Imaging of Salmonella Spondylodiscitis

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Contents

1 Introduction 200
2 Epidemiology 200
3 Pathophysiology 201
4 Sites of Infection 201
5 Clinical Presentation 202
6 Imaging 203
7 Diagnosis 206
8 Treatment and Outcome 207
9 Conclusion 207
References 208

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Abstract

Salmonella osteomyelitis is uncommon and generally associated with sickle cell disease. Vertebral location is extremely rare and has mainly been reported in case reports. Magnetic resonance imaging (MRI) is the modality of choice for assessing discovertebral and soft tissue abnormalities. Imaging features are similar to other spondylodiscitis. Bacteria isolation is necessary for definitive diagnosis and antibiotic susceptibility testing, allowing adequate medical treatment.

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Abbreviations

CT Computed tomography
MRI Magnetic resonance imaging

1 Introduction

Salmonella osteomyelitis is a rare condition that generally occurs in immunocompromised patients and mainly affects those with sickle cell disease (Mavrogenis et al. 2017). Vertebral location is extremely rare and has mainly been reported in case reports (Santos and Sapico 1998). In patients with sickle cell disease, differentiating between vaso-occlusive crisis and early osteomyelitis is a diagnostic challenge. Magnetic resonance imaging (MRI) is the modality of choice for spondylodiscitis assessment showing vertebral and disk signal abnormalities at an early stage (Sans et al. 2012). Definitive diagnosis is based on pathogen isolation (Santos and Sapico 1998).

2 Epidemiology

Salmonella is known to cause a broad spectrum of human illnesses and involves strains belonging essentially to *Salmonella enterica* subsp. *enterica*. These strains can be divided into typhoidal (serovars *typhi* and *paratyphi*) and non-typhoidal strains. Typhoidal strains cause typhoid in areas with unsafe water and poor sanitation. Non-typhoidal strains most commonly cause gastroenteritis transmitted through the consumption of contaminated food of animal origin and are the leading causes of bloodstream infection in low-resource settings (Stephanie and Schmalzle 2019). The incidence of *S. typhi* and *S. paratyphi* varies among countries. It is high (greater than 100 cases per 100,000 per year) in South-Central Asia and Southeast Asia; medium (10–100 cases per 100,000 per year) in Africa, Latin America, the Caribbean, the rest of Asia and Oceania; and low (less than 10 cases per 100,000 per year) in Europe, Australia, New Zealand and North America (Sánchez-Vargas et al. 2011).

Osteomyelitis is a rare extra-intestinal manifestation of Salmonella infection, due essentially to *Salmonella typhimurium* and *Salmonella enteritidis* and rarely to *Salmonella typhi*. It accounts for 1–4% of all bone infections (Kumar et al. 2008) and represents less than 1% of total Salmonella infection cases (Weston and Moran 2015). In a review of 7779 cases of Salmonella infection, only 59 patients (0.76%) had osteomyelitis (Saphra and Winter 1957). It is predominantly seen in patients with hemoglobinopathies such as sickle cell disease or thalassemia, presenting as a significant cause of morbidity and mortality in this population, and it is mainly located in long bones (Chambers et al. 2000; McAnearney 2015). Indeed, Salmonella is the main etiologic agent of osteomyelitis in patients with sickle cell disease (Burnett et al. 1998), with rates differing by region (Stephanie and Schmalzle 2019). However, it is a rare cause of osteomyelitis in patients with no sickle cell disease, accounting for approximately 0.5% of all cases (Khoo et al. 2016). Other risk factors are diabetes mellitus, a history of intravenous drug abuse, pulmonary diseases, hemodialysis, human immunodeficiency virus, chronic immunocompromised states like systemic lupus erythematous, collagen diseases, liver cirrhosis, lymphoma, steroid treatment, atherosclerosis, achlorhydria (Khoo et al. 2016), and biliary and urinary tract abnormalities and co-infections (Stephanie and Schmalzle 2019).

Vertebral location of salmonella infection is extremely rare, representing approximately one quarter of salmonella osteomyelitis cases (Santos and Sapico 1998). Its occurrence seems to be increasing in recent years, attributed probably to the aging population and the increasing number of immunocompromised individuals. The lumbar spine is the most common site of involvement (Cheng et al. 2018). The largest review of salmonella spondylodiscitis reported in the English literature, published by Santos and Sapico (1998), includes 46 reported cases. The majority of the other published articles are case reports. Forty-six of these articles were reviewed which included 104 patients (Miller 1954; Greenspan and Feinberg 1957; Weiss and

Table 1 Patients' characteristics in 104 cases of salmonella spondylodiscitis

Feature	Value or percentage
Age	
Range	1–79 years
Mean	42 years
Gender	
Male	64%
Female	46%
Predisposing factors	
Sickle cell disease	9%
Others	42%
Level of infection	
Lumbar	56%
Thoracic	24%
Cervical	2%

Katz 1970; Bussiere et al. 1979; Carvell and Maclarnon 1981; Gardner 1985; O'Keeffe 1991; Tsui et al. 1997; Santos and Sapico 1998; Skoutelis et al. 2001; Akiba et al. 2001; Chen et al. 2001; Gupta et al. 2004; Rajesh et al. 2004; Barkai et al. 2005; Devrim et al. 2005; Laloum et al. 2005; Altay et al. 2006; Liu et al. 2006; Ozturk et al. 2006; Khan and El-Hiday 2007; Abdullah et al. 2008; Chen et al. 2008; Kumar et al. 2008; Osebold 2008; Zheng et al. 2009; Rostom et al. 2009; Learch et al. 2009; Suwanpimolkul et al. 2010; Amritanand et al. 2010; Choi et al. 2010; Berngard and Miller 2013; Feng et al. 2014; Shrestha et al. 2015; McAnearney 2015; Effendi et al. 2016; Fukuda et al. 2016; Khoo et al. 2016; Oki et al. 2016; Fareed et al. 2017; Banerjee et al. 2018; Cheng et al. 2018; Dahlberg et al. 2018; Myojin et al. 2018; Popa et al. 2019). Their main characteristics are summarized in Table 1. Among those 104 patients, 64% were male and had a mean age of 42 years (range 1–79 years). Sickle cell disease was reported in 9% of cases and other predisposing factors in 42% of cases. By excluding the cases reported by Santos and Sapico (1998) who found 54% had predisposing factors, the percentage drops to 33%. This difference could be explained by the fact that atherosclerosis, the main predisposing factor in the study of Santos and Sapico, was not specified in other reported cases.

3 Pathophysiology

Vertebral osteomyelitis due to Salmonella occurs by the hematogeneous route. Contiguous spread from adjacent infected tissues is rare. Contamination after invasive diagnostic or therapeutic procedures is also possible (Cheng et al. 2018). Since clinical imaging nearly always reveals disease involving two adjacent vertebrae and subsequently the adjacent intervertebral disk, an arterial route is the probable source as the segmental arteries supplying the vertebrae bifurcate to supply both adjacent vertebral segments. In some patients, inflammation of the disk occurs before vertebral infection (Berngard and Miller 2013). In children, since there are persisting vascular channels in the disk, infective discitis may occur after bacteremia (Cheng et al. 2018).

The exact pathogenesis is not well established, although, theoretically, bowel micro-infarcts causing hematogeneous spread of Salmonella are likely to be the cause. Cases due to direct contiguous spread from an adjacent infected aortic aneurysm have also been reported (Effendi et al. 2016). Indeed, Salmonella is one of the major causes of mycotic aneurysm of the aorta (Chen et al. 2008). In sickle cell disease, Salmonella osteomyelitis seems to be due to a combination of factors. Sickling events may lead to infarct of both gut and bone, creating a permissive environment for both bacterial entry from the gut to the bloodstream and seeding of damaged bone by blood-borne bacteria.

4 Sites of Infection

The lumbar spine is the most frequent site of Salmonella spondylitis accounting for approximately 56% of infections, followed by thoracic spine with 24%. The cervical spine, along with cervicothoracic and thoracolumbar levels, is less frequently involved. Some authors have reported multifocal osteomyelitis (Rostom et al. 2009; Zheng et al. 2009). Involvement of multiple sites is usually reported in immunocompromised patients (Shrestha et al. 2015). Table 1 summarizes the different sites of infection of 104 cases of Salmonella spondylodiscitis (Miller 1954; Greenspan and Feinberg 1957; Weiss and Katz 1970; Bussiere et al. 1979; Carvell and Maclarnon 1981; Gardner 1985; O'Keeffe 1991; Tsui et al. 1997; Santos and Sapico 1998; Akiba et al. 2001; Skoutelis et al. 2001; Chen et al. 2001; Gupta et al. 2004; Rajesh et al. 2004; Devrim et al. 2005; Laloum et al. 2005; Barkai et al. 2005; Liu et al. 2006; Altay et al. 2006; Ozturk et al. 2006; Khan and El-Hiday 2007; Abdullah et al. 2008; Chen et al. 2008; Kumar et al. 2008; Osebold 2008; Learch et al. 2009; Rostom et al. 2009; Zheng et al. 2009; Choi et al. 2010; Amritanand et al. 2010; Suwanpimolkul et al. 2010; Berngard and Miller 2013; Feng et al. 2014; McAnearney 2015; Shrestha et al. 2015; Effendi et al. 2016; Fukuda et al. 2016; Khoo et al. 2016; Oki et al. 2016; Fareed et al. 2017; Cheng et al. 2018; Dahlberg et al. 2018; Myojin et al. 2018; Banerjee et al. 2018; Popa et al. 2019).

5 Clinical Presentation

Clinical presentation can be acute, subacute, or chronic. The duration of symptoms before diagnosis can vary from a few days to several years (Santos and Sapico 1998). Back pain is the most common symptom, reported in more than 90% of cases. It can be a lower back pain, thoracic pain, and/or cervical pain, depending on the site of the infection. This symptom can be isolated (Banerjee et al. 2018). Fever is the second most frequent sign, reported in 65% of cases. It can precede back pain, occur at the same time, or appear during evolution (Feng et al. 2014; Cheng et al. 2018; Myojin et al. 2018). Neurological signs, present in 27% of cases, constitute an emergency and reflect spinal cord or nerve root compression mainly by an epidural spread of infection. They include numbness, weakness or paralysis of the limbs, cauda equina syndrome, and hyperreflexia (Berngard and Miller 2013; Fareed et al. 2017; Popa et al. 2019).

Gastrointestinal symptoms at the moment of presentation are found in 25% of cases, consisting mainly of abdominal pain and diarrhea (Kumar et al. 2008; Fareed et al. 2017). A preexisting history of typhoid fever with abdominal pain, diarrhea and fever occurring weeks or months before spondylodiscitis is sometimes reported by patients and should raise suspicion of Salmonella spondylodiscitis, particularly if the patients are residing in or have travelled to an endemic area (Rajesh et al. 2004; Altay et al. 2006; Shrestha et al. 2015; Popa et al. 2019). Indeed, chronic carriage of Salmonella (persistence in stool or urine for periods greater than 1 year) has been reported in 1–4% of patients with untreated enteric fever (Stephanie and Schmalzle 2019).

Other signs, such as night sweats, weight loss, or fatigue, have also been reported (Gupta et al. 2004; Abdullah et al. 2008).

Table 2 summarizes the clinical findings in 55 patients with Salmonella spondylodiscitis (Miller 1954; Greenspan and Feinberg 1957; Weiss and Katz 1970; Bussiere et al. 1979; Carvell and Maclarnon 1981; Gardner 1985; O'Keeffe 1991; Tsui et al. 1997; Santos and Sapico 1998; Akiba et al. 2001; Skoutelis et al. 2001; Chen et al. 2001; Gupta et al. 2004; Rajesh et al. 2004; Devrim et al. 2005; Laloum et al. 2005; Barkai et al. 2005; Liu et al. 2006; Altay et al. 2006; Ozturk et al. 2006; Khan and El-Hiday 2007; Abdullah et al. 2008; Chen et al. 2008; Kumar et al. 2008; Osebold 2008; Learch et al. 2009; Rostom et al. 2009; Zheng et al. 2009;

Table 2 Review of clinical features in 55 patients with Salmonella spondylodiscitis

Feature	Value or percentage
Symptoms	
Back/neck pain	94%
Fever	65%
Neurological signs	27%
Gastrointestinal symptoms	25%
Others	31%
Duration of symptoms before diagnosis	
Range	1 day–7 years
Median	4 weeks

Choi et al. 2010; Suwanpimolkul et al. 2010; Berngard and Miller 2013; Feng et al. 2014; McAnearney 2015; Shrestha et al. 2015; Effendi et al. 2016; Fukuda et al. 2016; Khoo et al. 2016; Oki et al. 2016; Fareed et al. 2017; Cheng et al. 2018; Dahlberg et al. 2018; Myojin et al. 2018; Banerjee et al. 2018; Popa et al. 2019).

6 Imaging

The diagnosis of spondylodiscitis is largely based on imaging with MRI being the modality of choice. However, there are no specific signs allowing the precise diagnosis of the causative pathogen. Indeed, findings are common to all spondylodiscitis and include abnormalities of the intervertebral disk, adjacent vertebral bodies, and surrounding soft tissues (Sans et al. 2012). Spinal radiographs and MRI are the two main modalities used for diagnosis (Sans et al. 2012). CT is mainly used to guide percutaneous procedures such as needle tissue biopsy or paravertebral abscess drainage (Tsui et al. 1997; Khan and El-Hiday 2007; Zheng et al. 2009; Effendi et al. 2016). Bone scintigraphy can be useful in multifocal infections, showing an increased uptake at the sites of infection.

Table 3 Review of imaging features in 50 patients with Salmonella spondylodiscitis

Feature (no. of patients with findings)	Percentage
Disk abnormalities ($n = 36$)	
Disk height narrowing	83%
Hyperintense T2 signal (MRI)	28%
Enhancement (MRI)	14%
Disk abscess (MRI)	17%
Vertebral body abnormalities ($n = 38$)	
End-plate erosion/blurring	39%
Bone destruction	31%
Vertebral body collapse	31%
Bone marrow signal abnormalities (hyperintense T2 signal, enhancement) (MRI)	55%
Bone sclerosis and construction signs	5%
Paravertebral tissue extension of infection ($n = 32$)	
Paravertebral phlegmon	28%
Paravertebral abscess	72%
Epidural extension of infection ($n = 17$)	
Epidural abscess (MRI)	82%
Epidural phlegmon (MRI)	18%
Spinal cord/cauda equina compression (MRI)	47%

Table 3 summarizes the imaging features reported in 50 patients with Salmonella spondylodiscitis (Miller 1954; Greenspan and Feinberg 1957; Weiss and Katz 1970; Bussiere et al. 1979; Carvell and Maclarnon 1981; Gardner 1985; O'Keeffe 1991; Tsui et al. 1997; Santos and Sapico 1998; Akiba et al. 2001; Skoutelis et al. 2001; Gupta et al. 2004; Rajesh et al. 2004; Devrim et al. 2005; Laloum et al. 2005; Barkai et al. 2005; Liu et al. 2006; Altay et al. 2006; Ozturk et al. 2006; Khan and El-Hiday 2007; Abdullah et al. 2008; Chen et al. 2008; Kumar et al. 2008; Osebold 2008; Learch et al. 2009; Rostom et al. 2009; Zheng et al. 2009; Choi et al. 2010; Amritanand et al. 2010; Suwanpimolkul et al. 2010; Berngard and Miller 2013; Feng et al. 2014; McAnearney 2015; Shrestha et al. 2015; Effendi et al. 2016; Fukuda et al. 2016; Khoo et al. 2016; Oki et al. 2016; Fareed et al. 2017; Cheng et al. 2018; Dahlberg et al. 2018; Myojin et al. 2018; Banerjee et al. 2018; Popa et al. 2019).

Disk space abnormalities have been reported in 36 cases. Disk space narrowing is the most consistent sign (Fig. 1), reported in 83% of cases. The other abnormalities are disk abscess (17%), disk enhancement (14%), and T2 signal hyperintensity (28%). In two cases, disk space height was normal (Gardner 1985; Zheng et al. 2009). Bone abnormalities were reported in 38 cases. Vertebral end-plate erosion or blurring were found in 39% of cases (Figs. 1 and 2), and bone destruction was reported in 31% of cases and vertebral body collapse in 31% of cases. Bone marrow signal abnormalities (T2 signal hyperintensity and bone enhancement) were found in 55% of cases (Fig. 1). In two cases, bone sclerosis and construction were associated with destructive lesions (Tsui et al. 1997; Kumar et al. 2008). Involvement of the posterior arch has not been reported.

Paravertebral abscesses were reported in 23 cases. They were well-defined and had a thin smooth wall (Feng et al. 2014; Cheng et al. 2018). Epidural extension of infection has been reported in 17 cases (Fig. 1). Epidural abscess was found in 82% of cases. Spinal cord or cauda equina compression was reported in 47% of cases.

In sickle cell disease, differentiation between bone infection and infarction is difficult without local histological and bacteriological findings. MRI is considered to be an efficient tool for the diagnosis of osteomyelitis in patients with sickle cell disease. However, bone marrow edema, fluid collection in adjacent soft tissues, and abnormal gadolinium enhancement of muscle and fat are seen with infarction as well as with infection. Bone scintigraphy is not helpful in distinguishing bone infarction from osteomyelitis, since normal and increased uptake may be seen in both. A combination of 99mTc-sulfur colloid and 99mTc diphosphonate or 99mTc with gallium seems to improve the test accuracy. Labeled leucocyte scan is not reliable in the spine. Associated abnormalities reported include spleen abscesses or infected abdominal aortic aneurysm (Santos and Sapico 1998). The latter has mainly been reported in elderly patients (Santos and Sapico 1998; Chen et al. 2008; Learch et al. 2009) and is an emergency, generally requiring surgical treatment. CT and MRI show a saccular aortic aneurysm contiguous to the spondylodiscitis site, with soft tissue swelling and possible periaortic gas.

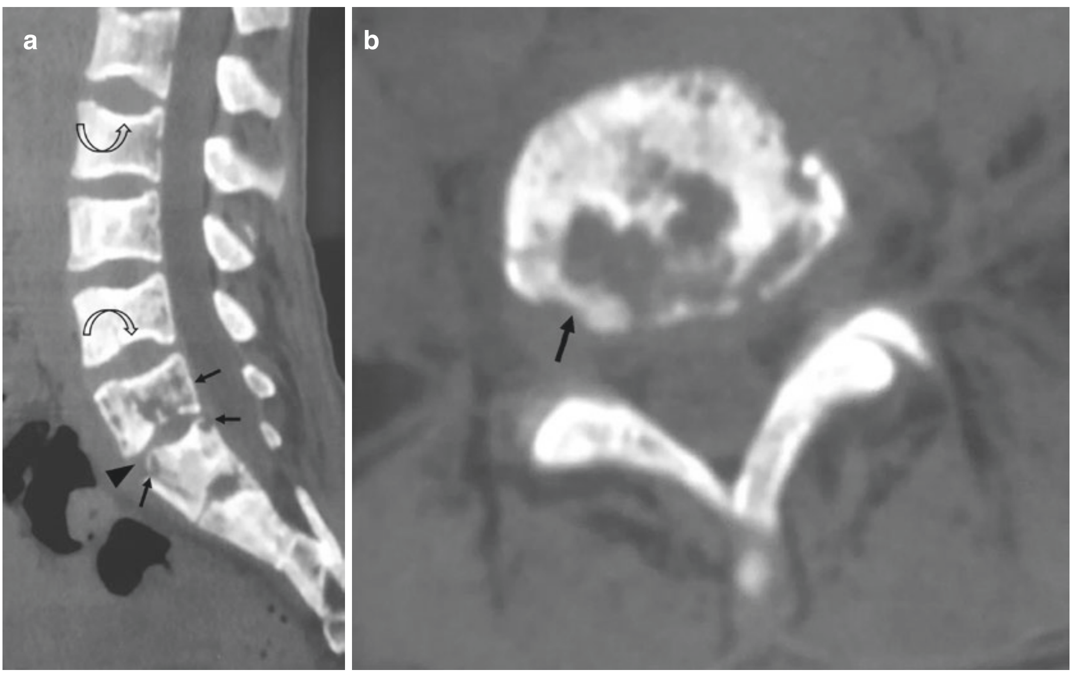

Fig. 1 Salmonella spondylodiscitis in a patient with sickle cell disease. (**a**) Sagittal and (**b**) axial CT images show narrowing of disk space at the L5/S1 level (black arrowhead) with adjacent end-plate erosions and vertebral body destruction (black arrows). Similar findings are present at the S1/S2 level. Notice the H-shape of vertebral bodies consistent with end-plate osteonecrosis characteristic of sickle cell disease (curved arrows). Sagittal (**c**) T2-W, (**d**) T1-W, and (**e**) contrast-enhanced T1-W and (**f**) axial contrast-enhanced T1-W MR images show T2-hyperintense signal of the disk at the L5/S1 and S1/S2 levels (white arrowheads) without enhancement and T2-hyperintense signal of vertebral bodies with enhancement (stars). There is also anterior (small white arrows) and paravertebral (curved arrows) phlegmon at the L5/S1 level along with epidural phlegmon (small black arrow)

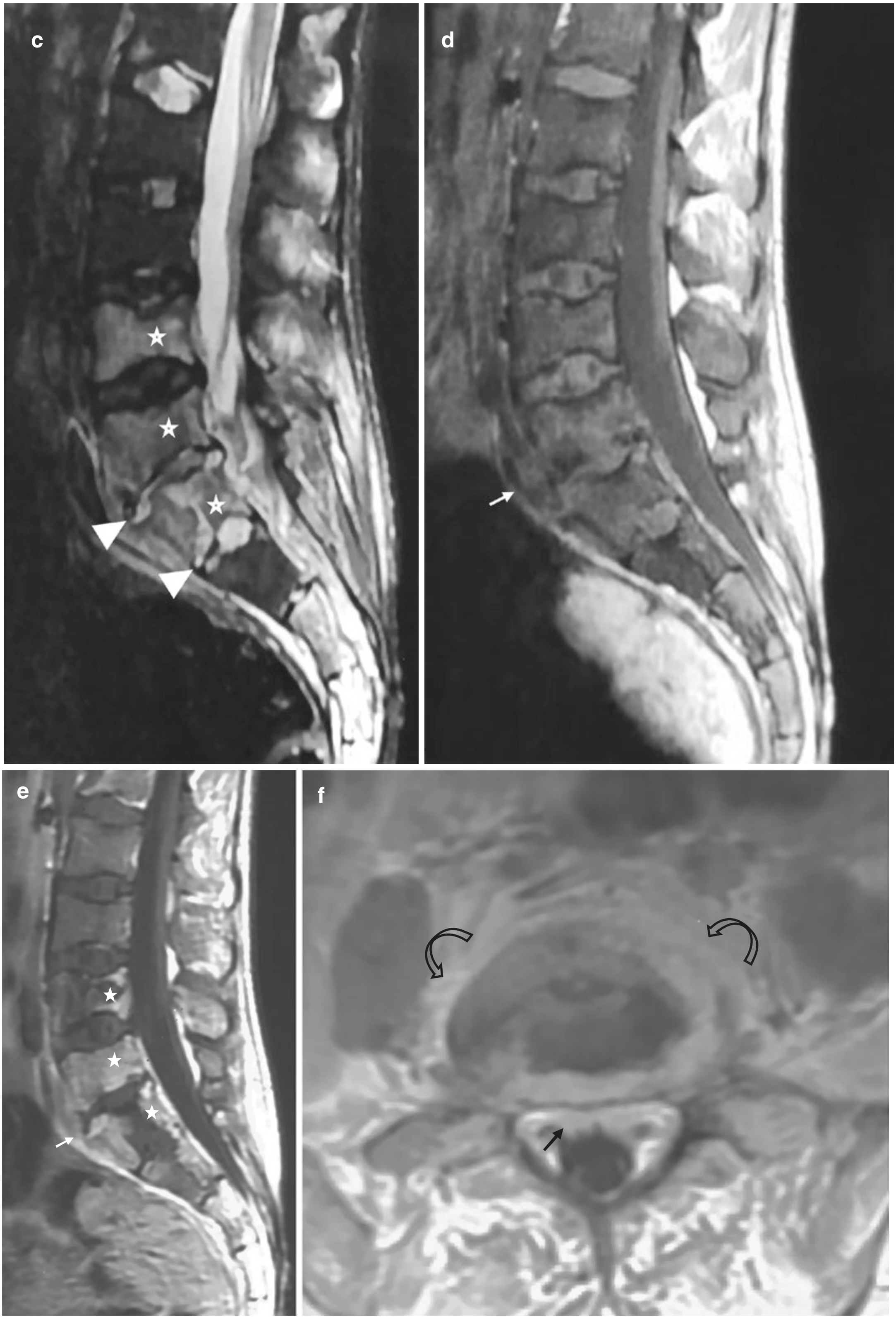

Fig. 1 (continued)

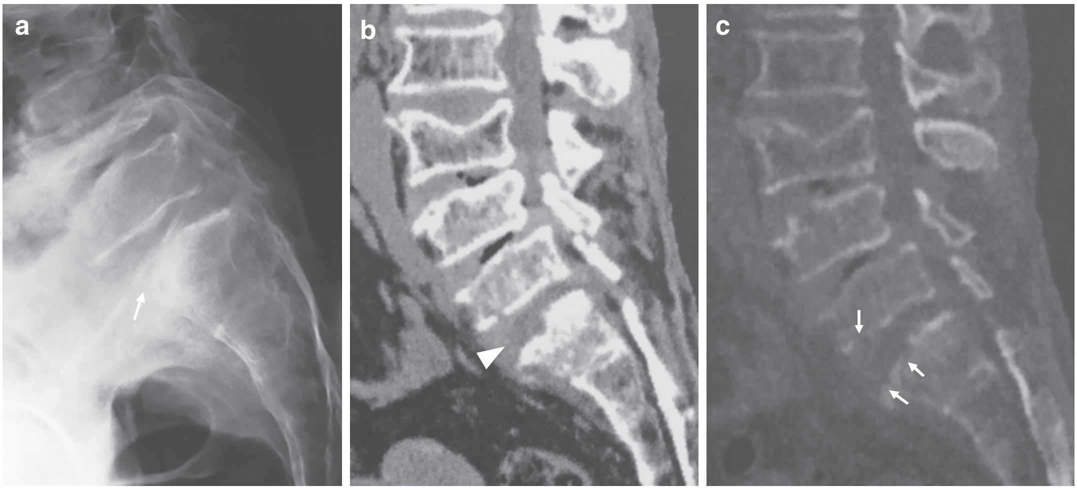

Fig. 2 (**a**) Lateral radiograph of the lumbar spine shows erosion of the anterosuperior corner of S1 segment (white arrow). (**b**, **c**) Sagittal CT images of the same patient show hypodensity of the disk at the L5/S1 level (arrowhead) with erosions of adjacent vertebral end plates (white arrows)

7 Diagnosis

The key to the diagnosis of Salmonella vertebral osteomyelitis is the identification of the organism mainly from a bone specimen obtained by needle or open biopsy (the gold standard), an aspirate of an adjacent fluid collection, or blood (Effendi et al. 2016; Cheng et al. 2018). The diagnosis can also be based on other clinical specimens (stool, urine, cerebrospinal fluid culture, joint fluid culture) (Santos and Sapico 1998; Rostom et al. 2009; Oki et al. 2016). In a review of 46 cases, Santos and Sapico (1998) found that culture of blood (*n* = 46), percutaneous or surgery specimen, stool (*n* = 31), and urine (*n* = 31) were positive in 22 (48%), 24 (52%), 11 (36%), and 7 (23%) cases, respectively. Forty-six articles including 66 patients with salmonella spondylodiscitis were reviewed. Cultures of specimens obtained by percutaneous procedure or surgery, blood culture, stool culture, and urine culture were positive in 93%, in 54%, and in 7/15 and 3/10 of cases, respectively.

Table 4 shows the different methods of diagnosis used by reviewing 46 articles (Miller 1954; Greenspan and Feinberg 1957; Weiss and Katz 1970; Bussiere et al. 1979; Carvell and Maclarnon 1981; Gardner 1985; O'Keeffe 1991; Tsui et al. 1997; Santos and Sapico 1998; Akiba et al. 2001; Skoutelis et al. 2001; Chen et al. 2001; Gupta et al. 2004; Rajesh et al. 2004; Devrim et al. 2005; Laloum et al. 2005; Barkai et al. 2005; Liu et al. 2006; Altay et al. 2006; Ozturk et al. 2006; Khan and El-Hiday 2007; Abdullah et al. 2008; Chen et al. 2008; Kumar et al. 2008; Osebold 2008; Learch et al. 2009; Rostom et al. 2009; Zheng et al. 2009; Choi et al. 2010; Amritanand et al. 2010; Suwanpimolkul et al. 2010; Berngard and Miller 2013; Feng et al. 2014; McAnearney 2015; Shrestha et al. 2015; Effendi et al. 2016; Fukuda et al. 2016; Khoo et al. 2016; Oki et al. 2016; Fareed et al. 2017; Cheng et al. 2018; Dahlberg et al. 2018; Myojin et al. 2018; Banerjee et al. 2018; Popa et al. 2019).

Table 4 Microbiological methods of diagnosis in 66 patients with Salmonella spondylodiscitis

Positive bacterial culture (no. of patients with findings)	Value or percentage
Blood culture (*n* = 41)	54%
Culture of specimen (percutaneous procedure or open surgery) (*n* = 44)	93%
Urine culture (*n* = 10)	3/10
Stool culture (*n* = 15)	7/15

The rate of positive blood culture associated with Salmonella vertebral osteomyelitis (48%)

is higher than that associated with pyogenic vertebral osteomyelitis due to other causes (25%) (Santos and Sapico 1998). Serum agglutination may be helpful if *S. typhi* infection is suspected. Its sensitivity is higher in osteomyelitis than in gastroenteritis, probably because of sufficient time for antibody response (Santos and Sapico 1998). In a study including 11 cases of Salmonella spondylodiscitis, Widal test was positive in all patients. In two patients, no organism was isolated, and the diagnosis was made based on Widal test along with histological features and a characteristic history (Amritanand et al. 2010). Nevertheless, Widal test can be negative at an early stage of disease, in cases of inadvertent administration of antibiotics, or in waning humoral immune response. Moreover, pathogen identification is necessary for antibiotic susceptibility testing. Laboratory markers, including white blood cell count, erythrocyte sedimentation rate, and C-reactive protein, are, to a certain extent, sensitive indicators of spinal infection. Nevertheless, none of them is specific enough in revealing the pathogens (Cheng et al. 2018).

8 Treatment and Outcome

The success of treatment depends on pathogen identification and antibiotic susceptibility testing (Santos and Sapico 1998). Outcome under antibiotic therapy and eventual surgery is favorable in the majority of cases with good recovery in 86% (57 out of 66 cases). Nevertheless, some patients are left with sequelae (Chen et al. 2008; Berngard and Miller 2013; Popa et al. 2019). Duration of medical treatment varies from 4 weeks to 6 months. Association with infected abdominal aortic aneurysm is characterized by a poorer prognosis with higher mortality. In these cases, surgery is generally needed. In a review of 46 cases of Salmonella spondylodiscitis, 12 patients out of 46 died, and the deaths were all related to infected abdominal aortic aneurysm (Santos and Sapico 1998). The usefulness of follow-up MRI has not been demonstrated. In a study including 33 patients with spinal infection, no correlation was found between imaging findings and clinical features (Kowalski et al. 2007). In another study including 253 patients with spinal infection, the follow-up MRI did not significantly affect outcome (McHenry 2002).

Table 5 Treatment and outcome in 66 patients with Salmonella spondylodiscitis

Features	Percentage
Medical treatment	100%
Surgery	44%
Outcome	
Good recovery	86%
Death	5%
Recovery with sequelae	9%

Table 5 summarizes the treatment and outcome of 66 cases by reviewing 46 articles (Miller 1954; Greenspan and Feinberg 1957; Weiss and Katz 1970; Bussiere et al. 1979; Carvell and Maclarnon 1981; Gardner 1985; O'Keeffe 1991; Tsui et al. 1997; Santos and Sapico 1998; Akiba et al. 2001; Skoutelis et al. 2001; Chen et al. 2001; Gupta et al. 2004; Rajesh et al. 2004; Devrim et al. 2005; Laloum et al. 2005; Barkai et al. 2005; Liu et al. 2006; Altay et al. 2006; Ozturk et al. 2006; Khan and El-Hiday 2007; Abdullah et al. 2008; Chen et al. 2008; Kumar et al. 2008; Osebold 2008; Learch et al. 2009; Rostom et al. 2009; Zheng et al. 2009; Choi et al. 2010; Amritanand et al. 2010; Suwanpimolkul et al. 2010; Berngard and Miller 2013; Feng et al. 2014; McAnearney 2015; Shrestha et al. 2015; Effendi et al. 2016; Fukuda et al. 2016; Khoo et al. 2016; Oki et al. 2016; Fareed et al. 2017; Cheng et al. 2018; Dahlberg et al. 2018; Myojin et al. 2018; Banerjee et al. 2018; Popa et al. 2019).

9 Conclusion

Salmonella is an uncommon cause of osteomyelitis, occurring generally in immunocompromised patients and mainly affects those with sickle cell disease. Vertebral location is very rare. MRI is the modality of choice to enable the diagnosis and assess the extent of infection. However, imaging does not allow differentiation between

Salmonella infection and infection caused by other pathogens. Bacteria isolation is necessary for definitive diagnosis and antibiotic susceptibility testing allows adequate antibiotic treatment. Blood culture and culture of specimens obtained by aspiration or biopsy are the two main ways of isolating the pathogen. CT may be used to guide percutaneous biopsy when other laboratory tests are negative and if surgery is not needed. Outcome is generally favorable under antibiotic therapy.

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