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Infiltrative Pattern of Carcinomatosis in Extremity Muscles on MRI

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Abstract

Carcinomas can cause an unusual, infiltrative pattern of metastatic carcinoma in extremity muscles on MRI. To assess this pattern, reports of MRI exams of 907 consecutive patients with a diagnosis of carcinoma were reviewed retrospectively to identify those that mentioned muscle metastasis or myositis in an extremity. Thirty-six (4%) of those reports described muscle metastasis (n=18) or myositis (n=18); based on medical record review and imaging follow-up, 17 cases represented metastases. Metastases manifested as an infiltrative carcinomatosis pattern in 5 patients; resulted from primary esophageal or gastric adenocarcinomas; and often were misdiagnosed as myositis.

Keywords

Muscle; Metastasis; Myositis; Infiltrative; MRI; Carcinomatosis

1. Introduction

Until recently, skeletal muscle metastases had been considered rare, largely due to the limited means to detect them noninvasively. Various factors have been proposed to explain why skeletal muscle seems relatively inhospitable to metastases, despite being well vascularized and constituting approximately 50% of body mass. These include variability of blood flow, intermittent muscular contraction, lactic acid metabolism and pH, and the presence of diffusible proteases and other inhibitors that may block enzyme-dependent processes of invasion or tumor growth [1–2]. Earlier reported prevalences of muscle metastases at autopsy ranged from 0.03% to 5.6% [3]; subsequent studies suggested higher

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prevalences, 16–17.5% [4–6]. Approximately two-thirds of metastases to skeletal muscle arise from various types of carcinoma; lymphoma and leukemia combined account for the remaining one third [7–8].

Numerous case reports and, more recently, larger group studies have characterized the imaging appearance of such metastases on CT, MRI and PET/CT [9–13]. On MRI, skeletal muscle metastases typically manifest as well defined intramuscular lesions that are isointense to normal muscle on T1-weighted and hyperintense to normal muscle on T2-weighted sequences, with marked enhancement [11, 13]. Whereas a well-defined nodular morphology of muscle metastases has been described on MRI, an infiltrative pattern caused by carcinoma is not as well known. Such a pattern, which can be considered analogous to carcinomatosis in other structures such as lung and peritoneum, may be misdiagnosed as myositis on MRI.

This study was undertaken to determine the types of primary carcinoma that can cause an unusual, infiltrative pattern of metastatic carcinoma in extremity muscles at MR imaging.

2. Materials and Methods

2.1. Patient population

This retrospective study was approved by our institutional review board, which waived the need for informed consent, and is HIPAA compliant. The study population consisted of patients with at least one known primary carcinoma, who underwent MRI of an extremity or limb girdle (i.e., shoulder, pelvis or hip) during the period January 2012 through December 2013, and whose MRI reports mentioned muscle metastasis or myositis. Only patients with a diagnosis of adenocarcinoma were used in this study because it is the most common cancer type, and inclusion of other cancer types (such as sarcoma or lymphoma) was beyond the scope of this study.

To identify the study population, our electronic radiology information system was searched for patients who underwent MRI of an extremity or limb girdle in the specified time period. The MRI reports for those patients then were searched electronically for the character strings “musc” or “soft” to cast a broad net for identifying lesions in muscle (which sometimes are described by radiologists as “soft tissue”). Due to the specific nature of our patient population at a tertiary cancer hospital, most extremity MRIs are performed for evaluation of possible metastasis or sarcoma, not internal derangement; this resulted in a more focused search than would be expected in a more general musculoskeletal radiology practice. Patients whose reports included such character strings were then cross-referenced with the institutional clinical database to determine which patients also had a diagnosis of carcinoma. Each MRI report in the resulting group of patients was reviewed by one author to determine which reports suggested muscle metastasis or its mimic, myositis. Bone metastases with an extraosseous soft tissue component were excluded.

2.2. MRI technique

MRI was performed on a 1.5T or 3T MRI scanner. Several different scanning protocols were used, depending on lesion location. MRI sequences included T1-weighted (T1W) spin-echo

or fast spin-echo or T1W gradient-echo (GRE) in- and out-of-phase; and fluid-sensitive sequences (T2-weighted (T2W), short-tau inversion recovery (STIR), or fat-suppressed (FS) T2W). If intravenous gadolinium-based contrast material was administered, post-contrast sequences included T1W, FS T1W, or 3D T1W GRE.

2.3. Image review

One of three musculoskeletal radiologists (each with at least 10 years of experience), in conjunction with one radiology resident, performed consensus review of the resulting MRI exams to assess the reported muscle metastasis or myositis. Readers were blinded to MRI reports, pathology results, and clinical information; and readers were aware of the purpose of the study. Anatomic location of each lesion was classified as upper extremity, pelvis, or lower extremity. Lesion morphology was recorded as nodular if a round or oval mass was present, as infiltrative if the lesion had a complex, irregular shape with poorly defined margins and invasion into normal tissues, or as a mixture of both morphologies. The presence of peritumoral edema alone was not considered indicative of tumor infiltration. The number of muscles involved by the lesion was noted, as were the presence of fascial involvement, subjacent bone involvement, and subcutaneous extension. Lesion size was based on the largest dimension measured in any plane. If intravenous contrast material had been administered, the pattern of lesion enhancement was classified as none, heterogeneous (if <90% of the lesion enhanced), or homogeneous (if >90% of the lesion enhanced). Necrosis was defined as an area of non-enhancement within an enhancing lesion on post-contrast sequences. Perilesional edema, defined as poorly defined high signal around a lesion, was assessed on fluid-sensitive sequences (FS T2W or STIR). Intralesional hemorrhage was recorded when high T1 signal was present on precontrast FS T1W images.

2.4. Imaging Follow-up and Medical Record Review

Subsequently, follow-up imaging available in PACS, clinical notes from the electronic medical record, and pathology reports were reviewed to confirm the diagnoses of metastasis or myositis mentioned in the MRI reports. A muscle lesion was considered a metastasis if it enlarged on serial imaging in the setting of concordant enlargement of metastases elsewhere in the body. A lesion was considered myositis if it decreased in size or resolved at follow-up imaging, despite persistence or enlargement of metastases elsewhere.

Clinical signs and symptoms related to the region of muscle abnormality were recorded for patients with the infiltrative pattern of muscle metastasis. Tumor stage at patient presentation to our institution was noted, as well as the relative time of appearance of the muscle abnormality. Patient outcome was reviewed.

3. Results

The initial computer search yielded 3414 MRI reports; 907 reports remained after excluding patients with a cancer diagnosis other than carcinoma. Thirty-six (4%) of 907 MRI reports described muscle metastases (n=18) or myositis (n=18), in 36 unique patients (25 male, 11 female; mean age, 64 years (range, 33–83 years)). The types of carcinoma in reports mentioning muscle metastasis were lung (n=4), renal (n=4), esophageal (n=2), and one each

of gastric, urothelial, colorectal, prostate and rectal (in same patient), head & neck, parotid, thyroid, and endometrial. The types of carcinoma in reports mentioning myositis were prostate (n=4), breast (n=2), esophageal (n=2), renal (n=2), bladder (n=2), and one each of gastric, pancreas, colorectal, lung and gastric (in same patient), ovarian, and squamous cell of unknown primary.

On the basis of clinical and imaging follow-up, 13 (72%) of 18 patients whose MRI report suggested myositis were deemed to have had myositis. The diagnosis of myositis was deemed indeterminate in two (11%) patients due to lack of clinical or imaging follow-up. In 3 (17%) of 18 patients, lesions diagnosed as myositis at initial imaging subsequently were shown to be infiltrative metastases by imaging follow-up.

Fourteen (78%) of 18 patients whose MRI report suggested muscle metastasis (of any morphology) were confirmed to have had muscle metastases by growth on serial imaging, biopsy, or both. Findings in three (17%) other patients were deemed indeterminate due to lack of clinical or imaging follow-up. One patient (5%) underwent a biopsy that showed nonspecific findings and no evidence of neoplasm.

3.1. MRI findings

Twelve patients had metastases with a purely nodular morphology. The metastases were classified as having an infiltrative pattern in four other patients (Patients 1–3 and 5) (Fig. 1) and mixed nodular and infiltrative pattern in another patient (Patient 4) (Fig. 2). All five patients with an infiltrative muscle metastasis on MRI were male, with a mean age of 54 years (range, 35–62 years) and a primary diagnosis of upper gastrointestinal tract adenocarcinoma (esophageal (n=3) or gastric (n=2)) (Table 1). Infiltrative metastases involved muscles of the pelvis (n=2), upper extremity (n=1), lower extremity (n=1), and both pelvis and lower extremity (n=1).

The metastasis affected one geographic region in 4 (80%) of 5 patients, with multifocal involvement of two or more muscles within that region as well as fascial involvement (Patients 1–3 and 5). In one (20%) other patient, the metastases were present in more than two separate areas of one muscle. In one patient (Patient 4), in whom several metastases were confined to one muscle, the affected muscle was not enlarged, nor was the fascia involved (Fig. 2). Subcutaneous extension of the metastasis occurred in two patients (Patient 1 and 2). No metastasis invaded adjacent bone. The mean largest dimension of infiltrative metastasis was 20.2 cm (range, 12.6–30.5 cm).

3.2. Signal intensity characteristics

All five patients with infiltrative muscle metastases had undergone intravenous contrast-enhanced MRI. Heterogeneous enhancement occurred in all muscle metastases. In all four patients for whom fluid-sensitive sequences were available, perilesional edema was present. Three (60%) of five patients showed areas of necrosis within the metastases. No intralesional hemorrhage was evident.

3.3. Imaging Follow-up and Medical Record Review

Muscle metastases were diagnosed prospectively on MRI in two patients with infiltrative metastases (Patients 1 and 5). Patient 1 underwent three PET/CT scans prior to MRI, showing increasing size, FDG avidity, and number of muscles affected in the shoulder, proximal arm and anterior chest wall. Patient 5 underwent CT at an outside institution, in which a lesion in the anterior thigh musculature was interpreted as a hematoma; subsequent MRI performed at our institution showed enhancing solid components, indicating the lesion was not a hematoma; subsequent biopsy confirmed metastatic adenocarcinoma from the known gastric primary.

Muscle abnormality was misdiagnosed as myositis on MRI in three patients (Patients 2, 3, and 4) who subsequently showed progression of the findings and other metastases on follow-up CT and PET/CT scans, accompanied by worsening symptoms, consistent with infiltrative carcinomatosis in muscle. The MRI of Patient 2 (Fig. 1) showed a complex, irregularly shaped mass with diffuse edema and enhancement in the right posterior thigh musculature, also involving the superficial and deep intermuscular fascia, as well as subcutaneous edema; the findings were reported as myositis with fasciitis. Follow-up CTs (Fig. 1D-1F) and PET/CT (Fig. 1G) performed within the subsequent three months demonstrated increasing enlargement and infiltration of the muscles in the pelvic girdle and thigh, with increasing peritoneal carcinomatosis (not shown). Biopsy was not performed in patients 2, 3, or 4 due to increasing metastases at other sites and deteriorating functional status; tissue sampling would not have affected management.

All five patients with infiltrative metastases presented with intense and debilitating pain in the affected region, sometimes with associated swelling (n=3 (60%)), weakness (n=3 (60%)), and paresthesia of the affected extremity (n=2 (40%)), which was often not sufficiently controlled with narcotics (n=5 (100%)), injected anesthesia n=(2 (40%)), or palliative radiation therapy (n=3 (60%)). All five patients had stage IV disease at presentation to our institution; muscle metastases developed during the subsequent course of treatment. Once infiltrative muscular metastases were shown on MRI performed after new onset of pain, rapid disease progression ensued; four patients died within a mean of 4.5 months (range, 2–6 months) (Table 1).

4. Discussion

The most common reported features of muscle metastases on MRI include solitary or multiple intramuscular lesions that are round or oval in shape; a less common manifestation is well-defined margins with lobulation. Such metastases are usually isointense in signal relative to unaffected muscles on T1W images and hyperintense on T2W images [11, 13]. Lesions often show marked, usually homogeneous enhancement after administration of intravenous gadolinium-based contrast material [13, 14]. The reported prevalence of perilesional edema varies widely, from 1.5 – 78% [11, 13, 15]. Necrosis within muscle metastases has been reported to be relatively common [11], sometimes accompanied by peritumoral enhancement [16].

A broad spectrum of appearances of skeletal muscle metastases has been reported on CT. Surov et al. described five different patterns: focal intramuscular mass with homogeneous contrast enhancement, abscess-like intramuscular lesion, diffuse metastatic muscle infiltration, multifocal intramuscular calcification, and intramuscular bleeding [17]. Diffuse metastatic muscle infiltration on CT, the pattern corresponding to the infiltrative carcinomatosis pattern on MRI in our study, was identified in 8.8% of skeletal muscle metastases in that study, manifesting as muscle swelling and diffuse heterogeneous enhancement, a pattern that some authors believe could be misdiagnosed as a soft tissue sarcoma [7,17].

In our study we identified five patients with primary carcinoma who developed an infiltrative pattern of infiltrative carcinomatosis within muscle; three of these were initially misdiagnosed as myositis on MRI, which could delay appropriate treatment. The margins of the metastases were ill defined and infiltrative, crossing fascial planes and affecting multiple contiguous muscles, with perilesional edema. Although not formally assessed in our study, use of such features would not likely distinguish myositis from infiltrative metastasis. The metastases enhanced, were often centrally necrotic, and frequently invaded into subcutaneous tissues; the later two features would favor infiltrative metastasis rather than myositis.

A case report by El Khoury et al. [18] described an unusual metastasis of invasive lobular breast carcinoma that infiltrated the anterior muscular compartment of the thigh, presenting as edema of the lower extremity ten years after treatment of primary breast carcinoma. This pattern of infiltration on MRI, with extension of tumor along thickened fascia, was considered to mimic fasciitis [18]. In our study, fascial involvement was seen in 80% of patients with infiltrative muscle metastases, but always was accompanied by other findings; also, no patient with infiltrative muscle metastasis in our study had primary breast carcinoma. A similar pattern of metastatic infiltration, specifically involving the psoas muscle, has been described in the so-called malignant psoas syndrome [19, 20].

Another pattern of infiltrative muscle metastases similar to ours has been described in patients with intramuscular leukemic relapse. Surov et al. [21] identified three patterns of muscle involvement: an intramuscular mass with homogeneous involvement; abscess-like lesions with rim enhancement and central liquefaction; and diffuse muscle infiltration. The pattern of diffuse muscle infiltration, which resembles myositis, was the most prevalent in that study and has also been identified in other hematologic malignancies such as lymphoma and plasmacytoma [22–24]. However, this pattern is quite unusual in intramuscular metastases from solid malignancies, in which a more mass-like lesion is characteristic [17, 25].

Myositis is a term used to describe inflammatory muscle disease, and encompasses a spectrum of disorders that can result from various causes. On MRI, the most prominent finding in myositis is poorly defined edema, manifesting as focal areas of increased signal intensity on fluid-sensitive sequences [26]. Edema also may occur in a myofascial distribution, around individual muscles or groups of muscles, in conjunction with muscle

edema. Skin thickening and an abnormal reticular pattern in the subcutaneous tissue that corresponds to thickened connective tissue septa are also common findings [27–29].

The most common primary malignancies causing metastasis to skeletal muscle have been reported to be lung carcinoma, followed by renal carcinoma [11, 30–31]. However, other studies have reported that genital and urological tumors are the malignancies that most often metastasize to muscle [17]. We found similar results in our study, with regard to all discrete muscle metastases; however, infiltrative carcinomatosis of extremity muscle was found only in five patients, all of whom had either gastric or esophageal carcinomas. Primary gastroesophageal carcinoma metastasizing to muscle appears to be rare, with available data limited to case reports or small series of patients [32–37]. In 205 patients with esophageal carcinoma, (2% were observed to have muscle metastases [32]. In four of those cases, such metastases were the first manifestation of metastatic disease.

Our results are somewhat different than in those previous studies. In our study, infiltrative muscle metastases developed in patients already known to have stage IV disease. Also, our study was notable for the relatively short survival time (2–6 months) after diagnosis of muscle metastases, suggesting a poor prognosis when this infiltrative pattern occurs.

Our study has several limitations. First, this is a retrospective study in which cases of infiltrative carcinomatosis in muscle were found by searching for character strings in MRI reports; additional MRI reports that used different words would have been excluded, potentially underestimating the number of relevant cases. All MR images related to reports that included the character strings were not reviewed; thus, other, additional cases may have been missed, again resulting in underestimation of the prevalence of this pattern. Muscle abnormality may not have been reported in all patients in whom it was present. Review of reports from a longer time period might have yielded a larger range of tumor types with infiltrative muscle metastases, although the types and frequencies of carcinomas in patients referred to our tertiary cancer center do not substantially change from year to year.

This study was not designed to determine MRI features that could be used to distinguish myositis and muscle metastasis. Images were reviewed in consensus, precluding assessment of interobserver variability; the latter was beyond the scope of this purely descriptive study. The reported spectrum of MR imaging findings in infiltrative carcinomatosis in muscle may be limited by the small number of such cases. The study group consisted of patients at a tertiary cancer center, which introduces selection bias. Diagnosis of muscle metastases was based on clinical course and imaging findings, as histopathologic confirmation generally was not obtained. Muscle metastases were found in patients with advanced metastatic disease, so pathologic confirmation would have been of little relevance to clinical management.

5. Conclusion

In summary, the infiltrative pattern of carcinomatosis in muscle typically occurs in patients with advanced metastatic disease, can produce severe pain, and portends a dismal prognosis. Infiltrative carcinomatosis in muscle may be misdiagnosed as myositis on MRI, adding to

the diagnostic challenge. In this study, infiltrative carcinomatosis in muscle occurred only in patients with primary esophageal or gastric cancers.

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References

1. Seely S. Possible reasons for the high resistance of muscle to cancer. *Med Hypotheses*. 1980; 6:133–137. [PubMed: 7393016]
2. Weiss L. Biomechanical destruction of cancer cells in skeletal muscle: a rate-regulator for hematogenous metastasis. *Clin Exp Metastasis*. 1989; 5:483–491. [PubMed: 2752602]
3. Willis, RA. The spread of tumours in the human body. Butterworth; London: 1952. p. 284–285.
4. Pearson CM. Incidence and type of pathologic alternations observed in muscle in a routine autopsy survey. *Neurology*. 1959; 9:757–766. [PubMed: 14431247]
5. Glockner J, White L, Sundaram M, McDonald DJ. Unsuspected metastases presenting as solitary soft tissue lesions: a fourteen-year review. *Skeletal Radiol*. 2000; 29:270–274. [PubMed: 10883446]
6. Garcia OA, Fernandez EG, Satué EG, Bueta SL, Val-Bernal JF. Metastasis of malignant neoplasm to skeletal muscle. *Rev Esp Oncol*. 1984; 31:57–67. [PubMed: 6545428]
7. Hundt W, Braunschweig R, Reiser M. Diffuse metastatic infiltration of a carcinoma into skeletal muscle. *Eur Radiol*. 1999; 9:208–210. [PubMed: 10101640]
8. Auerbach O, Garfinkel L, Parks VR. Histologic type of lung cancer in relation to smoking habits, year of diagnosis and sites of metastases. *Chest*. 1975; 67:382–387. [PubMed: 1122765]
9. Surov A, Pawelka MK, Wienke A, Schramm D. PET/CT imaging of skeletal muscle metastases. *Acta Radiologica*. 2014; 55:101–106. [PubMed: 23884841]
10. Emmering J, Vogel WV, Stokkel MPM. Intramuscular metastases on FDG PET-CT: a review of the literature. *Nucl Med Commun*. 2012; 33:117–120. [PubMed: 22124361]
11. Lee BY, Choi JE, Park JM, et al. Various image findings of skeletal muscle metastases with clinical correlation. *Skeletal Radiol*. 2008; 37:923–928. [PubMed: 18594814]
12. Arpacı T, Ugurluer G, Akbas T, et al. Imaging of the skeletal muscle metastases. *Eur Rev Med Pharmacol Sci*. 2012; 16:2057–2063. [PubMed: 23280019]
13. Surov A, Fiedler E, Voigt W, et al. Magnetic resonance imaging of intramuscular metastases. *Skeletal Radiol*. 2011; 40:439–446. [PubMed: 20697708]
14. Liu Y, Ghesani N, Mirani N, et al. PET-CT demonstration of extensive muscle metastases from breast cancer. *Clin Nucl Med*. 2006; 31:266–268. [PubMed: 16622333]
15. Magee T, Rosenthal H. Skeletal muscle metastases at sites of documented trauma. *AJR*. 2002; 178:985–988. [PubMed: 11906887]
16. Tuoheti Y, Okada K, Osanai T, et al. Skeletal muscle metastases of carcinoma: a clinicopathological study of 12 cases. *Jpn J Clin Oncol*. 2004; 34:210–214. [PubMed: 15121758]
17. Surov A, Hainz M, Holzhauser HJ, et al. Skeletal muscle metastases: primary tumours, prevalence, and radiological features. *Eur Radiol*. 2010; 20:649–658. [PubMed: 19707767]
18. El Khoury M, Cherel P, Becette V, et al. Unusual soft-tissue metastasis of an invasive lobular carcinoma mimicking fasciitis. *AJR*. 2004; 182:745–747. [PubMed: 14975980]
19. Stevens MJ, Gonet YM. Malignant psoas syndrome: recognition of an oncologic entity. *Australas Radiol*. 1990; 34:150–154. [PubMed: 2241667]
20. Agar M, Broadbent A, Chye R. The management of malignant psoas syndrome: case reports and literature review. *J Pain Symptom Manage*. 2004; 28:282–293. [PubMed: 15336342]
21. Surov A, Kiratli H, Im SA, et al. Intramuscular leukemic relapse: clinical signs and imaging findings. A multicentric analysis. *Skeletal Radiol*. 2015; 44:491–496. [PubMed: 25256752]
22. Surov A. Imaging findings of skeletal muscle lymphoma. *Clin Imaging*. 2014; 38:594–598. [PubMed: 24735681]

23. Chun CW, Jee WH, Park HJ, et al. MRI features of skeletal muscle lymphoma. *AJR Am J Roentgenol.* 2010; 195:1355–1360. [PubMed: 21098195]
24. Surov A, Tcherkes A, Meier F. Intramuscular plasmacytoma. *Skeletal Radiol.* 2014; 43:1561–1565. [PubMed: 24972917]
25. Surov A, Köhler J, Wienke A, et al. Muscle metastases: comparison of features in different primary tumours. *Cancer Imaging.* 2014; 14:21. [PubMed: 25608474]
26. May D, Disler D, Jones EA, et al. Abnormal signal intensity in skeletal muscle at MR imaging: patterns, pearls, and pitfalls. *Radiographics.* 2000; 20:S295–S315. [PubMed: 11046180]
27. Garcia J. MRI in inflammatory myopathies. *Skeletal Radiol.* 2000; 29:425–438. [PubMed: 11026710]
28. Adams EM, Chow CK, Premjumar A, Piotz PH. The idiopathic inflammatory myopathies: spectrum of MR imaging findings. *Radiographics.* 1995; 15:563–574. [PubMed: 7624563]
29. Al-Nahhas A, Jawad ASM. PET/CT imaging of inflammatory myopathies. *Ann NY Acad Sci.* 2011; 1228:39–45. [PubMed: 21718321]
30. Damron RA, Heiner J. Distant soft tissue metastases: a series of 30 new patients and 91 cases from the literature. *Ann Surg Oncol.* 2000; 7:526–534. [PubMed: 10947022]
31. Haygood TM, Wong J, Lin JC. Skeletal muscle metastases: a three-part study of a not-so-rare entity. *Skeletal Radiol.* 2012; 41:899–909. [PubMed: 22101865]
32. Cincibuch J, Myslivecek M, Melichar B, et al. Metastases of esophageal carcinoma to skeletal muscle: Single center experience. *World J Gastroenterol.* 2012; 18:4962–4966.
33. Heyer CM, Rduch GJ, Zgoura P, et al. Metastasis to skeletal muscle from esophageal adenocarcinoma. *Scand J Gastroenterol.* 2005; 40:1000–1004. [PubMed: 16165713]
34. Rehman SU, Cope DW, Basile JN. Metastatic gastroesophageal adenocarcinoma to skeletal muscle: a unique event. *South Med J.* 2002; 95:1076–1078. [PubMed: 12356116]
35. Kozyreva ON, Mezentesev DA, King DR, et al. Asymptomatic muscle metastases from esophageal adenocarcinoma. *J Clin Oncol.* 2007; 25:3780–3783. [PubMed: 17704428]
36. Heffernan E, Fennelly D, Collins CD. Multiple metastases to skeletal muscle from carcinoma of the distal esophagus detected by FDG PET-CT imaging. *Clin Nucl Med.* 2006; 31:810–811. [PubMed: 17117081]
37. Wu G, Bybel B, Brunken R, et al. PET detection of solitary distant skeletal muscle metastasis of esophageal adenocarcinoma. *Clin Nucl Med.* 2005; 30:335–337. [PubMed: 15827406]

Fig. 1. 62-year-old man (Patient 2) with esophageal carcinoma and infiltrative muscle carcinomatosis. MRI was interpreted as showing severe, extensive fasciitis and myositis in right thigh

Axial **A** T1W, **B** FS T2W, and **C** post-contrast FS T1W MR images through lower pelvis demonstrate an infiltrative process in proximal thigh, involving multiple muscles. Diffuse edema and enhancement are evident throughout posterior thigh musculature, particularly involving adductor muscles in proximal thigh, with associated diffuse edema (*) and enhancement of muscle fascia (arrows).

D Axial contrast-enhanced image from CT of right hip obtained a few days later shows enhancing infiltration and enlargement of muscles (*) in right hemipelvis and thigh, particularly right gluteus musculature, adductor compartment and posterior thigh. Note loss of fat planes between muscles and around femoral vessels (arrows).

E Axial contrast-enhanced CT image from pelvis obtained one month after **A–C** demonstrates increased loss of fat plane around neurovascular bundle (arrows) and increased muscle enlargement due to tumor infiltration in thigh (*).

F Axial post-contrast CT image of pelvis obtained three months after **A–C** shows further tumor progression in right thigh, with increased tumor infiltration (*) and further loss of fat plane surrounding neurovascular bundle (arrows), in addition to new infiltrating tumor involvement in left thigh (+).

G Fused PET/CT image obtained one month after **A–C** demonstrates increased FDG avidity throughout muscles of proximal right thigh, corresponding to asymmetric swelling and enhancement in **D–F**, and to diffuse edema, enhancement and enlargement of muscles in **A–C**.

Fig. 2. 35-year-old man (Patient 4) with gastric carcinoma, showing mixed pattern of nodular and infiltrative carcinomatosis in muscle which is more apparent on MRI than CT. MRI was interpreted as showing myositis of right thigh

A Axial post-contrast FS T1W MR image and **B** axial contrast-enhanced CT image through lower pelvis demonstrate multiple enhancing metastases (arrows) in gluteus maximus muscle, the borders of which in axial plane appear more discrete and nodular. **C** Coronal STIR image and **D** coronal contrast-enhanced CT image show slightly wavy, discrete, thick bands (arrowheads) of high signal and hyperattenuation, respectively, paralleling fibers of gluteus maximus muscle, corresponding to the infiltrative component of the metastases in **A** and **B**. Multiple metastases are located within a single muscle, which itself is not appreciably enlarged.

Table 1

Clinical and radiology report data in the five men with infiltrative muscle metastases.

Patient No.	Age (yrs)	Type of Carcinoma	Diagnosis Reported on Initial MRI	Biopsy of Metastasis	Additional Imaging	Clinical Outcome
1	59	Esophageal	Metastasis	No	PET/CT	Lost to follow-up
2	62	Esophageal	Myositis	No	CT, PET/CT	Death (6 months)
3	59	Esophageal	Myositis	No	PET/CT	Death (5 months)
4	35	Gastric	Myositis	No	CT	Death (3 months)
5	56	Gastric	Metastasis	Yes	CT	Death (2 months)