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# High resolution ultrasound features of prostatic rib metastasis: A prospective feasibility study with implication in the high-risk prostate cancer patient

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**Abstract**

**Objective:** In a prior study, high resolution ultrasound (US) was shown to be accurate for evaluating rib metastasis detected on bone scan. However, that study did not address the specific US appearance typical of osteoblastic rib metastasis. Our objective was to determine the specific US imaging appearance of osteoblastic prostate carcinoma rib metastasis using osteolytic renal cell carcinoma rib metastasis as a comparison group.

**Materials and methods:** The Institutional Review Board approval and informed consent were obtained for this prospective feasibility study. We performed high resolution US of 16 rib metastases in 4 patients with prostate carcinoma metastases and compared them to 8 rib metastases in 3 male patients with renal cell carcinoma. All patients had rib metastases proven by radiographs and computed tomography (CT). High resolution US scanning was performed by a musculoskeletal radiologist using a 12–5 MHz linear-array transducer. Transverse and longitudinal scans were obtained of each rib metastasis.

**Results:** All 16 prostate carcinoma metastases demonstrated mild cortical irregularity of the superficial surface of the rib without associated soft tissue mass, cortical disruption, or bone destruction. 7 of 8 (88%) renal cell carcinoma rib metastases demonstrated cortical disruption or extensive bone destruction without soft tissue mass. One of 8 (12%) renal cell carcinoma rib metastases demonstrated only minimal superficial cortical irregularity at the site of a healed metastasis.

**Conclusion:** Osteoblastic prostate carcinoma rib metastases have a distinctive appearance on US. Our success in visualizing these lesions suggests that US may be a useful tool to characterize isolated rib abnormalities seen on a bone scan in high-risk prostate cancer patients who are being evaluated for curative surgery or radiation treatment. 

*Keywords:* Musculoskeletal ultrasound; Rib metastasis; Fracture; Osteoblastic; Osteolytic

## 1. Introduction

Prostate cancer is the most common cancer in men, and the second most frequent cause of cancer-specific death in the United States [1]. Although controversial, the advent of prostate cancer screening has led to an increased diagnosis of the cancer at earlier stages resulting in high cure rates for those who have organ-confined disease. For men whose prostate specific antigen is $>20$ ng/ml, Gleason $\geq 8$, or have clinical T3 or T4 disease (high risk), a staging whole body bone scan is recommended to evaluate for osseous metastasis [2,3]. Unfortunately, given the high sensitivity of bone scintigraphy, areas of increased technetium-99 m-MDP uptake are often found and may be related to trauma, degenerative disease, infection, or healing bone which complicates the staging for osseous metastasis [4]. Therefore, the decision whether or not to subject the patient to morbidities of surgery or radiation therapy can be greatly affected by the bone scan interpretation, particularly in high-risk prostate cancer patients.

One such area that often results in confusion is the ribs [5]. Given that prostate cancer affects older men, who have various degrees of osteoporosis and less soft tissue (fat and muscle) padding the lateral ribs from daily trauma, it is not uncommon to see positive uptake in ribs on a staging bone scan. When no obvious history of trauma can be ascertained, one often attempts to further characterize these

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lesions with rib x-rays, computed tomography (CT), or magnetic resonance imaging, each with its limitations in evaluating this anatomic area.

Musculoskeletal ultrasound (US) is growing in popularity in the United States and may play a significant role in evaluating rib lesions, especially in the high-risk prostate cancer patient population. Well-known advantages of sonography include its accessibility, use of non-ionizing radiation, the ability to evaluate the costochondral junction [6], and not being affected by respiratory motion. One study showed that US is significantly more sensitive for detecting rib fractures compared to radiography [6].

In patients with a known primary malignancy, only 17% of rib lesions found on bone scintigraphy were malignant [7], and 6% to 8% of malignant bone lesions appeared as a single focus of radiotracer activity involving the ribs on bone scintigraphy [4]. Additional imaging is often needed to determine if a scintigraphic rib lesion represents a metastasis or a fracture. In a previous study, high resolution US was shown to be accurate in differentiating a rib fracture from a rib metastasis [5]. However, the study did not address the specific US appearance of an osteoblastic metastasis, which is the most common appearance for prostate cancer osseous metastasis. Therefore, our objective was to determine the specific US appearance of osteoblastic prostate carcinoma rib metastasis using osteolytic renal cell carcinoma rib metastasis as a comparison group.

## 2. Materials and methods

### 2.1. Patient selection

Institutional Review Board approval and informed consent were obtained for this prospective case-controlled study. We enrolled 7 consecutive patients through the University of Wisconsin Comprehensive Cancer Center Oncology Clinic from January 2006 to December 2008. The inclusion criteria included: (1) proven primary prostate or renal cell carcinoma with definite skeletal metastasis by imaging and clinical verification; (2) positive evidence on radiograph, CT, and bone scan of rib metastases by consensus review; and (3) agreement to participate in this study. We selected patients with these 2 primary malignancies for study as almost all prostate carcinoma bony metastases are osteoblastic while almost all renal cell carcinoma bony metastases are osteolytic. All patients were undergoing chemotherapy for their malignancy but had not received radiation therapy to their chest or ribs.

### 2.2. Sonographic technique

High resolution US scanning was performed and interpreted by 2 experienced musculoskeletal radiologists with a combined 15 years of musculoskeletal US experience;, both were blinded to the type of primary malignancy. US

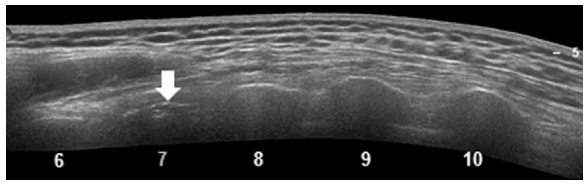


Fig. 1. Localizing method to evaluate a posterior seventh rib lesion in a 61-year-old male with renal cell carcinoma while in prone position. Extended field of view with US probe oriented longitudinally in the posterior paraspinal line demonstrating the typical appearance of the lower rib cage used for localizing rib lesions. The inferior most rib is the reference point used to locate the seventh rib-containing lesion (arrow).

examination was performed using a Philips iU22 ultrasound system (Philips Ultrasound, Bothell, WA) and a variable high frequency, high resolution 12–5 MHz linear-array transducer. Each subject was scanned in both the prone and lateral decubitus positions after determining the location of each rib lesion seen on the bone scan. Localization of rib level was performed using US and by counting the number of ribs in the paraspinal line just lateral to the costovertebral junction, locating the most inferior rib as the reference standard (Fig. 1). Once each rib metastasis was localized, transverse and longitudinal sonographic gray scale and Doppler images were obtained and stored on a radiology workstation (Horizon Rad Station, version 11.0 service package 6, McKesson) and DICOM viewer (eFilm Lite software, Merge Healthcare).

We did not evaluate lesions in the lateral arc of the first to fourth ribs because of shadowing from the scapula and clavicle, nor the costovertebral junction which was obscured by the orientation of the rib at this location. These limitations of US in assessing the ribs were noted in the study by Paik et al. [5].

### 2.3. Retrospective clinical review

The medical records of each subject were reviewed to determine the date of last follow-up at our hospital, the site of primary cancer, and the history for recent trauma or surgery.

### 2.4. Data analysis

The findings of all available radiographs, CT, and bone scintigraphy of each abnormal rib lesion site were reviewed along with the sonographic images, blinded to the diagnosis. Radiograph and CT findings of each scintigraphic rib lesion were classified into osteoblastic or osteolytic lesions, rib fracture, or normal appearance and then correlated with US findings.

The sonographic images were reviewed to characterize osteoblastic or osteolytic metastasis according to a modification of the criteria used by Paik et al. [5]: cortical disruption described as focal disruption or angulation of the normally smooth echogenic cortical line of the rib surface, cortical surface irregularity as loss of the normal smooth contour of