

Imaging of the skeletal muscle metastases

T. ARPACI, G. UGURLUER¹, T. AKBAS², R.B. ARPACI³, M. SERIN⁴

Department of Radiology, Acibadem Adana Hospital, Adana, Turkey

¹Department of Radiation Oncology, Acibadem University, Istanbul, Turkey

²Department of Radiology, Acibadem University, Istanbul, Turkey

³Department of Pathology, Mersin University, Mersin, Turkey

⁴Department of Radiation Oncology, Acibadem University, Istanbul, Turkey

Abstract. – **AIM:** To define the radiological imaging features and clinical findings of the patients with skeletal muscle metastasis.

MATERIALS AND METHODS: 4454 computed tomography (CT), 1802 magnetic resonance imaging (MRI) and 2569 positron emission tomography/computed tomography (PET/CT) imaging studies of the oncology patients performed between March 2009 and July 2012 in the Radiology and Nuclear Medicine Departments of our hospital were retrospectively reviewed.

RESULTS: Fifty-two patients had 91 different metastatic skeletal muscle masses. Twenty-one patients (40%) were diagnosed with lung carcinoma as being the most common primary source. Forty-seven patients (90%) had metastatic disease somewhere else at the time of detection of skeletal muscle metastasis. Thirty-three patients (63%) had lymph node metastasis which was the most common site. Muscles mostly affected by metastatic disease were gluteals (15%), psoas (8.7%), erector spinae (8.7%), rectus abdominis (7.6%), latissimus dorsi (6.5%). The mean size of the lesions was 30 mm (range, 10-120 mm). The most common appearance on contrast-enhanced CT was a rim-enhancing intramuscular mass with central hypoattenuation. On MRI, skeletal muscle metastases mostly revealed isointense signal on T1-weighted images, heterogeneous high signal with peritumoral edema on T2-weighted images and extensive enhancement with central necrosis on gadolinium-DTPA (diethylene triamine pentaacetic acid) enhanced images.

CONCLUSIONS: Skeletal muscle metastasis may be an incidental finding on CT. The most common CT appearance is a rim-enhancing intramuscular mass with central hypoattenuation. On MRI, extensive tumoral enhancement, central necrosis and peritumoral edema are highly acceptable features of skeletal muscle metastasis.

Key Words:

Computed tomography, Magnetic resonance imaging, Metastasis, Skeletal muscle.

Introduction

Although skeletal muscles constitute nearly half of the total body mass and obtain a significant percentage of the total cardiac output, hematogenous metastases to the skeletal muscles have been reported to be uncommon. It is thought that muscle movement and pH, muscle's capability to remove the lactic acid produced by tumor contribute to the resistance of skeletal muscles for the metastatic process^{1,2}. In spite of these protective factors, numerous case reports of skeletal muscle metastases from pancreatic, renal, colonic, pulmonary, gastric and ovarian malignancies have been reported³⁻⁹. Just a few case series were issued in the previous years^{10,11}. Most of the skeletal muscle metastases are usually detected on computed tomography (CT) and positron emission tomography/computed tomography (PET/CT) due to their routine use in oncologic scanning of the body. However, soft tissue resolution of the magnetic resonance imaging (MRI) is superior to CT that makes it the gold standard for imaging of the muscles¹². The purpose of this study is to define the radiological imaging features and clinical findings of the patients with skeletal muscle metastasis.

Materials and Methods

We retrospectively reviewed 4454 CT, 1802 MRI and 2569 PET/CT imaging studies of the oncology patients performed between March 2009 and July 2012 in the Radiology and Nuclear Medicine Departments of Acibadem Adana Hospital. All patients had previously been diagnosed with primary malignancies. The patients having skeletal muscle metastasis were included in the study. The patients underwent CT with dual source 64-slice CT scanner (Somatom Defi-

nition/AS 64 × 2: Siemens Medical Systems, Erlangen, Germany). The MRI was performed with a 1.5-T scanner (Magnetom Avanto Tim 32 × 8: Siemens Medical Systems, Erlangen, Germany). The PET/CT imaging was carried out with Biograph 6 True Point scanner (Siemens Medical Solutions, Knoxville, TN, USA). The main inclusion criteria were the existence of skeletal muscle mass which was away from the primary site and confirmed either histologically or by clinical and radiological diagnosis. Direct extension of tumor to a skeletal muscle, soft tissue metastases rather than the skeletal muscle and the involvement of the diaphragm were excluded. Fifty-two patients had 91 different metastatic skeletal muscle masses with no clinical symptoms of abscess or inflammatory process. The medical records and imaging studies of the all 52 patients were retrospectively reviewed. The age and sex of the patients, the type of primary malignancy, the type of previous therapy, the time period between the diagnosis of primary malignancy and the detection of muscle metastasis, pain or palpable mass at the site of muscle metastasis were recorded for evaluation. The images were reviewed by two radiologists and a nuclear medicine physician considering the location, size, margin and enhancement characteristics of the lesions, existence of calcification and necrosis, surrounding muscle edema and metastases to the other sites.

Results

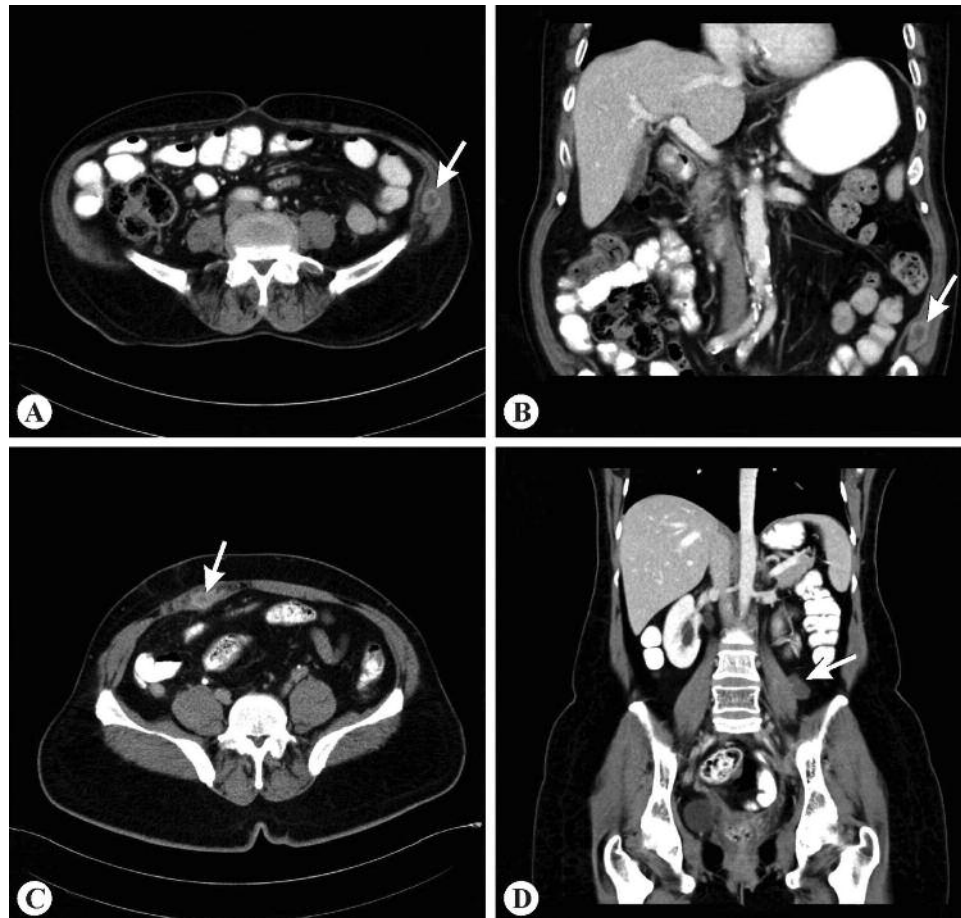
The mean age of the patients was 56 years (range, 23-83 years). Sixteen (31%) of the 52 patients were women. All of the 52 patients had been diagnosed with a primary malignancy at the time of detection of a muscle metastasis. These patients had previously received chemotherapy or radiation therapy with or without surgical removal of the primary tumor. Twenty-one of the 52 patients were diagnosed with lung carcinoma (40%), five with breast carcinoma (9.6%), four with rectal adenocarcinoma (7.7%), three with urethelial carcinoma of the urinary bladder (5.8%), two with pancreatic adenocarcinoma (3.8%), two with cervical adenocarcinoma (3.8%), two with ovarian carcinoma (3.8%) and the remaining patients (25.5%) with other primaries. The mean size of the lesions was 30 mm (range, 10-120 mm). Forty-seven (90%) of the 52 patients had metastatic disease somewhere else at the time of detection of skeletal muscle metasta-

sis. Thirty-three of the 52 patients (63%) had lymph node metastasis. Twenty patients (38%) had bone, 17 patients (33%) had lung, 14 patients (27%) had adrenal gland, 10 patients (19%) had periton, 10 patients (19%) had liver, 7 patients (13%) had subcutaneous fat tissue, 7 patients (13%) had brain, 2 patients (4%) had spleen metastasis. The remaining metastatic sites were each kidney, breast, pleura and thyroid. Muscles mostly involved by metastatic disease were gluteals (15%), psoas (8.7%), erector spinae (8.7%), rectus abdominis (7.6%), latissimus dorsi (6.5%), transversus abdominis (5.4%), vastus lateralis (4.3%), intercostal (4.3%), internal oblique (3.3%) muscles. The percentage of the other affected muscles were (36.2%). The most common appearance of the metastatic muscle lesions on contrast-enhanced CT was a rim-enhancing intramuscular mass with central hypoattenuation. Some of the lesions showed heterogeneous or homogeneous contrast enhancement on CT (Figures 1, 2). Metastases of the skeletal muscles mostly revealed isointense signal with ill-defined margins on T1-weighted MR images while T2-weighted images showed heterogeneous hyperintense signal with well-defined margins and also peritumoral edema. On gadolinium-DTPA enhanced MR images, extensive tumoral enhancement with central necrosis were seen in most of the patients (Figures 3, 4, 5). On PET/CT, maximum standardized uptake values (SUVmax) of the metastatic muscle lesions ranged between 2.05 and 26.50 (mean 8.58) g/ml (Figure 6).

Discussion

Skeletal muscle resists to the primary and metastatic carcinoma. Muscle contraction, pH alterations, accumulation of metabolites, intramuscular blood pressure and temperature have been reported as reasons of muscle resistance to malignancy. Lactic acid produced by skeletal muscle may prevent the improvement of tumor cells. Under the impact of adrenergic receptors, changing tissue pressure in skeletal muscle may influence tumor implantation. The protease inhibitors in the muscle extracellular matrix may resist to tumor invasion¹²⁻¹⁷. Weiss¹⁸ reported that cancer cells could live best in denervated muscle when compared with electrically stimulated muscle. Metastasis of carcinoma to the skeletal muscle is uncommon. Numerous case reports but a few studies on large case-series were reported for

Figure 1. A-B, 73 year old man with squamous cell carcinoma of the larynx. The patient had undergone partial laryngectomy in 1985. In 2009, he had radical neck dissection and total laryngectomy because of local recurrence. Axial (**A**) and reformat coronal (**B**) CT images of the abdomen show rim-enhancing metastatic lesion with central hypoattenuation in the left internal oblique muscle. **C,** 52 year old man with rectal adenocarcinoma. Axial CT image of the abdomen reveals a similar lesion in the right rectus abdominus muscle. **D,** 37 year old woman with cervical adenocarcinoma. Reformat coronal CT image of the abdomen shows a rim-enhancing lesion of the left psoas muscle.



this entity. Herring et al¹⁰ reported an extremely low prevalence of 0.03% (15 cases among 54 000 cases) in his study. Metastasis of carcinoma to the skeletal muscle is generally found in patients with advanced-stage neoplasms. Widespread metastatic disease was present in 90% of our patients. We believe that skeletal muscle metastasis is one of the deteriorating signs for prognosis of the patients with malignancies.

Significant improvement of the imaging modalities, development of multidetector computed tomography and PET/CT, advent of various post-processing techniques enabled incidental diagnosis of skeletal muscle metastasis. It may be an incidental finding on CT. Most of the intramuscular metastatic lesions defined in our CT series were neither painful nor palpable since most of the CT scans were carried out for assessment of oncologic staging and response to chemotherapy and/or radiotherapy. Unenhanced CT scan reveals skeletal muscle metastasis as an enlargement of a muscle. Intravenous contrast administration is essential to determine the extent

of the lesion¹⁴. Peritumoral muscle edema may be seen as an area of peripheral hypoattenuation surrounding the enhancing mass. Pretorius and Fishman¹² reported that 83% of the metastatic muscle lesions appeared as rim-enhancing intramuscular mass with central hypoattenuation in their series. They observed a percentage of 10% for heterogenous enhancement and 6.7% for homogenous enhancement of the intramuscular metastatic lesions. In our case load, most of the skeletal muscle metastases showed rim-enhancement with central hypoattenuation on CT. Intramuscular abscess may depict a similar CT appearance with metastasis. But when clinical findings of bacteremia and sepsis or a background of intravenous drug abuse do not exist in an oncology patient, metastasis should be considered. Biopsy may supply the exact diagnosis.

MRI is a valid imaging modality to determine the diagnosis and treatment of the metastasis to skeletal muscles. Munk et al¹⁹ described metastasis of renal cell carcinoma to the right trapezius muscle which showed low signal intensity on T1-

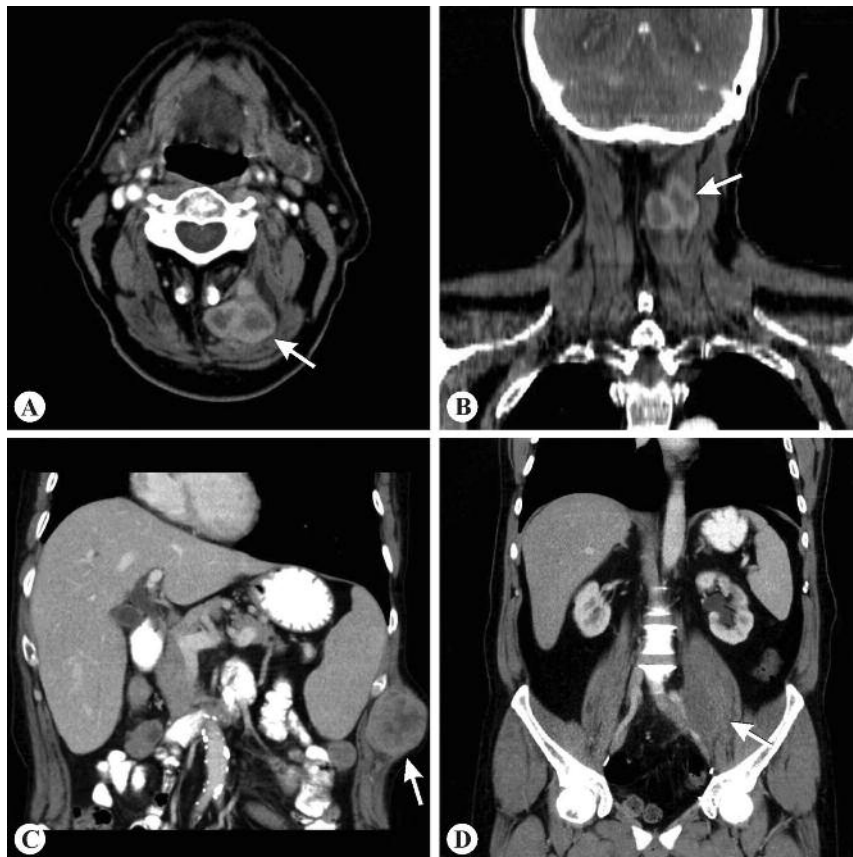


Figure 2. *A-B*, 66 year old man with squamous cell lung cancer. Axial (*A*) and reformat coronal (*B*) CT images of the cervical soft tissue show rim-enhancing metastatic lesion with central hypoattenuation in the left semispinalis capitis muscle (*C*) 66 year old man with non-small cell lung cancer. Coronal reformat CT image of the abdomen reveals heterogenous pattern of enhancement in the left external oblique muscle. (*D*) 50 year old man with urinary bladder cancer. Coronal reformat CT image of the abdomen demonstrates homogeneously enhancing mass in the left psoas muscle.

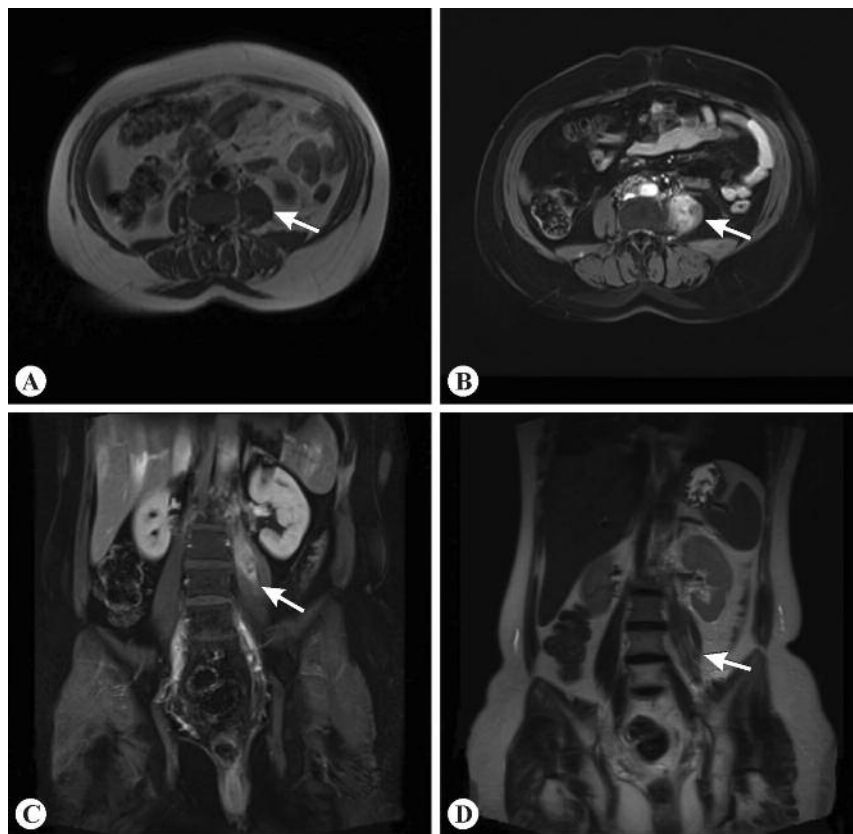


Figure 3. *A-D*, 50 year old woman with cervical adenocarcinoma. The patient had low back pain and restricted extension of the left leg. Axial T1-weighted MR image (*A*) reveals isointense expansile lesion in the left psoas muscle. On axial (*B*) and coronal (*C*) fat-suppressed T1-weighted MR images with gadolinium-DTPA, the lesion shows heterogeneous enhancement with focal areas of necrosis. Coronal T2-weighted MR image (*D*) demonstrates the peritumoral muscle edema.

Figure 4. A-D, 54 year old man with squamous cell lung carcinoma. The patient had a painful palpable mass in the left masseter muscle and restricted mouth opening. On pre-contrast axial T1-weighted MR image (**A**) the lesion has isointense signal to the muscle. Post-contrast axial fat-suppressed T1-weighted MR image with gadolinium-DTPA (**B**) shows extensive tumoral enhancement. On Axial T2-weighted MR image (**C**) the lesion has well defined margins. Coronal fat-suppressed T2-weighted MR image (**D**) demonstrates extensive peritumoral edema.

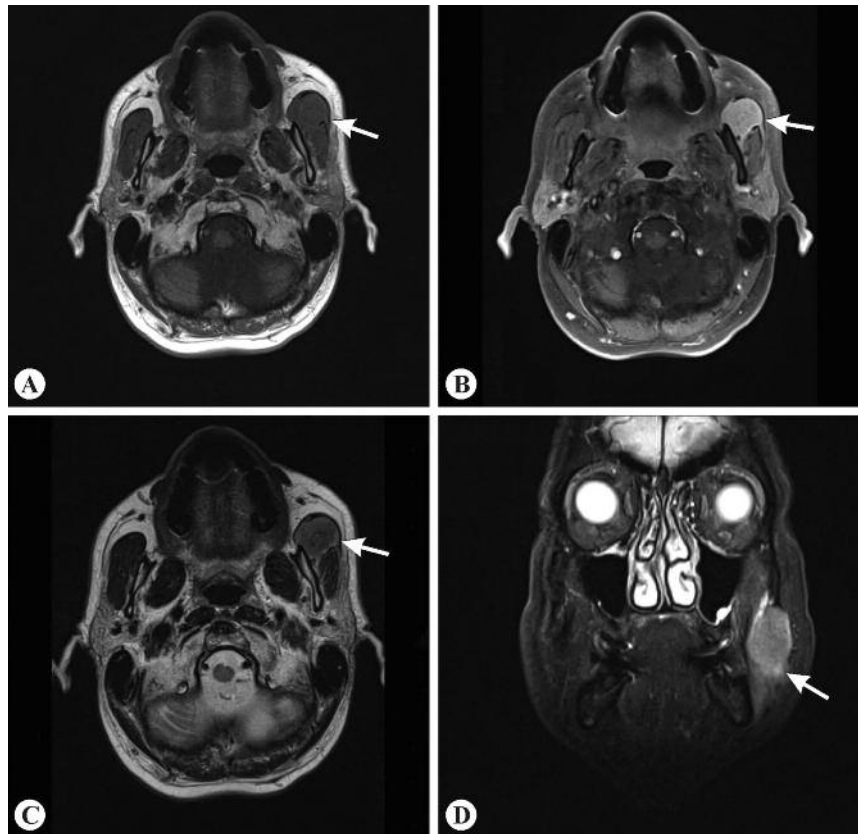
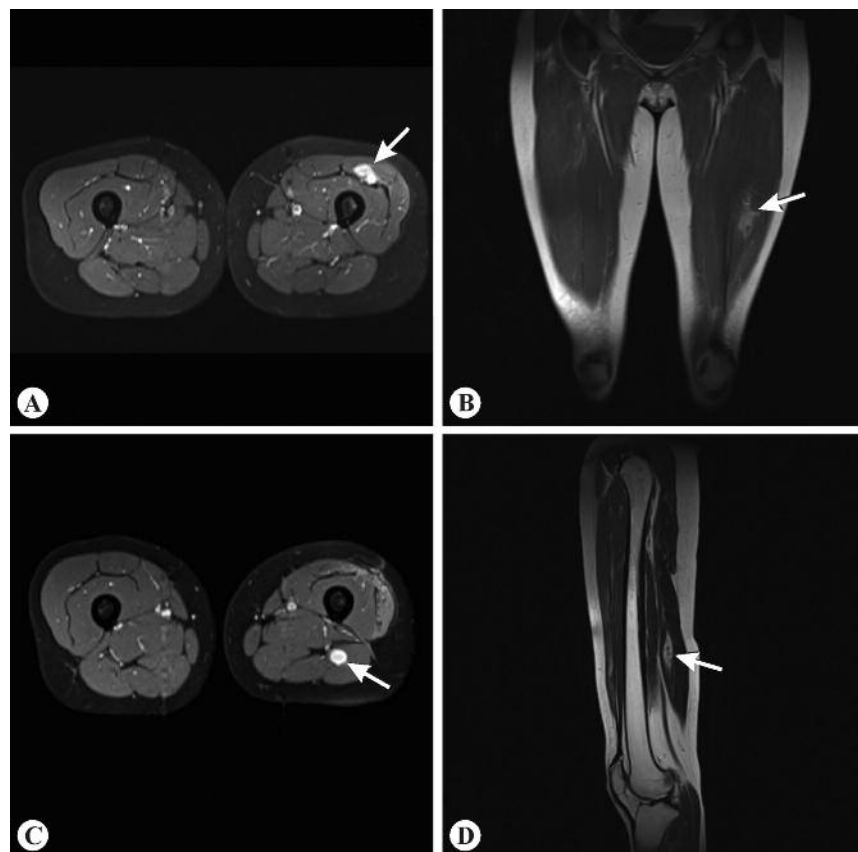


Figure 5. A-D, 23 year old woman with osteosarcoma of the left scapula. Axial fat-suppressed T1-weighted and coronal T1-weighted MR images with intravenous gadolinium-DTPA (**A-B**) show enhancing lesion with central necrosis in the left vastus lateralis muscle. Axial fat-suppressed T1-weighted MR image with intravenous gadolinium-DTPA (**C**) obtained 3 months after the surgical removal of the previous lesion reveals a new mass with similar imaging characteristics in the left biceps femoris muscle. Note post-operative signal abnormalities in the left vastus lateralis muscle. On sagittal T2-weighted MR image (**D**) the lesion has heterogeneous signal intensity.



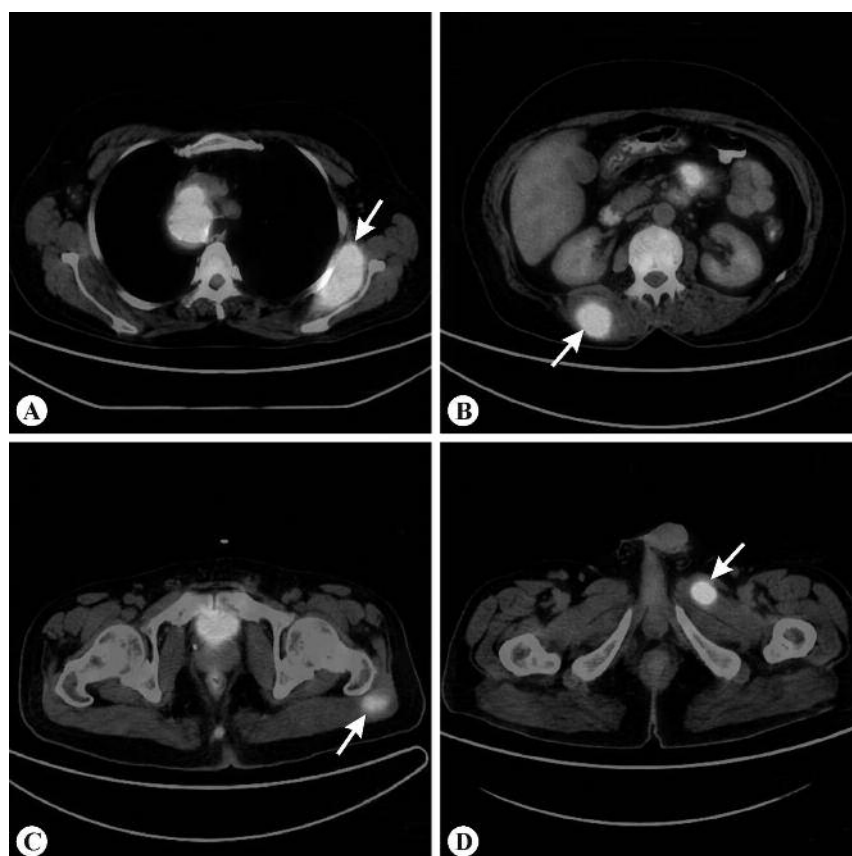


Figure 6. *A-B*, 54 year old woman with adenocarcinoma of unknown origin. Axial fused PET/CT images show hypermetabolic metastatic lesions in left subscapularis muscle (*A*) and right erector spina muscle (*B*). *C*, 43 year old man with small cell lung carcinoma. Axial fused PET/CT image reveals a hypermetabolic lesion in left gluteus maximus muscle. *D*, 62 year old man with adenocarcinoma of the lung. Axial fused PET/CT image demonstrates a hypermetabolic lesion in left adductor brevis muscle.

weighted MR images and high signal intensity on T2-weighted images. They also defined a slightly reticulated pattern with peritumoral edema. Tuoheti et al¹¹ reported that metastases of the skeletal muscles frequently revealed isointense signal to muscle with ill-defined margins on T1-weighted MR images and heterogeneous signal intensity with well-defined margins in addition to peritumoral edema on T2-weighted images in their series. On the gadolinium-DTPA (diethylene triamine pentaacetic acid) enhanced images, they frequently observed extensive tumoral enhancement with central necrosis. All of these imaging findings were detected in our study. MRI features of the skeletal muscle metastasis are not pathognomonic and the differential diagnosis must consist of soft tissue sarcoma, abscess and hematoma. On MRI, soft tissue sarcomas generally have low to intermediate signal intensity on T1-weighted MR images and uniform high signal intensity on T2 weighted images. Large, multinodular and hypervascular soft tissue sarcomas may depict internal hemorrhage, necrosis and calcification²⁰. Soft tissue infections show similar MRI features and significant edema¹⁴.

Hematomas may emerge within a primary or metastatic soft tissue tumor. Serial MRI examinations may be helpful in diagnosing a traumatic reason by detecting gradual resolution of a hematoma. Muscle edema has been identified as a frequent finding of both benign and malignant intramuscular lesions on MRI^{21,22}. Calcification had been defined as a finding of mucinous colonic adenocarcinoma metastasis to the skeletal muscle in the previous reports²³.

In spite of CT and MRI, many subclinical skeletal muscle metastases may be undiagnosed. In fact, these lesions may be more common than generally estimated and they are usually detected by PET/CT. A comprehensive autopsy study of 5298 patients died of malignancies reported that involvement of anterior chest wall muscles or abdominal wall muscles were detected in 6% of the patients. Most of these lesions were detected microscopically and could not be depicted by imaging techniques²⁴.

The widest muscles such as gluteals, psoas, erector spinae were the most common sites of metastatic involvement in our study. The most common primary lesion was carcinoma of the

lung (40%). The most common histological type was adenocarcinoma of the lung and gastrointestinal tract (35%). These findings were in agreement with the literature¹⁰⁻¹².

Treatment of the patients with skeletal muscle metastasis may be based on the clinical condition of the patient. The alternatives of the treatment may consist of radiotherapy, chemotherapy and selective surgical excision. When compared with surgical removal, radiotherapy may also effectively relieve the pain and diminish the size of the metastatic lesion.

Conclusions: Metastasis to the skeletal muscle may be more prevalent than previously estimated. It may be an incidental finding on CT. The most common contrast-enhanced CT appearance is a rim-enhancing mass with central hypoattenuation. Any intramuscular mass appearing in an oncology patient that shows extensive tumoral enhancement, central necrosis and peritumoral edema on MRI is highly acceptable as skeletal muscle metastasis. Metastasis to the skeletal muscle is one of the deteriorating signs for prognosis of the oncology patients.

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