.

Further imaging with F-18 PSMA PET/CT demonstrated high uptake on same location as on MRI examination, a 12mm lesion showed radiotracer uptake with maximum standardized uptake value (SUVmax) 5.8 on posterolateral part of right peripheral zone of the prostate, as well as 10 mm radiotracer positive (SUVmax = 3) on right ileum, and several small foci of uptake in the ribs on both sides (Figure 2).

WB-MRI test included the sequences T1W, T2W, STIR before and after gadolinium infusion. All of the above sequences didn't show any lesions. On DWI sequence a 10 mm lesion on the right ileum showed hyperintense on high b-value (800) DWI and restricted diffusion on ADC. Additionally, a 0.5 cm high-cellular lesion was observed on the posterior portion of the 6th right rib which didn't show restriction on ADC (Figure 3).

In this case we could provide valuable information on which PET/CT modality make an exclusive diagnostic prostate cancer staging of early bone metastatic lesions which could be missed without performing PET/CT modality. These findings, in conjunction with the PSMA PET/CT results, suggest the possibility of a bony metastatic lesion. Consequently, the patient was referred to the oncological department for further evaluation and management.

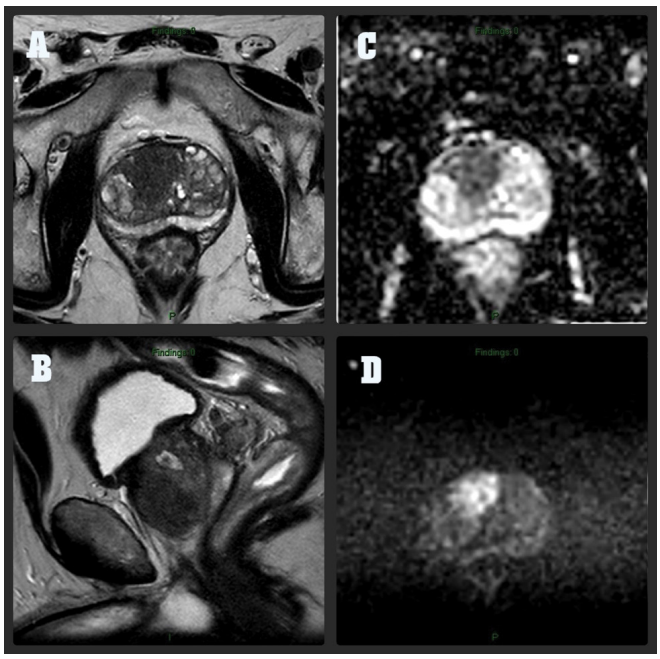

Figure 1: Magnetic resonance imaging protocol for primary prostate cancer localization. (A,B) A T2 low signal intensity focus was noted at right anterior-posterior part of right peripheral zone, with dimensions of 3.1cm, 3.4 cm axial & sagittal plane respectively. the possibility of extracapsular extension was excluded. (C,D) The lesion showed hyperintense on high b-value DWI and hypointense on ADC, DWI & ADC plane respectively.

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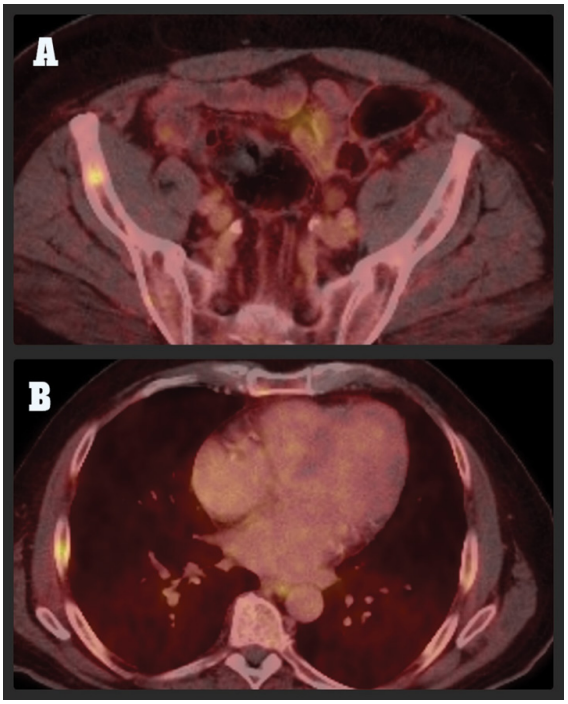

Figure 2: F-18 PSMA-PET/CT for metastatic lesions of primary prostate cancer localization. (A) A 10 mm radiotracer positive (SUVmax = 3) on right ileum, (B) Several small foci of uptake in the ribs on both sides.

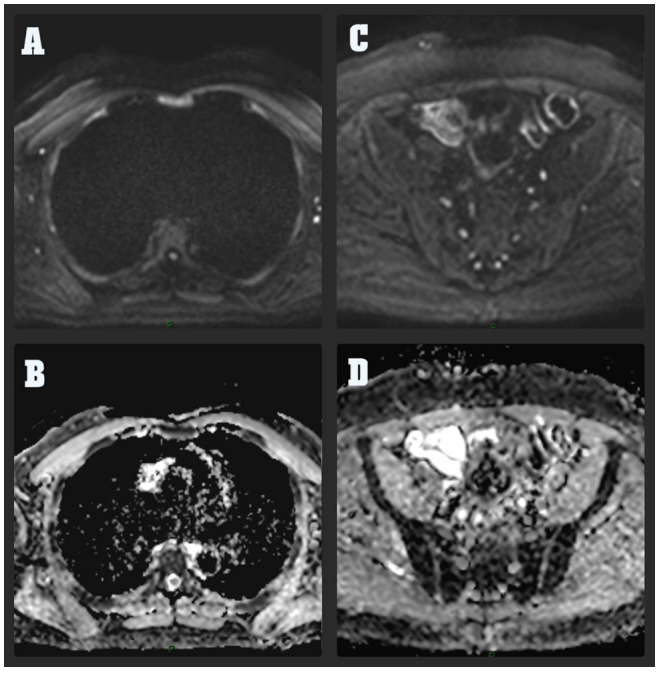

Figure 3: Chest & Pelvis Diffusion-weighted MRI . (A,B) Pelvis DWI & ADC Sequences respectively demonstrates a 10 mm lesion on the right ileum showed hyperintense on high b-value (800) DWI and restricted diffusion on ADC. (C,D) Chest DWI & ADC Sequences respectively, demonstrate a 0.5 cm hyperintense lesion was observed on the posterior portion of the 6th right rib without restriction on ADC.

The patient expresses a readiness to commence stereotactic body radiotherapy (SBRT) for prostate cancer, in conjunction with hormonal therapy involving luteinizing hormone-releasing hormone (LHRH) injections and Bicalutamide (CASODEX).

Discussion

The latest radiological imaging techniques offer comprehensive anatomical and functional insights into the various body systems, revolutionizing the approach to diagnosing prostate cancer. The utilization of these advanced imaging methods may potentially lead to the replacement of bone scintigraphy and CT scans, depending on factors like accessibility and the expectations of referring physicians. It is crucial to consider the local availability and cost-effectiveness of the healthcare system when selecting the most suitable imaging techniques for optimal diagnostic accuracy, supported by objective research.

The case-report focuses on the sensitivity of PSMA PET/CT in detecting early metastatic lesions. Our results indicate that the patient was diagnosed with early metastatic bone lesions without requiring additional investigations such as whole-body MRI. This approach proves to be more accessible and cost-effective for the diagnosis and management of this condition.

In previous research, the superiority of WB-MRI over PSMA PET-CT in detecting bone metastasis has been demonstrated [9,10,11]. Nevertheless, alternative studies have indicated comparable diagnostic accuracy between PSMA PET/CT and WB-MRI in the detection of bone metastasis [1]. In our case PSMA PET/CT has demonstrated superior sensitivity compared to WB-MRI in the detection of early bone metastatic lesions in various anatomical locations, including the right ileum and the ribs.

Conclusion

PSMA PET/CT offers essential insights in addition to WB-MRI for identifying bone metastases in prostate cancer patients. PSMA PET/CT excels in accurately staging local tumors with bone metastases. PSMA PET/CT proves to be a superior imaging method for detecting early distant bony metastases, although the cost-effectiveness of comparing these two modalities remains to be thoroughly investigated.

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