Adult bacterial myositis: report of a single-center series of 26 cases

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ABSTRACT

Bacterial infections involving muscle are quite uncommon and generally require specific predisposing factors. Bacterial myositis is more rarely described in the typical kind of patients observed in Internal Medicine (presence of multiple co-morbidities, partial/limited immune-deficiency, advanced age). Twenty-six patients suffering from bacterial myositis (8 women and 18 men; mean age 58.5 years, range 27-82) observed in a single Internal Medicine Unit were reported. Muscles involved were ileopsoas, thigh, paravertebral, gluteus, calf, forearm and rectus abdomen. Simultaneous presence of arthritis was registered in 17 patients and all patients presented relevant comorbidity. Main cultured bacteria were *Staphylococcus aureus*, *Escherichia coli*, other Gram-negative bacteria, *Streptococcus spp*. Multi-drug-resistance was observed in 14 out 26 (53.8%). Computed tomography, ultrasound and magnetic resonance imaging were utilized for diagnostic purposes. Antibiotic treatment was administered to all patients. Surgical debridement and drainage were performed in 12 patients; 7 patients were treated with percutaneous aspiration and drainage. At discharge, relevant functional impairment was present in 17 patients (65.3%). Four patients died (in-hospital mortality 7.6%, global mortality at three months 15.3%). Management of bacterial myositis is difficult and its prognosis is poor. In the near future, this demanding infection will be more frequently observed in Internal Medicine setting as co-morbidity, which is very often the main characteristic of these patients.

Introduction

The different causes of myositis include infection, genetic disorders, drug adverse effects, electrolyte disturbances, autoimmune disorders and endocrine system diseases.[1,2] Infectious myositis may be due to a wide variety of pathogens, including bacteria, fungi, parasites, and viruses. Bacterial infections involving the muscle are relatively uncommon and they may result from contiguous sites of infection, penetrating trauma, vascular insufficiency, or by hematogenous dissemination. These infections are generally categorized according to the determinant event, anatomic location, and the causative organisms into the categories of pyomyositis, psoas abscess, *Staphylococcus aureus* myositis, group A-streptococcal necrotizing myositis, group B-streptococcal myositis, clostridial gas gangrene, and non-clostridial myositis.[3,4] Bearing in mind that the earliest cases were described in the tropics, bacterial myositis, and pyomyositis in particular, have been known as *tropical myositis*. Over the last few decades an increasing number of cases have been reported in the western world, especially in paediatric age. More recently, myositis has also been described in adults with immune deficiency including HIV-infected patients, cancer patients receiving chemotherapy and those taking immunomodulatory agents for rheumatologic disorders.[5,6] Furthermore, some cases have been associated with co-morbidities and without relevant immune-deficiency, a condition that typically represents patients observed in Internal Medicine wards. The true incidence of bacterial myositis and its main clinical features within these latter patients has hardly been investigated and only sporadic cases being described.[2]

We herein report the clinical, bacteriological, diagnostic and therapeutic features of 26 consecutive adult patients with bacterial myositis observed in our Internal Medicine Unit.

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Case Reports

From January 2008 to December 2014 (83 months) we observed 26 patients suffering from bacterial myositis; 8 women and 18 men; mean age was 58.5 years (range 27-82). According to the Crum-Cianflone criteria,[2] diagnosis relied on the compound of imaging (see below) and bacteriologic isolation and culture directly from the muscle and/or from blood culture. The data concerning these patients were prospectively collected in a specific report-schedule; all patients gave written informed consent for anonymous evaluation of their personal data. The main characteristics of these patients are shown in Table 1. Reasons for observation were the following: local pain (dorsal and lumbar column, thighs, coxo-femoral) in 19 patients (73%), walking impairment in 17 (65.4%) fever in 13 (50%), anemia in 12 (46.1%), multiple symptoms in 22 (84.6%). All patients had high serum level of muscle enzymes. The most frequent muscle involved was the ileopsoas (19 cases, 73%), both as the sole site of bacterial myositis (12 cases, 46.1%), and in association with other muscular localization (7 cases, 26.9%). Thigh muscles were involved in 10 patients (38.4%), 3 of them as a unique localization; paravertebral muscles were concerned in 3 patients, gluteus in 2 patients whereas calf, forearm and rectus abdomen muscles in 1 patient respectively. A simultaneous presence of arthritis was registered in 19 patients (73%). In particular, coxitis was observed in 9 of these patients (47.3%), vertebral spondylodiscitis

Table 1. Main characteristics of the patients.

Patient	Muscle	Bacterium	Co-morbidity	Arthritis
#1 - 27 years, F	Ileopsoas	*Staph a**°	SLE	Sacroileitis
#2 - 71 years, M	Ileopsoas bilateral	*Staph a**	Diabetes, CHD, renal failure	-
#3 - 38 years, M	Ileopsoas bilateral	*Strept A*-group	Liver disease, opiate addiction	Spondylodiscitis
#4 - 71 years, F	Ileopsoas bilateral+gluteus+thigh	*Escherichia coli*	Diabetes, CHD, CVD	Coxitis, sacroileitis
#5 - 70 years, F	Ileopsoas+thigh	*Acinetobacter*	Diabetes, AH	Spondylodiscitis
#6 - 70 years, M	Ileopsoas+rectus abdomen	*Staph a**°	CHD, AH, COPD	Spondylodiscitis
#7 - 41 years, M	Thigh	*Staph a**+*Escherichia coli*	Deep venous thrombosis, liver disease, opiate addiction	Coxitis
#8 - 45 years, F	Thigh	*Staph a**	Diabetes	-
#9 - 62 years, M	Ileopsoas+thigh	*Escherichia coli*+*Pseudomonas**	Diabetes	Coxitis
#10 - 71 years, F	Ileopsoas+thigh+gluteus+lions	*Escherichia coli**+*Fusobacter*	Diabetes, renal failure, arteriopathy	Coxitis
#11 - 58 years, F	Ileopsoas	*Staph a*	Renal failure, AH	Coxitis
#12 - 76 years, F	Ileopsoas	*Staph a**°	Pneumonitis, CVD, AH	Spondylodiscitis
#13 - 68 years, M	Para-vertebral	*Staph a*	COPD, CVD, HA	Spondylodiscitis
#14 - 28 years, M	Ileopsoas+para-vertebral	*Mycobacterium tubercolosis*	Pulmonary tubercolosis	Spondylodiscitis
#15 - 61 years, M	Ileopsoas	*Staph a**°	Colon cancer	-
#16 - 69 years, M	Ileopsoas	*Escherichia coli**	CHD	Spondylodiscitis
#17 - 66 years, M	Calf	*Strept anginosus**	Arteriopathy	-
#18 - 54 years, M	Para-vertebral	*Staph a**°	Vasculitis, renal failure	Spondylodiscitis
#19 - 55 years, M	Thigh	*Staph a*	Diabetes, arteriopathy	-
#20 - 32 years, M	Ileopsoas+ thigh	*Staph a*+*Strept viridans*	Cerebral cancer	Coxitis
#21 - 51 years, M	Ileopsoas	*Escherichia coli*+*Enterococcus f.*	Pyelonephritis	Coxitis
#22 - 79 years, F	Ileopsoas+thigh	*Staph a**	CHD, HA, COPD	Coxitis
#23 - 52 years, M	Ileopsoas	*Escherichia coli*+*Enterococcus f.*	Renal failure	-
#24 - 82 years, M	Ileopsoas	*Klebsiella*+*Acinetobacter*	CHD, CVD	-
#25 - 59 years, M	Ileopsoas	*Pseudomonas**	Colon cancer, CHD	-
#26 - 69 years, M	Forearm, gluteus, thigh	*Staph a*	-	-

Staph a, Staphylococcus aureus; SLE, systemic lupus erythematosus; CHD, coronary heart disease; *Strept, Streptococcus*; CVD, cerebrovascular disease; AH, arterial hypertension; COPD, chronic obstructive pulmonary disease. *Multi-drug resistant; °methicillin-resistant.

in 8 (42.1%), and sacroileitis in 2 (10.5%). None of these patients with arthritis presented any previous history of articular disease and negativity of principal serum tests for primary arthritis or collagen-vascular disease (rheumatoid factor, anti-citrullinated peptides, anti-nuclear antibodies, anti-neutrophil-cytoplasmic antibodies, HLA-B27). All the patients presented relevant comorbidity diagnosed according to the usual validated criteria; 16 out of 26 (61.5%) with at least two important co-diseases.

Microbiological features

The bacteria involved in this series are listed in Table 1. Infectious agents were isolated from the specimens obtained by using computed tomography (CT) (9 cases) or ultrasonography (US) (5 cases)-guided percutaneous aspiration (Figure 1) and surgery (9 cases, 6 without any previous isolation from percutaneous procedures). Bacterial growth was registered in repeated blood cultures for the remaining 6 patients in whom needle aspiration was not practicable because of difficult access and unperformed surgery.

A single bacterial strain was isolated in 19 patients (73%) and two strains in the remaining 7 patients (26.9%). *S. aureus* was cultured in 14 cases (53.8%), *Escherichia coli* in 7 cases, (26.9%), other Gram-negative bacteria in 8 cases, (30.7%), *Streptococcus* in 2 cases (7.7%). One patient with pulmonary tuberculosis presented ileopsoas and paravertebral myositis associated with spondylodiscitis due to Koch's *bacillus*.

Multi-drug-resistant bacteria resulted to be 14 out of 26 (53.8%); 64.3% *S. aureus* (9 strains), 28.5% *Escherichia coli* (2 strains). The two isolated strains of *Pseudomonas aureuginosa* and the unique strain of *Streptococcus anginosus* also presented multi-drug-resistance. Five strains of cultured *S. aureus* presented methicillin resistance (MRSA) (35.7%; four isolations from CT-guided percutaneous aspiration and one from surgical specimen).

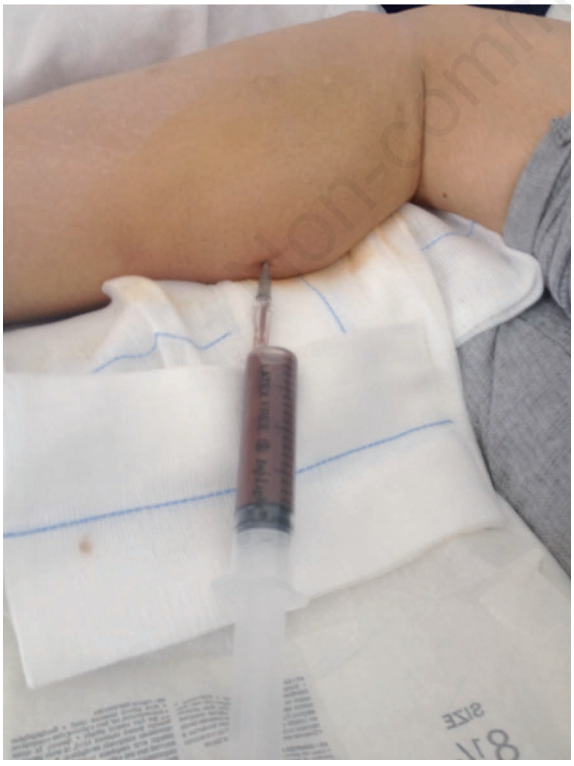

Figure 1. Percutaneous aspiration-drainage of an infected collection from calf muscles (patient #17, Tables 1 and 2).

Radiological features

Diagnostic imaging exams are listed in Table 2. A large proportion of patients underwent magnetic resonance imaging (MRI) (22 patients, 84.6%); in the remaining 4 patients MRI was not possible for technical reasons (metallic devices in 2, severe claustrophobia in 2).

MRI imaging was performed on a 1.5-T unit (Signa; General Electric Medical Systems, Milwaukee, WI, USA). Pulse sequences included axial T1-weighted (TR/TE, 500/10; both early and late after contrast administration), axial short-time-inversion-recovery (STIR) (3500/48; inversion time, 150 ms) and axial T2-weighted (4000/60), coronal T2-weighted (5000/500) and T1-weighted (500/12) sequences before and after the intravenous (i.v.) gadolinium administration. Studies after contrast enhancement were fat suppressed, with early images being acquired immediately and late images being obtained after a 15-min delay (Figures 2 and 3).

CT-scan examination was performed in 16 patients (61.5%). Images were obtained using a 16 MDCT scanner (Brightspeed; General Electric Medical Systems). The patients were scanned from the symphysis pubis to the apices of the lungs before and after i.v. injection of 100 mL of iopromide in 5 cases and from the knee to the upper abdomen in additional 5 cases. Slices with 5-mm-thickness image reconstruction were obtained (Figure 4).

US was performed in 13 patients (53.8%); linear probes, 5-10 MHz, were utilized.

Treatment

Antibiotic treatment with various antimicrobial agents was utilized in all patients (Table 2). For all patients treatment is started only after the cultural exams; empiric treatment was then guided by bacterial *in vitro* susceptibility. No measurement of antibiotic concentration in serum was available in our Institution and, consequently, optimal dosing of each drug was established as follows: antibiotic dosing was set at the maximum dosage indicated for serious infections but, to

avoid overdosing, any physiological changes in patients that might alter antibiotic dosing was carefully considered.[7] Such changes include altered fluid status, changes in serum albumin concentrations, renal and hepatic function.[8]

Surgical debridement and drainage were performed in 12 patients (46.1%): in 9 patients as first choice due to the size of collections and in 3 patients after unsuccessful percutaneous attempts. In addition, other 7 patients (26.9%) were treated with CT or US-guided aspiration and drainage. Thus, 19 patients in total (73%) required an invasive approach. Percutaneous procedures were performed within 2-3 days from the morphological diagnosis whereas surgery was planned after at least one week (mean 9.45 days; range 7-21 days). The remaining 7 patients (26.9%) were conservatively treated as the collections and infection foci show a rapid decrease in size and are certainly not approachable using percutaneous procedures. Both in these latter patients and in those invasively treated, antibiotic treatment continued also after discharge shifting to oral agents whenever possible. After discharge, the patients continued to assume antibiotic treatment for quite a long period (mean 45 days, range 21 to 75 days). A shift to oral anti-bacterial agents (antibiotics with excellent oral bioavailability) such as linezolid, levofloxacin, ciprofloxacin, trimethoprim-sulfamethoxazole and rifampicin was pursued at hospital discharge and therapeutic adherence was verified at planned controls

Table 2. Diagnostic exams, treatment and outcome of patients.

Patient	Imaging	Intervention	Antibiotics	Outcome
#1	CT, MRI	CT-guided percutaneous aspiration	VANC	Functional impairment
#2	US, MRI, CT	None	LNZ	Recovery
#3	CT	Surgery	MRP + TZB	Functional impairment
#4	US, MRI	US-guided percutaneous aspiration	GENT + CYP	Functional impairment
#5	MRI, CT	CT-guided percutaneous aspiration and then surgery	COL + TYG	Functional impairment
#6	US, CT, MRI	CT-guided percutaneous aspiration and then surgery	LNZ	Recovery
#7	US, MRI	Surgery	DPM + GENT	Functional impairment
#8	US, MRI	US-guided percutaneous aspiration	VANC	Recovery
#9	US, CT, MRI	CT-guided percutaneous aspiration	COL + AMY	Functional impairment
#10	US, MRI	Surgery	TZB + AMY	Functional impairment
#11	CT	CT-guided percutaneous aspiration	AMP + SBT	Functional impairment
#12	MRI	CT-guided percutaneous aspiration	LNZ	Functional impairment; death 2 months after discharge
#13	CT, MRI	None	OXA	Functional impairment
#14	US, CT, MRI	CT-guided percutaneous aspiration and then surgery	RFM + SM	Recovery
#15	MRI	Surgery	DPM	Functional impairment; death 3 months after discharge
#16	CT	None	MRP	Recovery
#17	US, MRI	US-guided percutaneous aspiration	TZB + GENT	Recovery
#18	CT, MRI	CT-guided percutaneous aspiration	LZD	In-hospital death
#19	US, CT	Surgery	OXA	Recovery
#20	US, CT, MRI	None	MRP followed by LNZ	Functional impairment
#21	MRI	None	TZB + GENT	Recovery
#22	CT, MRI	CT-guided percutaneous aspiration	TYG	Functional impairment
#23	MRI	None	DAPT + GENT	Recovery
#24	CT, MRI	Surgery	TZB + MRP	In-hospital death
#25	US, CT, MRI	US-guided percutaneous aspiration	COL + AMY	Functional impairment
#26	US, MRI	US-guided percutaneous aspiration	VANC	Functional impairment

CT, computed tomography; MRI, magnetic resonance imaging; VANC, vancomycin; US, ultrasonography; LNZ, linezolid; MRP, meropenem; TZB, tazobactam; GENT, gentamycin; CYP, ciprofloxacin; COL, colystine; TYG, tygeciclin; DPM, daptomycin; AMY, amykacin; AMP, ampicillin; SBT, sulbactam; OXA, oxacyllin; RFM, rifampycin; SM, streptomycin.

(weekly for the first month and monthly thereafter). Criteria for discontinuation of antimicrobial treatment include symptom resolution or improvement and the normalization of erythrocyte sedimentation rate or C-reactive protein. The patient who assumed antibiotic for the longest period (75 days) presented a mycobacterium tuberculosis spondylodiscitis with involvement of ileopsoas and para-vertebral muscles.

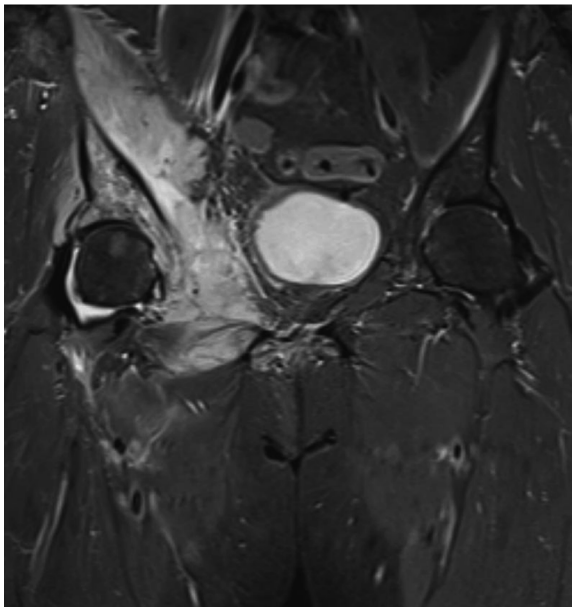

Figure 2. Pyomyositis of left thigh at its purulent stage (multiple abscesses formation) with septic arthritis; magnetic resonance imaging coronal short-time-inversion-recovery image showed multiple abscesses from left buttock and also in left upper thigh; septic arthritis of left coxofemoral joint with loss of joint spaces, erosions, bone marrow edema of femoral head.

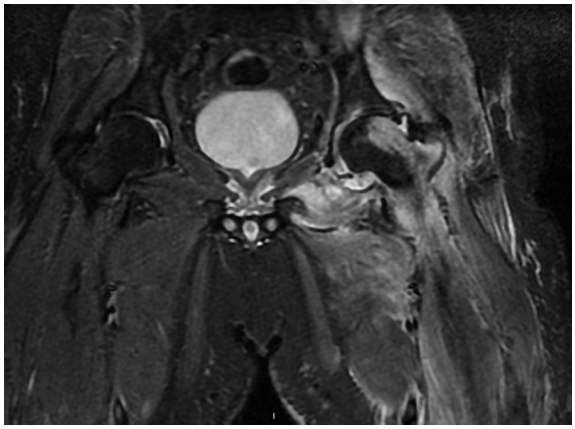

Figure 3. Pyomyositis of right buttock and pelvis; magnetic resonance imaging coronal short-time-inversion-recovery image showed multiple abscesses in the right ileopsoas muscle, in the right *obturator externus* muscle, in the right *pectineus* muscle and bone marrow edema in the right ilium bone.

Outcome

Relevant functional impairment defined by the inability to maintain an erect posture and/or regular gait at discharge was observed in 15 patients (57.7%). Almost all these patients (12 out of 15) presented a contemporary loco-regional articular involvement. On the other hand, only 4 out of 9 patients without residual functional impairment showed simultaneous articular damage (Chi-square 1.800, P=0.18, not significant). Four patients died (in-hospital mortality 7.7%, global mortality at three months 15.3%). Two patients died during hospitalization because of multi-organ failure; two patients (one with cancer of the colon, one with severe cardiovascular disease) after two and three months from discharge, respectively.

Discussion

Bacterial myositis is a complex infectious process and its pathogenesis is not fully understood, as skeletal musculature is somewhat resistant to infection. In addition, transient or persistent bacteremia not frequently colonizes large skeletal muscles and, interestingly, myositis is rarely associated with other metastatic infections or endocarditis despite the occurrence of bacteremia.[2,9] Pyomyositis, more frequent in tropical regions, is defined by an acute bacterial infection typically associated with abscess formation.[10] Predisposing factors are muscular trauma, surgery, ischemia, presence of a foreign body, intensive exercise, dia-

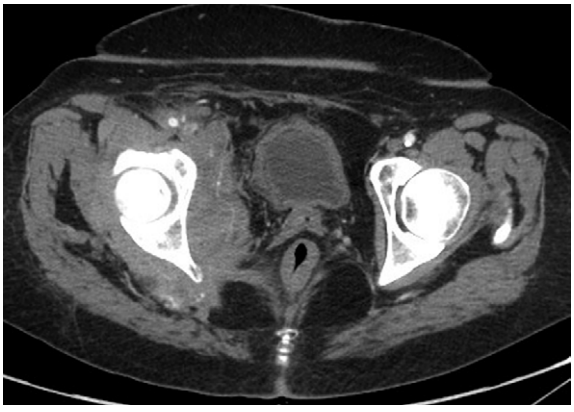

Figure 4. Pyomyositis of right pelvis; axial computed tomographic scan after intra-venous contrast injection shows thickening of right *obturator internus* muscle with irregular contrast enhancement.

betes mellitus, malignancies under chemotherapy, malnutrition, HIV infection and long-term steroid treatment. As concerns infection induced by *S. aureus*, it has been suggested that Panton-Valentine leukocidin (PVL), a toxin that induces cytolysis of human phagocytes, could play a major role in pathogenesis. PVL has been reported to be associated with more-severe cases of myositis,[11] and recently, PVL has been shown to contribute to more-severe muscle injury in mice.[12,13]

S. aureus resulted being the most frequent etiological agent in our series. The virulence of the isolated strains is in line with surveys reported in Europe over the last five years.[14-16] The percentage of *S. aureus* isolates reported as MRSA is currently stabilizing or decreasing in most European Countries; in Italy it is within the range of 25-50% (35.7% in our series). Burdette and co-workers[17] recently reported a series of patients with *S. aureus* (29 cases) and non-*S. aureus* (31 cases) pyomyositis; the authors found that the former patients in comparison with the latter (non-*Staphylococcus* infections) were significantly younger, more often presents a previous traumatic event and less often a localized muscular swelling. Only two patients in our series, both with an infection of the thigh muscles, presented a previous local trauma. Otherwise, the finding of a recent (within three months) abdominal surgery was found in additional three patients. Interestingly, low incidence of previous muscle trauma (0 to 23%) had already been reported in other series of bacterial myositis.[18,19] In this regard, an important clinical consideration is that all patients in our series presented relevant comorbidity and more than half of them suffered from at least two important extra-muscular diseases. Definite immunodeficiency status was registered in three patients; on the other hand, many of the observed chronic co-morbidities may rather be associated with various degrees of immunodeficiency. Our findings are in line with literature data suggesting a strong correlation between infectious myositis and underlying medical conditions.[3,17,20,21] This was verified for all bacterial responsible strains even if a distinction must be made as concerns *E. coli* myositis. In fact, of 18 cases reported in literature up till December 2014[6,22-24] almost all patients (94%) were severely immune-compromised for malignancy (mainly hematologic) or HIV-AIDS. In our series (7 patients), no major disease able to induce severe immune response derangement was registered.

Diagnosis of bacterial myositis is mainly based upon clinical and radiological criteria. From a clinical standpoint, the occurrence of multiple signs such as local pain, functional impairment, fever and anemia in patients with the typical co-morbidities usually observed in Internal Medicine wards should lead to a diagnostic suspicion. Three clinical stages have been described in pyomyositis: invasive, suppurative and toxic stages.[1,2,4] During the first one, the infected muscle becomes inflamed and painful and physical examinations will reveal a *woody* muscle texture with no fluctuation, palpable abscess or surrounding erythema. The second stage presents the formation and growth of a muscle abscess with more severe pain, greater swelling and fever; the majority of patients are diagnosed at this stage, which lasts 1-3 weeks. The third stage is characterized by systemic toxicity and septicemia, multifocal abscess formation and possible shock.

Once the clinical suspicion is advanced, the diagnostic mainstay remains linked to the imaging techniques. US can be useful and it is commonly utilized as first line examination; affected muscles are sometimes identified showing an abnormal echotexture with hypoechoic focal lesion with a bulky muscle mass. In clinical practice, integration with other imaging techniques is necessary in almost all cases regardless of whether US is inconclusive or not. CT is also useful for the diagnosis of muscular and osteoarticular involvement, particularly if intravenous contrast is used.[9,25] Typically, the walls of abscesses enhance and can show variable thickness. Thick, shaggy, irregular walls are commonly encountered and septations may also enhance and be readily visualized. MRI is preferable to CT as it is able to identify soft tissue abnormalities and still remains the diagnostic gold standard for a number of reasons. MRI is particularly valuable in delineating the extent of the muscle involvement in all patients, as the high signal intensity of the pathological process (prolonged T2) can be easily distinguished from the relatively low signal intensity of normal muscle (shortened T2). The ability of MRI to obtain multiplanar contiguous sections provides excellent anatomical detail of each muscle group and pinpoints the site of disease.[26,27] 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. With the progression of the inflammatory process, MRI images reveal single or multiple intra-muscular abscesses characterized by a peripheral rim of increased signal intensity (blood products on T1-weighted images) and a central region, representing fluid, of intense signal on T2-weighted and STIR images.[28] Pus within the abscess can be hypo-intense, iso-intense, or hyper-intense on T1-weighted images depending on the proteinaceous content of the fluid collection. The rim surrounding the abscess is hypo-intense on T2-weighted images and enhances after intravenous administration of gadolinium-based contrast material, whereas necrotic tissue and purulent material show no enhancement.[28,29] Abscesses are of variable size and extent, and typically form deep within the infected muscle. On rare occa-

sions, an abscess may be mistaken for myonecrosis because both abnormalities are characterized by contrast enhancement at the periphery of lesion; generally speaking, abscess may be differentiated on T2-weighted images by the presence of central high signal intensity and a mass effect. In patients with pyogenic myositis, subcutaneous edema and unorganized phlegmonous collections may be seen in soft tissue adjacent to areas of active muscle inflammation. Co-existing osteomyelitis and septic arthritis are also well studied by MRI; in addition, this technique represents the gold-standard for the follow up.[2,30,31]

In the present series, US and CT were utilized not only for diagnostic morphologic purposes but also for percutaneous intervention aimed at identifying the responsible pathogen(s) –53.8% of cases, and at achieving aspiration and drainage of lesions (38.4%). We should not be afraid of guided percutaneous aspiration procedures as identification and *in vitro* antibiotic susceptibility of the implicated pathogens is crucial to warrant the best therapeutic success rate bearing in mind that reduced vascular permeability at the site of infection or the presence of a walled-off abscess may lead to a sub-optimal activity of antibiotics. Patients with deep-seated infections should receive without delay any required drainage (surgical or percutaneous); conservative treatment should be reserved for the small percentage of patients (26.9% in our experience) showing a rapid attenuation of symptoms and decrease in size of lesions.

Conclusions

In conclusion, the severity of bacterial myositis with inherent potential for bacteremia and systemic toxicity requires an early definitive diagnosis and treatment. Despite the availability of a wide range of antibiotics, these infections may nonetheless prove difficult to treat. This reflects not only the presence of bacteria resistant to one or more first-line drugs, but the problems also stem from the patient, who may be prone to persistent infection due to factors such as immunosuppression or multiple co-morbidity as observed in the present series. As a rule, treatment requires a multidisciplinary approach, including internists, microbiologists, radiologists, and surgeons.

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