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Case Report

Multimodality imaging of an unusual giant cell tumor of thoracic spine with mediastinal invasion: a case report

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Abstract: Giant cell tumor (GCT) is a benign yet locally aggressive bone neoplasm typically situated in the juxta-articular metaphysis of long bones. Although spinal involvement is rare, it is predominantly reported in the axial skeleton, with the sacrum being the primary location. Conversely, GCTs are notably uncommon in the thoracic spine. In this report, we present computed tomography (CT), magnetic resonance imaging (MRI), and 2-Deoxy-2-[fluorine-18]-fluoro-D-glucose (^{18}F-FDG) positron emission tomography combined with computed tomography (PET/CT) multimodality imaging findings of a 36-year-old woman diagnosed with a GCT of the thoracic spine. CT scans provide a precise evaluation of cortical thinning and penetration. While MRI lacks specific diagnostic indicators for GCT, it remains invaluable for delineating the extent of soft tissue expansion and the tumor's relationship with intraspinal neural elements - critical information for surgical planning. ^{18}F-FDG PET/CT effectively illustrates the lesion's hypermetabolic and locally aggressive characteristics. It is noteworthy that GCT occasionally exhibits metastatic malignant potential, underscoring the value of FDG PET as a pivotal modality for staging, restaging, or assessing therapy response, and for monitoring the efficacy of radiotherapy. Familiarity with the imaging features of GCT is essential for physicians to avoid misinterpretation. This tumor should be considered in the differential diagnosis of spinal tumors, distinguishing it from bone metastases or neurogenic tumors.

Keywords: Thoracic spine, giant cell tumor, computed tomography, magnetic resonance imaging, ^{18}F-FDG PET/CT, case report

Introduction

Giant cell tumor (GCT) is a benign yet locally aggressive primary bone neoplasm comprising a proliferation of mononuclear (monocytic) cells, multinucleated osteoclast-like giant cells, and stromal spindle cells [1]. GCTs are uncommon before adolescence or after the age of 50 and are most frequently encountered during the second to fourth decades of life, with a slight female predominance. Typically, GCTs are located in the juxta-articular metaphysis of long bones, while their occurrence in the spine is relatively rare, with an incidence ranging from 1.4% to 9.4%, particularly when thoracic involvement is present [1-6]. GCTs of the spine usually affect the vertebral body but may extend into the neural arch. Radiographically, they manifest as moth-eaten or irregular lesions with the vertebral body displaying signs of expansion and thinning [7].

In this report, we present the imaging findings of a 36-year-old woman diagnosed with a GCT of the thoracic spine, the only symptoms that occur are chest tightness and chest pain, which revealed osteolytic lesions and a substantial thoracic mass with high 2-Deoxy-2-[fluorine-18]-fluoro-D-glucose (^{18}F-FDG) uptake. This tumor can mimic metastases or neurogenic tumors, so that it should be considered as part of the differential diagnosis for spinal tumors.

Case presentation

A 36-year-old woman presented with a 10-day history of pain originating in the left diaphrag-

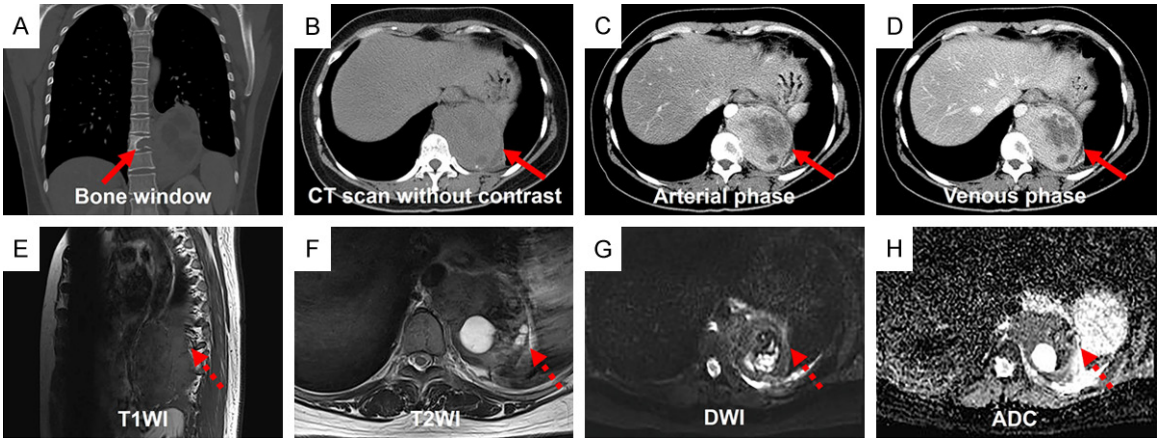

Figure 1. Computed tomography (CT) images and magnetic resonance imaging (MRI) of giant cell tumor (GCT) of thoracic spine with mediastinal invasion. Coronal bone window image shows bone destruction on the left side of the T10 vertebra (A). Inside the vertebral body, a hypodense lesion extended into the left thoracic cavity, forming a soft-tissue mass (red long arrows), measuring approximately 7.5 cm × 6.9 cm × 10.7 cm. The transverse image shows necrosis and calcification within a soft tissue mass (B). The CT attenuation values of plain scan, arterial phase, and venous phases were 43 HU, 81 HU, and 102 HU, respectively, the mass was progressive enhancement following the administration of contrast agent (C, D). The MRI demonstrated the lesion (red dashed arrows) with a heterogeneous signal, appearing as low signal intensity on T1-weighted images (E), slightly reduced signal intensity on T2-weighted images (F), slightly increased signal intensity on DWI (G), and a slight reduction in ADC values (H).

matic angle and radiating towards the back. The physical examination revealed constrained expansion of the left thorax, diminished palpable speech fibrillation, and tenderness in the T10 and T11 vertebrae. Laboratory tests revealed a markedly elevated CA-125 level (104.10 U/mL). The computed tomography (CT) scan displayed bone destruction on the left side of the T10 vertebra (**Figure 1A**). Inside the vertebral body, a hypodense lesion extended into the left thoracic cavity, forming a soft-tissue mass combined with necrosis and calcification (**Figure 1B**). Moreover, there was progressive enhancement following the administration of contrast agent (**Figure 1C**, **1D**). The magnetic resonance imaging (MRI) demonstrated a lesion with a heterogeneous signal, appearing as low signal intensity on T1-weighted images (**Figure 1E**), slightly reduced signal intensity on T2-weighted images (**Figure 1F**), slightly increased signal intensity on diffusion weighted imaging (DWI) (**Figure 1G**), and a slight reduction in apparent diffusion coefficient (ADC) values (**Figure 1H**). The diagnosis of spinal lesion might be neurogenic tumors or bone metastasis. ^{18}F-FDG positron emission tomography combined with computed tomography (PET/CT) was conducted to find potential primary tumor and further characterize the spinal lesion. The maximum intensity projection (MIP) image from the PET scan revealed FDG-avid lesions on the left side of the T8 to T12 vertebra (**Figure 2A**). A soft tissue lesion measuring 6.5 × 6.8 cm grew from the T10 vertebra towards the thoracic cavity with invasion of the cortical bone of the T10 vertebra. Inside the mass, heterogeneous FDG uptake was observed with maximum standardized uptake value (SUVmax) of 11.5 (**Figure 2B-D**).

A CT-guided puncture biopsy of the lesion was performed. Hematoxylin and eosin staining of the lesion (**Figure 3A**) revealed a substantial presence of osteoclastic multinuclear giant cells distributed uniformly. Immunohistochemical staining showed tumor cells were positive for the expression of smooth muscle actin (SMA), cluster of differentiation (CD)34, CD68 (**Figure 3B**) and CD163 (**Figure 3C**). In addition, Ki-67 was observed to be positive in 10% of the tumor cells. The pathological diagnosis was made with a GCT. The patient underwent a complete surgical resection. At the 3-month and 6-month postoperative follow-up, there was no evidence of lesion recurrence, and the patient exhibited no significant complications, indicating a favorable prognosis.

Discussion

GCTs exhibit a wide biologic spectrum, ranging from latent benign to highly recurrent forms [8, 9]. These tumors, known for their aggressive-

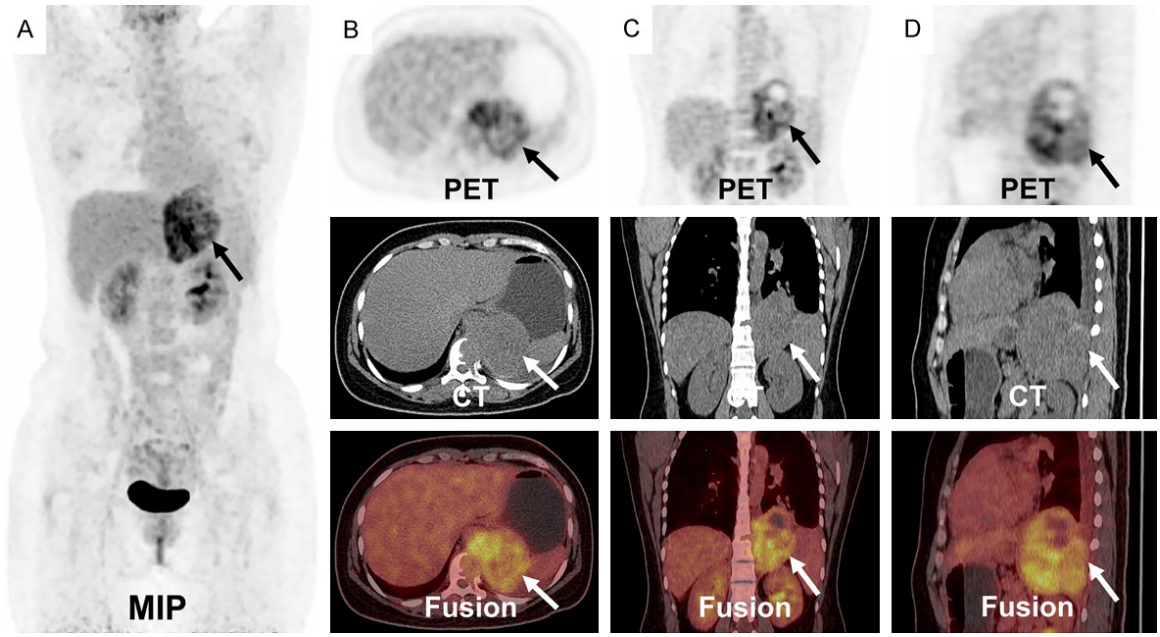

Figure 2. ^{18}F-FDG PET/CT images of GCT of thoracic spine with mediastinal invasion. The anteroposterior 3-dimensional maximum intensity projection (MIP) image demonstrated FDG-avid lesions (long arrows) on the left side of the T8 to T12 vertebra (A). Transverse, coronal, and sagittal images show a soft tissue lesion measuring 6.5 × 6.8 cm growing from the T10 vertebra toward the thoracic cavity with invasion of the cortical bone of the T10 vertebra (B-D). Inside the mass, heterogeneous FDG uptake was observed with SUVmax of 11.5.

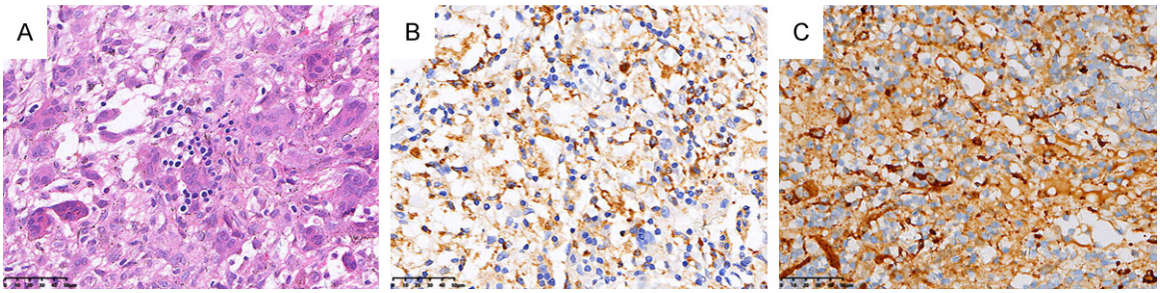

Figure 3. Histopathological and immunohistochemical images of GCT. Hematoxylin-eosin (HE) staining (magnification ×400) of the lesion (A) revealed a substantial presence of osteoclastic multinuclear giant cells distributed uniformly. Immunohistochemical staining (400×) showed tumor cells were positive for the expression of CD68 (B) and CD163 (C).

ness, constitute 4% to 8% of all primary bone neoplasms and are primarily situated in the juxta-articular metaphysis of long bones. Although spinal involvement varies, it is most frequently reported in the axial skeleton, with the sacrum being the predominant location (2%-8% of cases) [2-6]. Conversely, GCTs are notably rare in the thoracic spine. GCTs of the spine frequently infiltrate the spinal canal and nerves, resulting in pain, neurological dysfunction, and pathological fractures [10]. Diagnosis often hinges on the recognition of distinctive imaging features, ultimately confirmed through biopsy. Pathologically, GCTs exhibit mononuclear stromal cells and multinucleated giant cells displaying osteoclastic activity [11].

Familiarity with the imaging features of GCT is paramount for physicians to prevent misinterpretation. GCTs of the spine can manifest as the classic 'soap bubble' appearance on plain radiographs or as purely lytic lesions. CT scans offer a more precise evaluation of cortical thinning and penetration. These tumors are consistently lytic and infiltrate surrounding tissues, often with a thin sclerotic rim - or more commonly, without any bony constraint [1]. In some instances, GCTs breach the cortical bone, form-

ing extensive soft tissue masses; in our case, the left-side thoracic spine cortex exhibits thinning or complete erosion, resulting in tumor extension into the thoracic cavity. While MRI lacks specific diagnostic indicators for GCT, it remains invaluable for delineating the extent of soft tissue expansion and the tumor's relationship with intraspinal neural elements, crucial for surgical planning [12]. GCTs present as hypointense on T1-weighted images and display heterogeneous signal intensity on T2-weighted images. The solid components exhibit low signal intensity due to collagen and hemosiderin deposition and demonstrate heterogeneous contrast enhancement with gadolinium [13, 14].

^{18}F-FDG PET/CT effectively illustrates the lesion's hypermetabolic and locally aggressive characteristics. The elevated SUVmax of GCTs results from the overexpression of glucose transporter type 1 and hexokinase-2 in macrophages and giant cells, as well as reactive fibroblast proliferation and enhanced angiogenesis. These distinct features present challenges in distinguishing this entity from other conditions, particularly bone metastases in cancer patients and neurogenic tumors [15, 16]. Larger lesions exhibiting high FDG uptake may lead to misdiagnosis as pleural cavity malignancies. As the primary malignancy was not detected via PET/CT scan, the initial diagnosis considered a primary vertebral lesion rather than metastasis. It is noteworthy that GCT occasionally exhibits metastatic malignant potential [17, 18], underscoring the value of FDG PET as a pivotal modality for staging, restaging, or assessing therapy response, particularly in the context of vertebral canal involvement, and for monitoring the efficacy of radiotherapy [10, 19]. Park et al. [16] reported two cases of FDG PET/CT findings of GCT of the rib, present as large lobulated soft tissue masses with intense FDG uptake. Song et al. [10] reviewed PET/CT and clinical data of 16 patients with spinal GCTs and found that for recurrent GCTs, PET/CT may provide incremental value in the assessment of the vertebral canal and intra-prosthetic involvement and the response to radiotherapy.

In clinical practice, the imaging physician must possess a thorough understanding of the various types of solitary osteolytic lesions affecting the thoracic spine and skillfully formulate a comprehensive differential diagnosis. Specifically, this case should be incorporated into the differential diagnosis for spinal tumors, considering neoplastic entities like solitary metastases and nerve sheath tumors, as well as tumor-like lesions such as eosinophilic granuloma. Considering the patient's age, a middle-aged female, it is noteworthy that metastatic tumors are infrequently encountered, typically presenting with a history of primary tumors involving multiple vertebrae and forming paravertebral soft-tissue masses, often accompanied by severe pain. Single metastatic tumors, in contrast, exhibit invasive growth without notable morphologic changes, facilitating their differentiation from the presented case. The spine or paraspinal region is a common site for neurogenic tumors. Nerve sheath tumors, though frequently located outside the bone, tend to compress adjacent bone structures, often manifesting with sclerotic margin formation due to their relatively slow growth. Additionally, these tumors may spread to the intervertebral foramen, resulting in its enlargement. However, in the current case, the absence of intervertebral disc involvement and the lack of enlargement in the intervertebral foramen allow for clear differentiation from nerve sheath tumors. Coronal images reveal that the lesion in this case originated from the vertebral body, exhibiting an exophytic growth pattern towards the mediastinum. This growth pattern diverges from the prevailing understanding of the disease. Eosinophilic granuloma, typically observed in children, adolescents, and occasionally in adults, is characterized by osteolytic destruction at the center of the vertebral body, resulting in a "flat vertebra". The imaging characteristics of this disease do not align with the current diagnosis. Coupled with the frequent elevation in blood sedimentation and eosinophilic granulocytosis associated with eosinophilic granuloma, differentiation from other diseases is facilitated through a combination of laboratory and pathologic examinations.

Spinal GCTs exhibit considerably poorer prognoses compared to those found in the appendicular skeleton, with recurrence rates reaching up to 80% post-treatment [3, 20]. Various treatment modalities, including surgery, radiotherapy, embolization, cryotherapy, and chemical adjuvants, are employed for managing spinal GCTs. The primary treatment objective is complete tumor removal and recurrence prevention while safeguarding neurological structures and preserving spinal integrity [5, 8, 21-23]. Surgical resection is recommended for

intractable pain, progressive neurologic deficits, pathologic or impending fractures, and to reduce the risk of tumor progression or recurrence. Studies by Yin et al. [24] and Yokogawa et al. [25] have indicated that en bloc resection is associated with lower recurrence rates compared to piecemeal resection or curettage. The prognosis for our patients who underwent complete resection is favorable, aligning with previous study reports that advocate complete resection as the foundation of treatment. Charest-Morin et al. [26] have advocated for en bloc resection when technically feasible, recognizing the challenges imposed by the anatomical constraints of neural elements and the potential for morbidity during spinal lesion resections [20, 23, 27]. For larger lesions, Martin et al. [28] have recommended preoperative embolization followed by lesion resection, with en bloc resection being suitable in appropriate cases. In recent years, Denosumab has emerged as an adjuvant therapy [1, 29, 30]. Denosumab, a monoclonal antibody targeting RANKL, specifically inhibits the binding between RANKL and RANK, thereby suppressing the formation, differentiation, and activation of osteoclasts, reducing bone resorption, and yielding therapeutic benefits [31]. Denosumab is primarily employed in the treatment of refractory, recurrent, or metastatic giant cell tumors of bone [4, 32]. Anticipated advancements in molecular imaging technology, coupled with the development of denosumab-coupled radionuclide drugs, are poised to enhance the diagnosis and management of GCT. These innovations hold promise for improving patient prognosis and overall disease management.

Conclusion

In conclusion, due to the rarity of GCT occurrence in the thoracic spine, its diagnosis is often ignored when investigating the origin of thoracic lesions. Our case highlights an atypical imaging characteristic of GCTs, which should be considered as a potential differential diagnosis from other neoplastic spine diseases when interpreting similar presentations on ^{18}F-FDG PET/CT.

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Disclosure of conflict of interest

None.

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