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PICTORIAL ESSAY

MR imaging findings of pyogenic bacterial myositis (pyomyositis) in patients with local muscle trauma: illustrative cases

Stavroula J. Theodorou · Daphne J. Theodorou · Donald Resnick

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Abstract Pyogenic myositis (pyomyositis) represents a bacterial infection of muscle, usually caused by *Staphylococcus aureus* that is endemic in tropical regions. Pyomyositis commonly affects patients who are immunocompromised or who have underlying chronic disorders. Lower extremity localization of infection is typical. The most common pattern of disease, however, appears to be a solitary abscess in the quadriceps musculature. Delay in accurate diagnosis is frequent and clinical deterioration can be precipitous. In view of the high associated morbidity, early imaging to detect, localize, and define disease extent is important. Magnetic resonance imaging (MRI) plays a key role in the definitive diagnosis of pyomyositis. This article provides a pictorial illustration of the spectrum of MRI findings associated with pyogenic myositis.

Keywords Pyogenic myositis · Pyomyositis · Muscle · Infection · Abscess · Magnetic resonance imaging (MRI)

S. J. Theodorou · D. J. Theodorou · D. Resnick
Department of Radiology, School of Medicine,
University of California San Diego Medical Center,
San Diego, CA, USA

S. J. Theodorou · D. J. Theodorou · D. Resnick
Department of Radiology,
Veterans Administration Medical Center,
San Diego, CA, USA

Present address:
D. J. Theodorou (✉)
13 Papadopoulos street,
Ioannina 45444, Greece
e-mail: daphne_theodorou@hotmail.com

Pyomyositis: the disease

Pyogenic myositis (pyomyositis), a serious infection of skeletal muscle, is typically seen in tropical regions (tropical pyomyositis) [1] where it affects mainly children and young adults following penetrating trauma. Recently, pyomyositis has been reported in intravenous drug abusers, diabetics, and malnourished and immunodeficient patients, including patients with the acquired immunodeficiency syndrome (AIDS) [1, 2]. Because of an increasing number of immunocompromised and substance abuse patients, however, the risk of this soft tissue infection is likely to increase.

Local muscle trauma may increase susceptibility of skeletal muscle to infection [3, 4]. A variety of pathogens can cause pyogenic myositis, with *Staphylococcus aureus* accounting for 90% of the cases [3, 4]. Patients with pyomyositis present with symptoms of fever, pain, and swelling of affected muscle(s) [2, 4, 5]. Because of atypical symptoms and signs, the infection is often initially misdiagnosed as muscle strain, thrombophlebitis, osteomyelitis and septic arthritis, hematoma, lymphedema, and neoplasm [2, 5]. Not infrequently, nonspecific clinical presentation results in delayed diagnosis of muscle infection.

Given that pyogenic myositis can result in serious disability, early recognition of pathology is critical to implementing aggressive treatment, often allowing calamitous complications as systemic toxicity or death to be avoided. Imaging plays a central role in early and accurate diagnosis. Radiography has a limited role in imaging muscle infection because usually, it does not demonstrate soft tissue changes directly. Rather, radiography reveals indirect signs of infectious involvement, such as an increase in soft tissue volume, or deformation or obliteration of fat

planes [1, 6]. Radionuclide studies with indium 111 and gallium 67 isotopes are sensitive for the diagnosis of pyomyositis [1, 7–9]. The limitations of scintigraphy, however, include low specificity, increased examination time, inability to provide anatomic detail, and radiation exposure. For these reasons, scintigraphy generally has been relegated to a supplemental role in those patients with clinical suspicion of additional nearby or distant abscesses or patients who have indeterminate computed tomography (CT) or MRI findings [10].

Sonography is most useful in the evaluation of superficial abscesses, as deep intramuscular fluid collections (i.e., in the pelvic and lumbar regions) usually require cross-sectional imaging studies [11]. For example, in one study of 12 children with pyomyositis, sonography revealed infectious changes in all cases with involvement of the extremities and identified the infectious condition in only 25% of cases with involvement of the pelvis [12]. Further, sonography is sensitive in the detection of clinically occult fluid collections and can be used to guide biopsy or aspiration [4, 12, 13]. Not infrequently, however, aspiration is required to differentiate an abscess from other types of fluid collections, such as hematoma, seroma, and cystic or necrotic tumors [11]. In the absence of an abscess, the sonographic diagnosis of

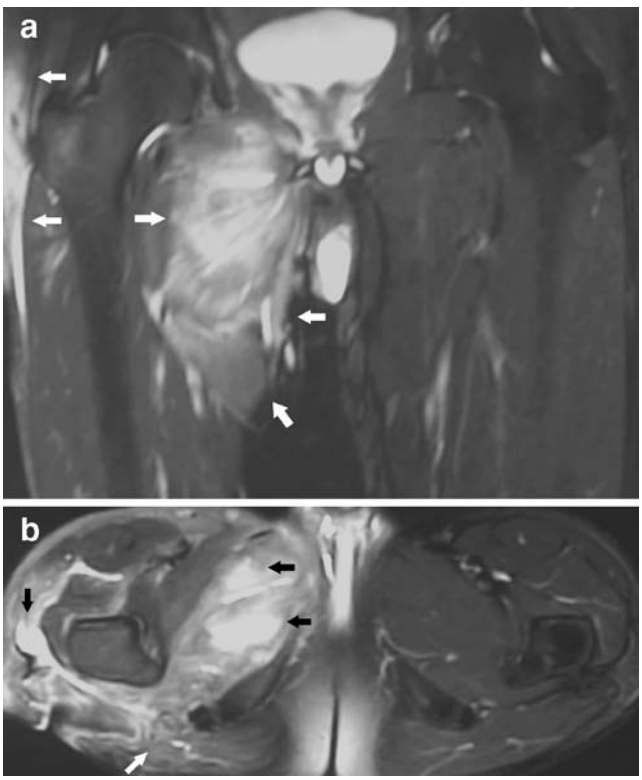

Fig. 1 Pyogenic myositis in a 33-year-old man who committed a suicide leap 6 days previously (courtesy of Y. Kakitsubata, Miyazaki, Japan). *Streptococcus faecalis* was recovered from site of infection. **a** Coronal fat-suppressed fast spin-echo T2-weighted (TR/TE=4,000/94) and **b** axial fat-suppressed fast spin-echo T2-weighted (TR/TE=5,000/94) MR images show abnormal high signal intensity in inflamed muscles of right upper thigh and buttock (*arrows*)

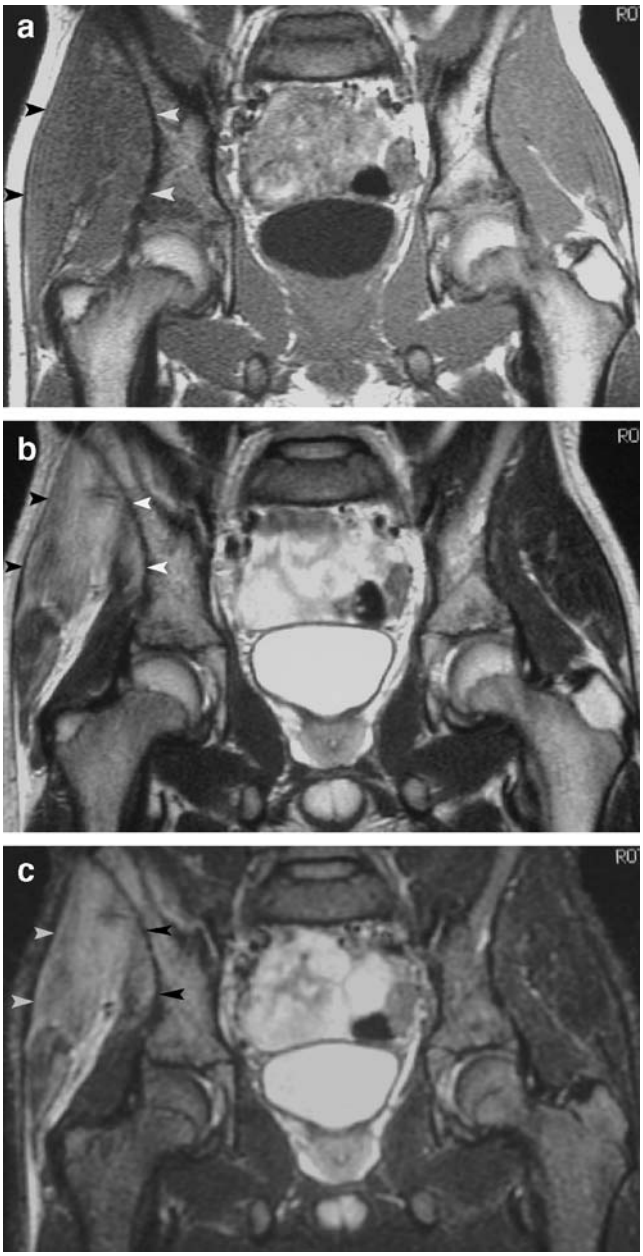

Fig. 2 Early pyogenic myositis (invasive stage) in a 15-year-old boy with a history of injury while playing football who presented with right hip pain and inability to walk. The patient was thought to sustain injury of gluteal muscles; he was treated with anti-inflammatory medications and rest and was released. **a** Coronal T1-weighted MR image (TR/TE=500/10) shows enlargement of right gluteal muscles (*arrowheads*) whose signal intensity is similar to that of normal muscle. **b** Coronal fast spin-echo T2-weighted MR image (TR/TE=4,800/90) and **c** fast spin-echo inversion recovery MR image (TR/TE=4,200/46; inversion time, TI=150 ms) reveal gluteus medius and part of gluteus minimus muscles (*arrowheads*) of inhomogeneous but mainly high signal intensity

Fig. 3 Pyogenic myositis at its purulent stage in a 15-year-old boy (same patient as in Fig. 2) with right hip pain, fever, and leukocytosis 1 week after initial presentation. *Staphylococcus aureus* was recovered from the abscess. **a** Sagittal T1-weighted MR image (TR/TE=550/9) shows rim of increased signal intensity at the periphery of abscess in right gluteus medius muscle (*arrows*). **b** Coronal fast spin-echo T2-weighted MR image (TR/TE=4,800/87) and **c** fast spin-echo inversion recovery MR image (TR/TE=5,200/42; TI=150 ms) display abnormal high signal intensity, in abscess (*arrow*) at right gluteus medius muscle. Diffuse edema infiltrates enlarged, inflamed musculature (*arrowheads*). **d** Coronal T1-weighted MR image (TR/TE=550/12) shows abscessed collection (*arrows*) in right gluteus medius muscle, containing hypointense fluid

pyomyositis can be difficult as altered echogenicity in the affected muscle(s) can be subtle [12].

On CT images, the infected muscle group appears enlarged and shows abnormal decreased attenuation [14–16]. CT can document the presence of an intramuscular accumulation of fluid or gas and is particularly useful in guiding therapeutic drainage procedures, especially when deep abscesses are detected [14, 17]. MRI has emerged as

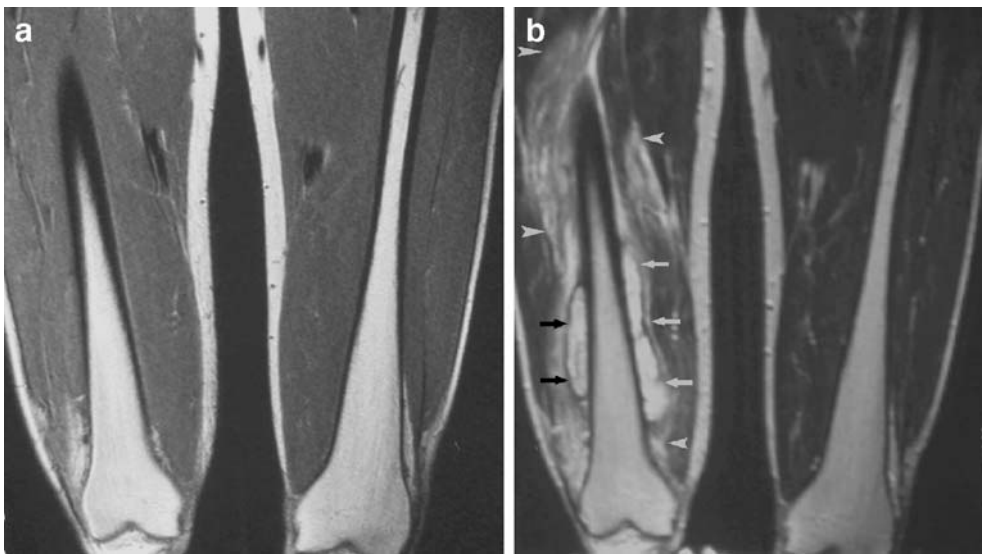

Fig. 4 *Staphylococcal pyomyositis* in a 26-year-old man who fell from a ladder 1 month before MR examination. The patient reported night sweats, fever, and progressive pain in right thigh. **a** Coronal T1-weighted MR image (TR/TE=652/15) displays no gross abnormality in right thigh and shows symmetric appearance of two femurs. No significant abnormal signal intensity is observed in muscle, fallaciously excluding presence of an abscess that is isointense to muscle. **b** Coronal fast spin-echo T2-weighted MR image (TR/TE=4,750/95) clearly reveals multiple, loculated high signal intensity abscesses involving right vastus intermedius and lateralis muscles (*arrows*). Extensive edema is evident along the infected muscles (*arrowheads*)

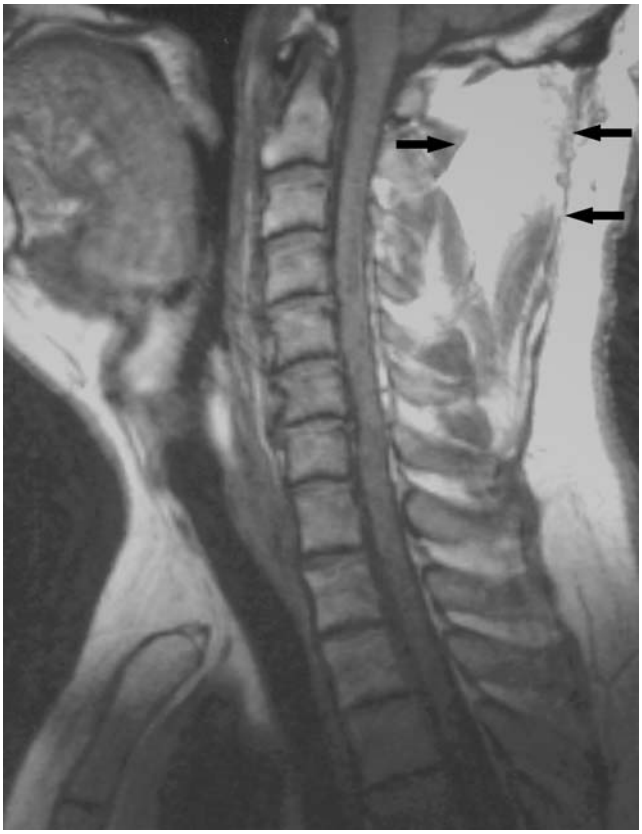

Fig. 5 Pyogenic myositis in a 54-year-old man with fever and cervical pain 2 weeks following an acute episode of neck trauma (courtesy of J. Edwards, Savannah, GA). Cultures of the abscess grew *Escherichia coli*. Sagittal T1-weighted MR image (TR/TE=450/12) of cervical spine shows large, triangular high signal intensity abscess (*arrows*) overlying spinous processes at the C1–C5 level

the imaging method of choice in assessing a large number of soft tissue abnormalities [4, 6, 7]. MRI generally is preferred over CT because it is highly sensitive, although not highly specific, for early detection of the infectious process (before the development of a frank abscess) and precise delineation of the inflamed muscle(s) [5, 10, 13–16, 18–21]. MRI can provide detailed information regarding the localization and regional extent of infection and the presence or absence of surgical lesions, such as abscesses [4, 22–24].

In this review, we present the MRI findings seen with both the early and late stages of pyogenic myositis at various sites in patients who had sustained local muscle trauma.

Pathophysiology of muscle infection

Although virtually every infectious agent has the potential to cause pyomyositis, little is known about the early pathophysiology or the pathogenetic mechanisms involved in the various forms of the disease. Skeletal muscle is resistant to bacterial infection [1, 5]. It is well documented that under normal circumstances, there is sequestration of iron, a nutritional requirement of proliferating bacteria, by myoglobin, which prevents establishment of infection. Once damaged, skeletal muscle is susceptible to hematogenous invasion by bacteria. Pyomyositis is regarded as a result of compromised muscle resistance to infection via transient bacteremia. Included among the multiple factors associated with muscle damage are trauma, bacterial, parasitic, viral and spirochetal infection, nutritional deficiencies, and underlying disease [3–5]. Indeed, local muscle trauma results in muscle infection in almost 40% of cases [3, 25]. Large muscle groups in the lower extremity, especially in the thigh and buttocks, are affected more frequently than muscles in the upper extremity or trunk [1, 5] (Fig. 1). Although involvement of a single muscle group is typical, in a large series of patients with

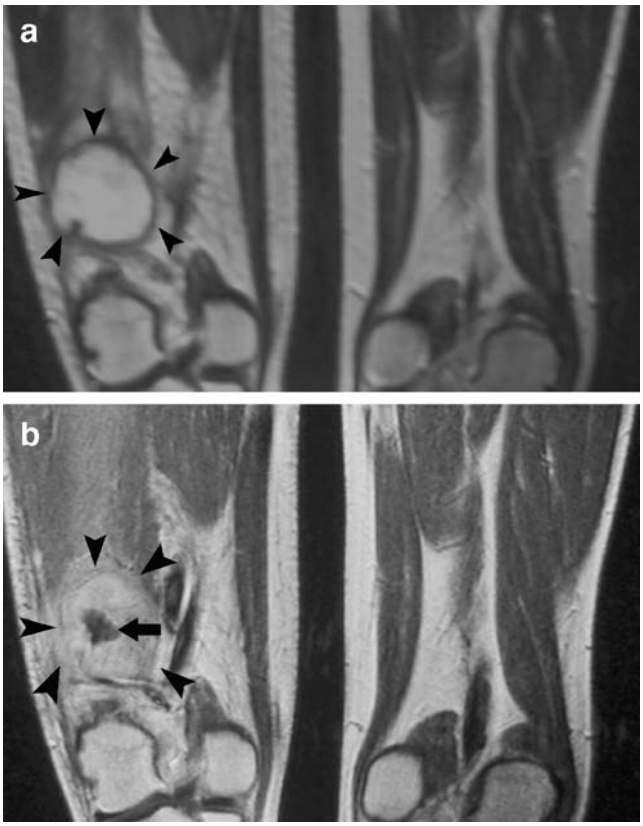

Fig. 6 Pyogenic myositis in a 36-year-old man with fever, and progressive pain and swelling in right knee that began after a jet-ski accident 2 weeks previously. *Streptococcus pyogenes* was recovered from the abscess. **a** Coronal T2-weighted MR image (TR/TE=4,000/90) shows focal, loculated high signal intensity fluid collection in distal third of the biceps femoris muscle. Note that the abscess is surrounded by hypointense rim (*arrowheads*). **b** Coronal T1-weighted MR image (TR/TE=700/12) after intravenous administration of gadolinium containing contrast material shows enhancement of signal intensity in the wall of abscess (*arrowheads*). Central necrotic material (*arrow*) of low signal intensity is seen within the abscess cavity

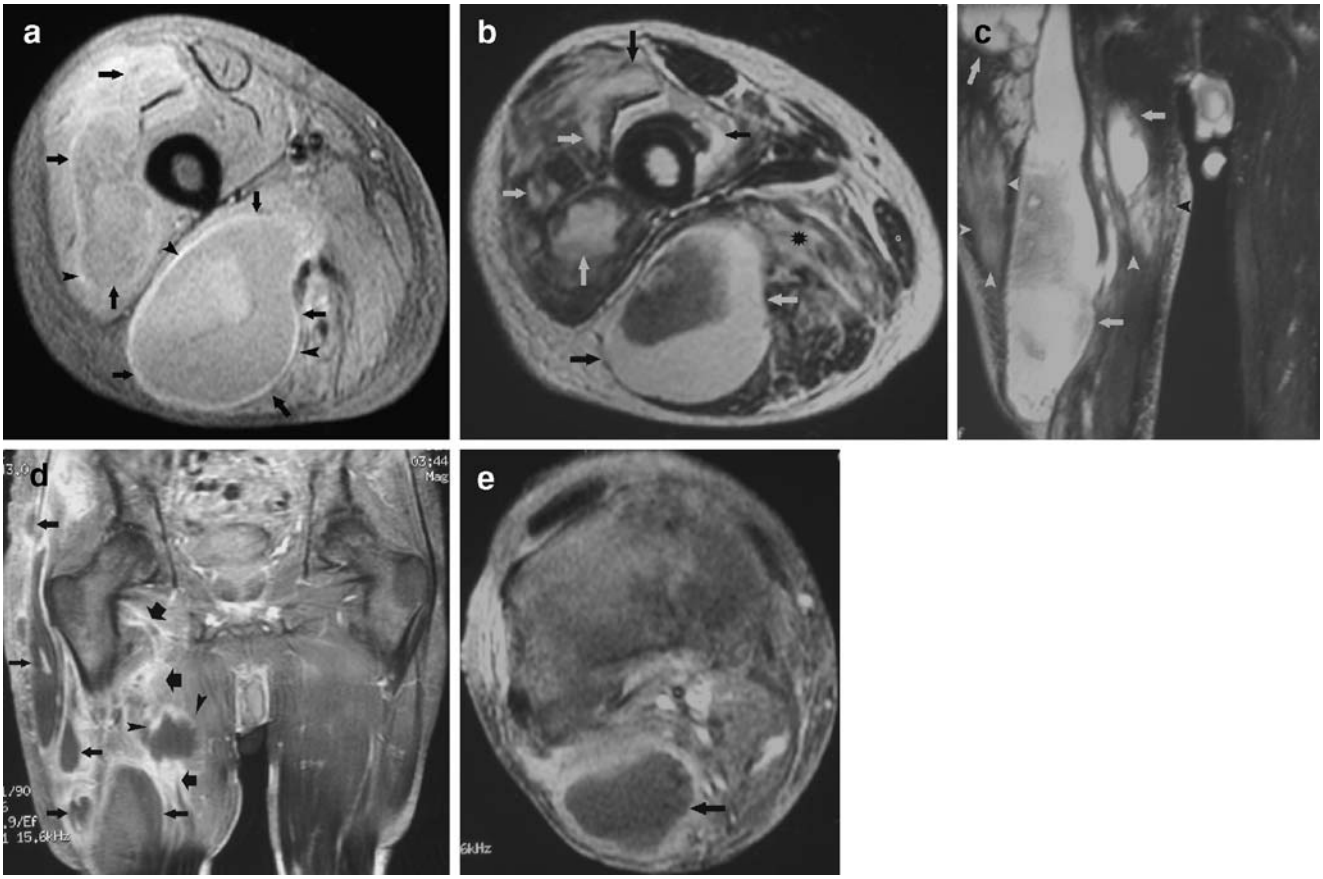

Fig. 7 *Staphylococcal pyomyositis* in a 55-year-old disabled man with history of multiple falls who presented with enlarged and painful right lower extremity. **a** Axial fat-suppressed T1-weighted MR image (TR/TE=666/14) shows large, lobulated fluid collections (*arrows*) of intermediate signal intensity in right vastus lateralis, vastus intermedius, biceps femoris, semitendinosus, and adductor magnus muscles. Abscesses are marginated by rim of high signal intensity (*arrowheads*). **b** Axial fast spin-echo T2-weighted MR image (TR/TE=4,250/109) delineates more extensive inflammatory abnormalities, with high signal intensity abscess collections in the deep muscles of right midthigh (*arrows*). Diffuse inflammatory changes deep to the gracilis muscle (*G*) are evident (*asterisk*). **c** Coronal fat-suppressed fast spin-echo T2-weighted MR image (TR/TE=4,150/58) reveals large abscesses (*arrows*) of abnormal high signal intensity that extend along the entire right thigh virtually replacing muscle mass. Widespread inflammation (*arrowheads*) is seen in surrounding musculature. **d** Coronal fat-suppressed T1-weighted MR image (TR/TE=566/14) obtained after gadolinium administration shows additional abscesses, in the enlarged right thigh and buttock (*arrows*). There is enhancement at margins of loculated fluid collections (*arrowheads*). Diffuse edema infiltrates muscles adjacent to abscesses (*thick arrows*). Note that the contralateral thigh has normal muscle bulk. **e** Axial fat-suppressed T1-weighted MR image (TR/TE=666/14) obtained after gadolinium administration reveals extension of infection to the knee, with large abscess involving the lateral head of right gastrocnemius muscle (*arrow*)

pyomyositis, multiple lesions were found in 43% of patients [26].

In patients with pyomyositis, versatility of predisposing factors or pathogenetic mechanisms has led clinicians to conclude that the etiology of muscle infection is likely multifactorial. Because different management approaches are applied to each stage of infection, early diagnosis is critical for optimizing clinical treatment of these patients. MRI is very sensitive for detecting inflammatory changes within muscle and provides useful information about the severity of infection [4, 13, 22]. In addition, the lack of ionizing radiation in MRI is particularly advantageous in the typically younger population evaluated for pyogenic myositis.

MRI technique

Infection affecting skeletal muscle can cause alteration in muscle size, shape, or signal intensity. The characteristic MRI findings of pyogenic myositis include muscle swelling and enlargement, with or without intramuscular abscesses [1, 2]. Several MRI protocols can be implemented for imaging inflammatory changes in muscle. At our institution, MRI is performed using a 1.5-T system (Signa, GE Healthcare). Coronal and axial T1-weighted spin echo sequences [TR/TE, 500–700/9–16] and T2-weighted fast spin-echo (4,000–5,800/58–110) with fat suppression are performed in each case. Imaging in the sagittal plane is often done. An alternative to the fat-

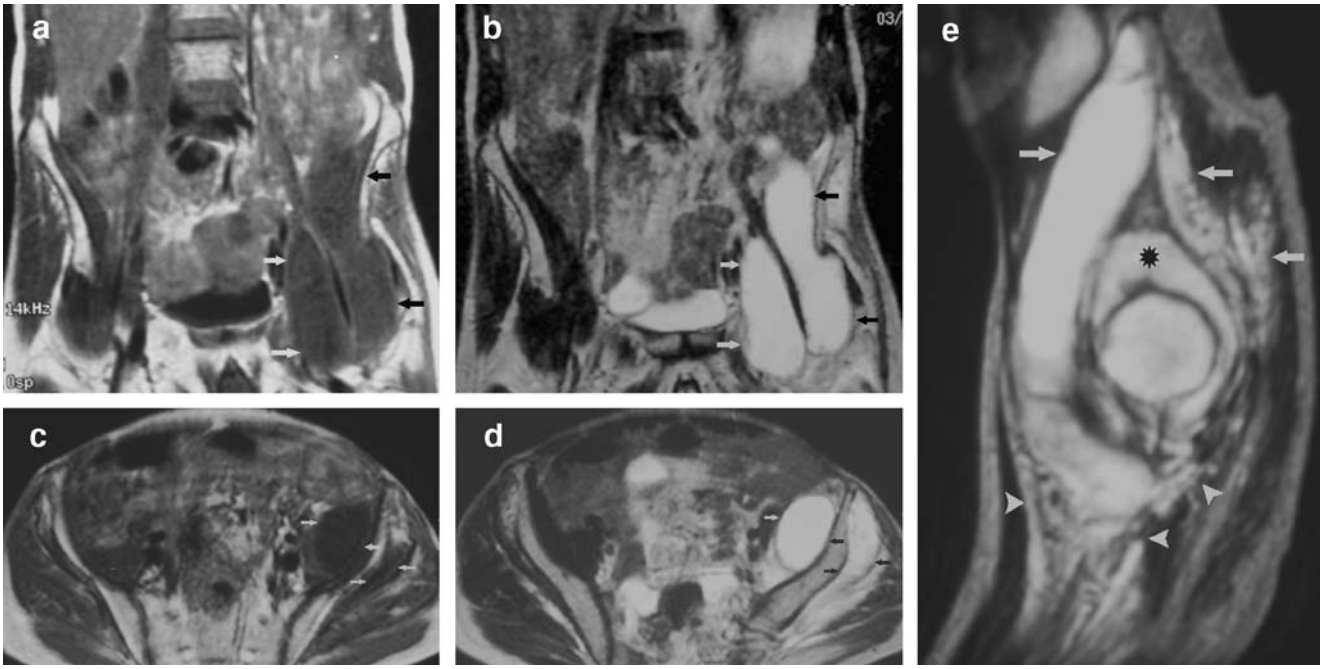

Fig. 8 *Staphylococcal pyomyositis* in a 59-year-old man with paralysis who sustained direct trauma to the lower extremity and presented with left hip pain, fever, and malaise (courtesy of D. Arteniann, Fresno, CA). **a** Coronal T1-weighted MR image (TR/TE= 500/16) shows large, elongated hypointense fluid collections in left iliopsoas muscle (*arrows*), extending from hemipelvis to hip. **b** Coronal fast spin-echo T2-weighted MR image (TR/TE=4,000/ 105) shows large, sausage-like high signal intensity abscesses in left iliopsoas muscle (*arrows*). **c** Axial T1-weighted MR image (TR/TE= 550/14) reveals hypointense fluid collections (*arrows*) in iliacus and gluteus minimus muscles adjacent to the wing of ilium on left side (*arrows*). **d** Axial fast spin-echo T2-weighted MR image (TR/TE= 5,800/110) shows abscesses of high signal intensity involving iliacus and gluteus minimus muscles adjacent to left iliac wing (*arrows*). **e** Sagittal fat-suppressed fast spin-echo T2-weighted MR image (TR/ TE=4,500/125) reveals extent of hyperintense abscesses (*arrows*) in left iliopsoas and gluteal muscles. Inflammatory changes in perisciatic muscles are seen (*arrowheads*). Note associated pyarthrosis (*asterisk*) and osteomyelitis of left hip

suppressed T2-weighted sequence is a STIR sequence. T1-weighted MR sequences after intravenous administration of gadolinium-based contrast material are useful in determining whether muscle is viable or necrotic [13]. In patients with diffuse pain and a suspected lesion, the use of a large field of view to include both sides of the body allows assessment of muscle symmetry and may prove helpful in the detection of subtle signal intensity changes.

Clinical and MRI features

Regardless of its etiology, pyogenic myositis comprises three clinical stages [3, 5]. The first, *invasive* stage occurs at the time the organism enters the muscle and is characterized by pain and swelling of the involved muscle group with minimal changes in the overlying skin and low-grade fever. The second, *suppurative* or *purulent* stage relates to the formation of deep collection of pus in the muscle and is characterized by intense pain, fever, and marked edema of affected muscle. The third, *late* stage is characterized by the presence of fluctuant abscess(es) with necrosis of the affected muscle (myonecrosis), pain, high fever, and septic shock. Patients rarely present in the early stage of infection, while most patients present at the purulent stage. Gradual resolution of symptoms and recovery is the rule when diagnosis is not delayed. In those cases with fluctuation and systemic manifestations, especially patients with AIDS, the infection may lead to fatal outcome [3].

In pyogenic myositis, a muscle is replaced by fluid and inflammatory cells [3]. Consequently, in the early stage of infection, the affected muscle is enlarged and shows preserved intermediate to slightly increased signal intensity compared with normal muscle on T1-weighted images and abnormal high signal intensity on T2-weighted and STIR images (Fig. 2). With progression of the inflammatory process, MR images reveal single or multiple intramuscular abscesses characterized by a peripheral rim of increased signal intensity, representing blood products on T1-weighted images and a central region, representing fluid, of intense signal on T2-weighted and STIR images (Fig. 3a–c). Pus within the abscess can be hypointense, isointense, or hyperintense on T1-weighted images depending on the proteinaceous content of the fluid collection (Figs. 3d, 4 and 5). The rim surrounding the abscess is

Fig. 9 Pyogenic myositis in a 5-year-old boy with fever and right hip pain after a bike accident one week previously. Group A β-hemolytic streptococcus was recovered from the abscess. **a** Coronal fast spin-echo inversion recovery MR image (TR/TE=4,000/30; TI=130 ms) shows focal abscess of high signal intensity in right gluteus medius muscle (*arrow*). Note that the entire gluteus medius muscle is of abnormal increased signal intensity owing to inflammatory process (*arrowheads*). **b** Coronal fat-suppressed T1-weighted MR image (TR/TE=700/14) obtained after gadolinium administration reveals contrast enhancement at the periphery of abscess (*arrow*). Ample enhancement of the entire gluteus medius muscle is seen (*arrowheads*). **c** Axial fat-suppressed T1-weighted MR image (TR/TE=500/16) obtained after gadolinium administration shows enhancement at margins of the loculated fluid collection (*arrows*) in gluteus medius muscle (*arrows*). Note diffuse enhancement of inflamed gluteus medius muscle (*arrowheads*)

hypointense on T2-weighted images and enhances after intravenous administration of gadolinium-based contrast material, whereas necrotic tissue and purulent material show no enhancement [1, 2, 4, 13, 22, 25] (Fig. 6). Abscesses are of variable size and extent, and typically form deep in the infected muscle (Figs. 7, 8 and 9). On rare occasions, an abscess may be mistaken for myonecrosis because both abnormalities are characterized by contrast enhancement at the periphery of lesion; abscess generally may be differentiated on T2-weighted images by a presence of central high signal intensity and a mass effect [2]. In patients with pyogenic myositis, subcutaneous edema and unorganized phlegmonous collections may be seen in soft tissue adjacent to areas of active muscle inflammation. Osteomyelitis and septic arthritis can be additional complications of spread of muscle infection to surrounding structures [1].

Treatment

Reducing morbidity and mortality rests on early diagnosis and prompt treatment. Management includes aggressive antibiotic treatment, needle aspiration and/or abscess drainage and surgical debridement [3]. Identification of the infectious microorganism in the pus, which may be sterile in 15–30% of cases, allows administration of the appropriate antimicrobial agent [10]. Penicillin is the drug of choice for infections caused by penicillin susceptible staphylococcus, while effective alternatives are also used for reasons related to breadth of spectrum. In addition to antistaphylococcal antibiotics, immunocompromised patients and patients with AIDS receive broad-spectrum antibiotics including aminoglycosides and clindamycin [10]. In each case, the duration of treatment is adjusted to the patient's clinical course.

Conclusion

Pyogenic myositis has been—and will remain—a serious infection of muscle, with corresponding MRI findings that range from muscle swelling, to intramuscular abscess (es), to muscle destruction and necrosis. As expected, early-stage muscle infection has a better prognosis than late-stage infection. Because patients with early stage pyogenic myositis present with nonspecific symptoms and signs, diagnosis is often delayed. MRI plays a pivotal role in timely diagnosis, precise localization, and definition of the extent of muscle infection. Recognition and accurate diagnosis of this life-threatening infection is critical for rapid initiation of treatment and resolution of symptoms.

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