BRITISH JOURNAL OF HOSPITAL MEDICINE

Spondylodiscitis in adults: diagnosis and management

Kwaku Baryeh[1,2]
Fitzgerald Anazor[1]
Shabnam Iyer[3]
Trichy Rajagopal[1]

Author details can be found at the end of this article

Correspondence to:
Kwaku Baryeh;
kwaku.baryeh1@nhs.net

Abstract

Spondylodiscitis is often diagnosed late in its course because its symptoms are vague. The incidence in adults increases with age, being seen most commonly in men in their 50s and 60s, so the presence of other medical conditions or infections can make it more difficult to identify spondylodiscitis. Diagnosis is made based on clinical suspicion, raised levels of inflammatory markers, a positive blood or tissue biopsy culture and radiological findings. Once a diagnosis is confirmed, treatment must be started promptly. The mainstay of treatment is medical management, with antibiotics tailored to the relevant organism, as well as immobilisation. Where surgery is indicated, the aims are debridement of infected tissue, tissue sampling, neural decompression and stabilisation. Spondylodiscitis is associated with high rates of mortality and morbidity and should be treated promptly to ensure the best outcome.

Key words: Discitis; Neurological deficit; Spinal infection; Spondylodiscitis; Vertebral osteomyelitis

Submitted: 19 October 2021; accepted following double-blind peer review: 24 May 2022

Introduction

Spondylodiscitis is an infective inflammatory process that can affect the intervertebral discs, vertebrae and surrounding structures (Homagk et al, 2019). Its incidence is increasing globally, which has been attributed to an increased ageing population combined with better recognition of the condition (Nickerson and Sinha, 2016). The non-specific nature of many of its symptoms means that it can often go undiagnosed initially, resulting in delayed presentation and treatment (Herren et al, 2017). Treatment is usually medical, with surgical management reserved for patients with failed conservative treatment, instability or cord compression (Dragsted et al, 2017). Treatment can prove difficult not only as a result of delays in diagnosis, but also because of difficulties in isolating the causative pathogen (Homagk et al, 2019). This article highlights the diagnostic challenges of spondylodiscitis in adults, the clinical features and findings that should raise clinical suspicion for this condition, and how spondylodiscitis can be managed once diagnosed.

Epidemiology

Spondylodiscitis has an incidence of 2.4/100 000 per year and rising (Sur et al, 2015). It has a male preponderance and a bimodal distribution – it is seen in the first and second decades of life in children, whereas in adults it tends to affect patients in the fifth and sixth decades of life (Nickerson and Sinha, 2016; Shenoy et al, 2018). The condition predominantly affects the lumbar spine, which accounts for more than half of cases, followed by the thoracic and cervical spine (Shenoy et al, 2018).

How to cite this article:
Baryeh K, Anazor F, Iyer S, Rajagopal T. Spondylodiscitis in adults: diagnosis and management. Br J Hosp Med. 2022. https://doi.org/10.12968/hmed.2021.0448

Risk factors

Risk factors for the development of spondylodiscitis include conditions affecting the immune response such as diabetes and chronic kidney disease, excessive alcohol consumption, intravenous drug use, recent infections of the genitourinary system and previous spinal surgery (Sur et al, 2015; Nickerson and Sinha, 2016; Mavrogenis et al, 2017; Shenoy et al, 2018) (Table 1).

Pathophysiology

The most common route of infection in spondylodiscitis is haematogenous spread (Petkova et al, 2017; Nasto et al, 2021), with other potential routes including direct inoculation following spinal surgery or contiguous spread from surrounding tissues (Nickerson and Sinha, 2016; Taylor et al, 2018). In haematogenous spread, bacteria arrive via the arterioles of the endplates and deposit onto the relatively avascular intervertebral discs (Taylor et al, 2018). As the infection becomes established in the vasculature, it can worsen because of a vicious cycle of increasing intraosseous pressure and decreasing blood flow (Taylor et al, 2018). Retrograde seeding via the venous plexus of Batson (a valveless system that drains blood from pelvic organs to the vertebral venous system) has also been noted with infection seeding from intra-pelvic sources (Raghavan et al, 2018; Shenoy et al, 2018).

History and examination

Spondylodiscitis is notoriously difficult to diagnose because of the non-specific nature of symptoms. A thorough history and examination are crucial to establishing the diagnosis. Patients may present with a history of localised back or neck pain, worsening at night and on weight bearing, with an associated fever (Shenoy et al, 2018; Nasto et al, 2021). This combination of symptoms should always raise the suspicion of spondylodiscitis. Other non-specific symptoms include general malaise, weight loss, night sweats, lethargy, nausea, vomiting and confusion (Mavrogenis et al, 2017; Shenoy et al, 2018; Pandita et al, 2019). These symptoms, particularly in the multi-morbid older patient, can often be attributed to pre-existing conditions which can delay diagnosis (Nasto et al, 2021). Another symptom which can be challenging, particularly in patients with pre-existing spinal pathology, is neurological deficit (Taylor et al, 2018; Homagk et al, 2019). A careful account of onset, duration and any change to neurological deficits is important to help delineate existing pathology from that caused by spondylodiscitis. A thorough medical history should aim to elicit risk factors, for example immunocompromise, which may indicate spondylodiscitis as the cause of otherwise vague symptoms.

Clinical examination findings may be limited to localised tenderness at the affected level, paraspinal muscle spasm and reduced range of motion at the spine, although swelling and localised warmth have also been reported (Mavrogenis et al, 2017; Shenoy et al, 2018). Neurological deficits may include bladder or bowel dysfunction, sensory and/or motor deficits. While less common, these signs and symptoms can particularly be seen in delayed presentations (Nickerson and Sinha, 2016). Where present, neurological deficit should trigger prompt imaging and referral to spinal services.

Baseline observations (heart rate, blood pressure, temperature, respiration rate) should also be undertaken to look for any evidence of sepsis.

Laboratory investigations

Given the predisposing factors for spondylodiscitis (Table 1), in addition to white cell count, C-reactive protein and erythrocyte sedimentation rate as markers of infection and inflammation (Taylor et al, 2018), renal and liver function tests may also be useful. These

Table 1. Risk factors associated with spondylodiscitis

Risk factors	Examples
Immunocompromise	Human immunodeficiency virus, rheumatoid arthritis, diabetes, malignancy
Organ dysfunction	Chronic kidney disease, heart failure, liver failure
Infection	Cardiac, genitourinary, gastrointestinal, respiratory, oral cavity, skin, soft tissue
Surgical	Spinal surgery (instrumented and non-instrumented)
Patient related	Intravenous drug use, alcohol excess, advancing age

provide information on the degree of renal or hepatic failure that may have increased susceptibility to developing spondylodiscitis, and also provide a baseline for monitoring antibiotic toxicity. Blood cultures are vital for pathogen isolation as part of the workup for a septic patient and in cases where spondylodiscitis is suspected (Nickerson and Sinha, 2016; Petkova et al, 2017). However, delays in presentation and recent or ongoing treatment with antibiotics for other infections can result in negative cultures (Nickerson and Sinha, 2016; Petkova et al, 2017; Taylor et al, 2018). Biopsy and tissue culture is another useful tool for pathogen identification, with image-guided biopsy producing a diagnostic yield of up to 48% (McNamara et al, 2017). However, the diagnostic yield is lowered by antibiotic use and can be affected by biopsy-dependent factors such as imaging modality, needle used, site of biopsy and open vs percutaneous sampling (McNamara et al, 2017). Tissue and fluid samples should be sent for microscopy, culture (aerobic, anaerobic, fungal and mycobacterial) and histology (Lew and Waldvogel, 2004). Antibiotics should be omitted until after biopsy in patients who are not septic.

Radiological investigations

The gold standard investigation for spondylodiscitis is magnetic resonance imaging, although patients with back pain may undergo X-ray or computed tomography scanning before magnetic resonance imaging is performed.

X-ray findings in patients with spondylodiscitis may be absent or very subtle early in the disease course. Loss of disc space height and end plate definition can be found in patients with spondylodiscitis, but these are also common in patients with degenerative spinal disease (Raghavan et al, 2018). X-ray fluoroscopic guidance can be used to obtain biopsy specimens for culture, which has similar accuracy to computed tomography guidance with the benefit of a lower radiation dose (Kim et al, 2013; Lee et al, 2020).

Where spondylodiscitis is suspected from X-ray findings, magnetic resonance imaging should be the investigation of choice, although computed tomography may be performed if there are difficulties in obtaining magnetic resonance imaging, particularly out of hours. In addition to loss of disc space height and loss of end plate definition, computed tomography may show soft tissue changes such as abscess formation, fracture or malignancy (Raghavan et al, 2018). As with X-ray, computed tomography can be used to help accurately obtain a biopsy specimen and is the first-line modality for this in practice (Lee et al, 2020).

Magnetic resonance imaging is the gold standard for diagnosis of spondylodiscitis because of its high accuracy, sensitivity and specificity (Mavrogenis et al, 2017; Ahn et al, 2020). Once spondylodiscitis is suspected, urgent magnetic resonance imaging should be obtained to confirm the diagnosis and avoid unnecessary delays to treatment. Image sequencing should include T1- and T2-weighted imaging with T1-weighted post-gadolinium contrast images (Mavrogenis et al, 2017; Raghavan et al, 2018; Shenoy et al, 2018). Typical features on magnetic resonance imaging include low signal changes on T1-weighted images and high signal changes on T2-weighted images (**Figures 1** and **2**) in the region of the vertebral end plates and intervertebral discs (Mavrogenis et al, 2017; Raghavan et al, 2018). Following administration of gadolinium contrast, enhancement of the affected disc and vertebral body on T1-weighted images is expected (Mavrogenis et al, 2017; Raghavan et al, 2018). Distinguishing between a phlegmon and an abscess is another key benefit of using magnetic resonance imaging and has implications for treatment, as while abscesses can be drained, phlegmons represent inflammatory change and hyperaemia, and are not drainable (Raghavan et al, 2018).

Where magnetic resonance imaging is contraindicated, such as in patients with cochlear implants, some cardiac implantable devices, metallic intraocular foreign bodies or other internal metallic fragments or devices (Dill, 2008), alternative methods for diagnosis include bone scintigraphy, positron emission tomography computed tomography and single-photon emission computed tomography-computed tomography. Bone scintigraphy can be used in isolation, but the sensitivity of diagnosis is improved if it is used in combination with single-photon emission computed tomography-computed tomography (Raghavan et al, 2018). Positron emission tomography-computed tomography scanning can more accurately localise the region of uptake, and is nearly 100% accurate in identifying spondylodiscitis in patients with spinal hardware in situ (Raghavan et al, 2018).

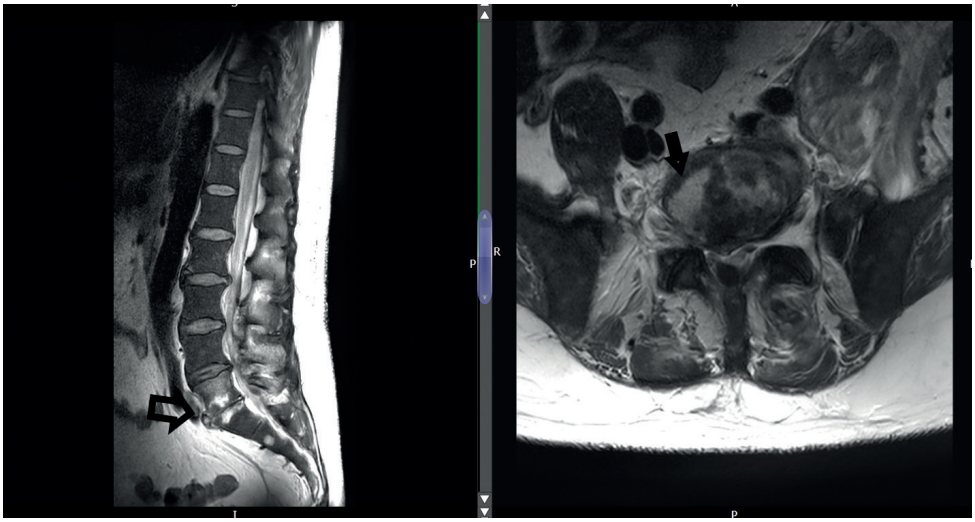

Figure 1. T2-weighted magnetic resonance imaging showing (a) a sagittal view of the lumbar spine demonstrating high signal in the end plates of the L5 and S1 vertebrae with (b) an axial image at the same level demonstrating high signal within the L5–S1 intervertebral disc.

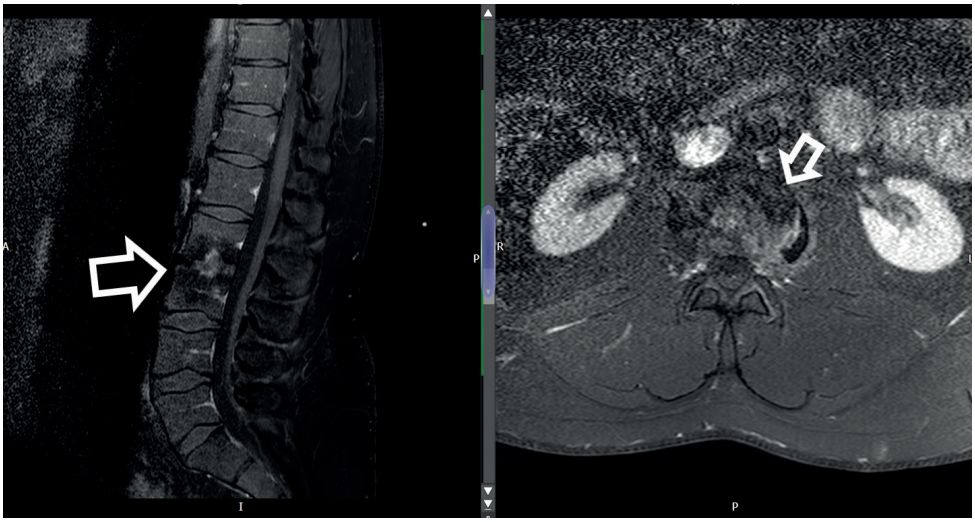

Figure 2. T1-weighted magnetic resonance imaging showing (a) a sagittal view of the lumbar spine with low signal uptake in the end plates of L2 and L3 with early destructive changes of the L2 vertebrae. b. An axial view taken at the L2–L3 level shows low signal within the intervertebral disc.

Pathogens

Several pathogens have been implicated in the development of spondylodiscitis. Over time, the most prevalent organism has changed from *Mycobacterium tuberculosis* to *Staphylococcus aureus* (Mavrogenis et al, 2017). Infections tend to be monomicrobial in nature. *S. aureus* is the most commonly identified organism (Nickerson and Sinha, 2016; Petkova et al, 2017; Shenoy et al, 2018) and *Escherichia coli* is the most common Gram-negative organism identified, with *Proteus*, *Klebsiella* and *Pseudomonas* also implicated (Mavrogenis et al, 2017; Petkova et al, 2017). Gram-negative organisms usually seed from gastrointestinal or genitourinary infections and are also prevalent in patients who are immunosuppressed or who have diabetes (Mavrogenis et al, 2017; Petkova et al, 2017). Postoperative infection is often caused by *S. epidermidis* (Mavrogenis et al, 2017; Petkova et al, 2017) (Table 2).

In the developing world, organisms such as *Brucella* and *M. tuberculosis* are still common. These should be suspected as the causative organisms in travellers from countries with a high prevalence of Brucellosis such as the Mediterranean, Middle East and parts of central and South America (Kutlu et al, 2018), or tuberculosis, such as the Indian subcontinent

Table 2. Common causative organisms	
Gram positive	*Staphylococcus aureus*
	Staphylococcus epidermidis
	Streptococcus spp.
	Enterococcus spp.
Gram negative	*Escherichia coli*
	Pseudomonas aeruginosa
	Proteus mirabilis

(Aithala et al, 2020). Fungal spondylodiscitis is incredibly rare, most often presenting in immunocompromised patients, with *Candida* spp. accounting for most of these infections (Mavrogenis et al, 2017; Petkova et al, 2017; Stolberg-Stolberg et al, 2017).

Medical treatment

Treatment of spondylodiscitis is generally conservative, involving antibiotics and immobilisation of the spine (Mavrogenis et al, 2017; Petkova et al, 2017). A multidisciplinary approach to treatment should be adopted, involving physicians, the spinal service (orthopaedic or neurosurgeons depending on local configuration), radiologists, microbiologists and physiotherapists.

Antibiotics should not be given until after cultures have identified the causative agent, except in septic patients or those with neurological deficits (Shenoy et al, 2018). If antibiotics need to be given before the causative organism is identified, these should ideally cover *S. aureus*, as this is the most common causative organism (Nickerson and Sinha, 2016).

The duration and administration route of antibiotics is controversial. Most studies advocate a duration of antibiotics from 4–12 weeks (Nickerson and Sinha, 2016; Mavrogenis et al, 2017; Shenoy et al, 2018). Traditionally, this would be undertaken as extended intravenous therapy with subsequent oral therapy, but there have been moves towards early oral treatment (Nickerson and Sinha, 2016). Periods of bed rest and/or bracing of the spine are also advocated to aid stability, reduce pain and reduce the pressure on affected segments of the spine (Nickerson and Sinha, 2016; Mavrogenis et al, 2017; Shenoy et al, 2018; Giordan et al, 2019). Features of instability may include spinal malalignment, vertebral body collapse, bony destruction and the involvement of posterior elements (Pennington et al, 2019). However, the optimal duration of immobilisation is unclear and the potential risks in frail older patients must be mitigated against the benefits. Treatment response should be monitored with serial blood tests to check levels of inflammatory markers (white cell count, C-reactive protein, erythrocyte sedimentation rate), with interval imaging to assess for resolution of identified changes if appropriate (Nickerson and Sinha, 2016; Mavrogenis et al, 2017; Shenoy et al, 2018).

Surgical treatment

Indications for surgical management include spinal cord or cauda equina compression, instability caused by bony destruction, large abscess, intractable back pain or failure of conservative management (Dragsted et al, 2017; Mavrogenis et al, 2017; Shenoy et al, 2018). Surgical treatment of spondylodiscitis aims to decompress neural structures, restore stability and obtain tissue samples for analysis (Petkova et al, 2017).

Surgical management is required in 10–20% of cases of spondylodiscitis (Cheung and Luk, 2012). It involves decompression of any neural compromise, thorough debridement of affected tissues with sampling, drainage of any abscess formed and stabilisation if required (Mavrogenis et al, 2017; Petkova et al, 2017). Using instrumentation to achieve stability leads to quicker postoperative mobilisation and reduces the risk of morbidity (Shenoy et al, 2018).

There is debate about the appropriate approach for any surgery (anterior vs posterior vs combined), as well as over the use of single-stage vs two-stage procedures (Shenoy et al, 2018). Patient comorbidities and general health should be considered when making these decisions, eg a two-stage approach with its shorter procedural time may be favoured for patients in extremis (Mavrogenis et al, 2017). The appropriate approach can be influenced by the surgeon's practice, the involvement of posterior spinal elements and whether suitable debridement and stability can be achieved through a single approach (Mavrogenis et al, 2017).

Complications

Delays in diagnosis of spondylodiscitis can lead to higher rates of and more severe complications. Potential complications include paralysis secondary to neural compression, abscess formation, spinal instability and even death as a result of sepsis (Sur et al, 2015; Gentile et al, 2019). Complications related to surgery include wound infection, dural tear, neurological injury, anaemia, failure of fusion, neurological deterioration or haematoma formation (Dragsted et al, 2017; Segreto et al, 2018).

Prognosis

The mortality rate 1 year after a diagnosis of spondylodiscitis has been reported to be 4–20% (Dragsted et al, 2017; Giordan et al, 2019), and is affected by the patient's age and the presence of comorbidities. The recurrence rate has been reported to be 5% (Giordan et al, 2019), although this might be higher if spondylodiscitis was caused by a chronic condition (eg renal failure, diabetes, rheumatoid arthritis). The mortality and morbidity rates highlight the importance of prompt recognition and treatment.

The authors' experience

This article summarises the available evidence for the treatment of spondylodiscitis. The authors' institution has developed a treatment algorithm (Figure 3) based on the available evidence, the 2015 Infectious Diseases Society of America guidelines (Berbari et al, 2015) and the authors' experience of managing patients with spondylodiscitis. Key points from this are:

- Two sets of blood cultures performed between 30 minutes and 4 hours of a tissue biopsy may increase the rate of positive blood culture in the face of previous negative blood culture (Cherasse et al, 2003)
- Repeat tissue biopsy, if cultures are initially negative, may be necessary to isolate a pathogen, particularly if spondylodiscitis remains the most likely diagnosis
- The treatment end point should be an asymptomatic patient with a C-reactive protein level <5 mg/litre on at least two consecutive occasions after antibiotic treatment is stopped.

Key points

- Spondylodiscitis can have an insidious course, with several non-specific symptoms that can lead to significant delays in diagnosis.
- Any patient presenting with localised back or neck pain, worsening at night, with an associated fever should be investigated for spondylodiscitis.
- The gold standard investigation for spondylodiscitis is magnetic resonance imaging and, once diagnosed, identification of the causative pathogen should ideally occur before treatment.
- The mainstay of treatment is conservative with antibiotics tailored to the causative organism and immobilisation as required.
- Surgery is indicated in cases of instability, abscess, neurological deficit or failure of conservative treatment, and suitability should be assessed on a case-by-case basis.

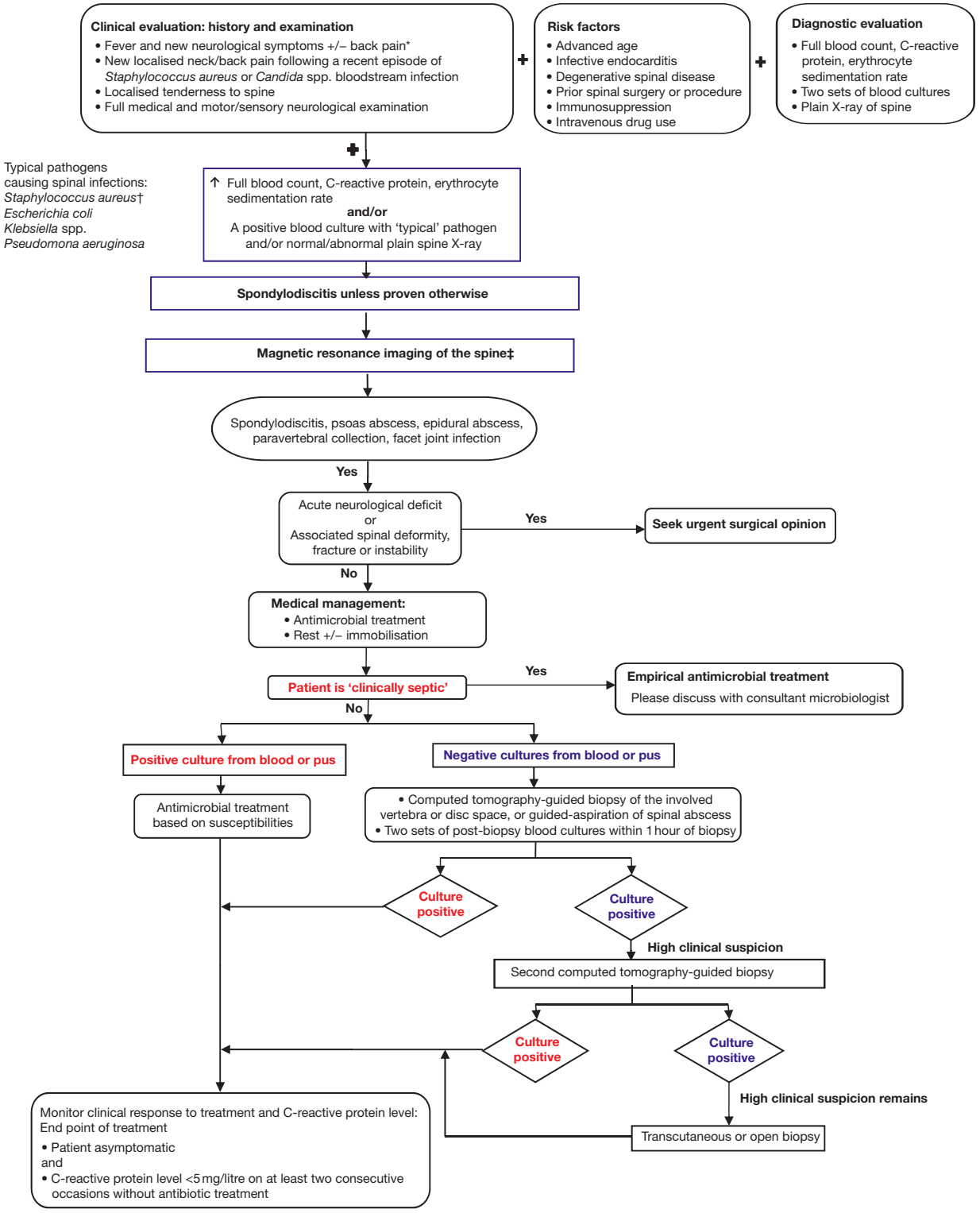

Figure 3. Management of spinal infection. *Pain may be absent in patients with paraplegia. † Evaluate for potential concurrent infectious endocarditis. ‡ Computed tomography scan if magnetic resonance imaging is contraindicated.

Conclusions

Spondylodiscitis can be a diagnostic challenge given its typically non-specific presentation. A high index of suspicion should be maintained in patients with relevant risk factors, history, clinical and biochemical findings. A multidisciplinary approach to treatment ensures the best possible outcome for patients and should be used in all cases.

Curriculum checklist

This article addresses the following requirements from the core surgical training curriculum:

- Basic sciences – knowledge – microbiology
- Basic sciences – knowledge – medical physics
- The clinical method in surgical practice.

Author details

[1]Department of Trauma and Orthopaedics, Royal Berkshire Hospital, Reading, UK

[2]Department of Medical Education, West Middlesex University Hospital, Middlesex, UK

[3]Department of Microbiology, Royal Berkshire Hospital, Reading, UK

Conflicts of interest

The authors declare that there are no conflicts of interest.

References

Ahn K-S, Kang CH, Hong S-J, Kim BH, Shim E. The correlation between follow-up MRI findings and laboratory results in pyogenic spondylodiscitis. BMC Musculoskelet Disord. 2020;21(1):428. https://doi.org/10.1186/s12891-020-03446-4

Aithala JP, Attar A, Imthiaz AKA, Rai M. Is there a change in trend towards pyogenous spondylodiscitis compared to tubercular spondylodiscitis in India–a study of percutaneous biopsy evaluation in spondylodiscitis. Indian J Tuberc. 2020;67(4):509–514. https://doi.org/10.1016/j.ijtb.2020.07.002

Berbari EF, Kanj SS, Kowalski TJ et al. 2015 Infectious Diseases Society of America (IDSA) clinical practice guidelines for the diagnosis and treatment of native vertebral osteomyelitis in adults. Clin Infect Dis. 2015;61(6):e26–e46. https://doi.org/10.1093/cid/civ482

Cherasse A, Martin D, Tavernier C, Maillefert JF. Are blood cultures performed after disco-vertebral biopsy useful in patients with pyogenic infective spondylitis? Rheumatology. 2003;42(7):913–913. https://doi.org/10.1093/rheumatology/keg224

Cheung WY, Luk KDK. Pyogenic spondylitis. Int Orthop (SICOT). 2012;36(2):397–404. https://doi.org/10.1007/s00264-011-1384-6

Dill T. Contraindications to magnetic resonance imaging. Heart. 2008;94(7):943–948. https://doi.org/10.1136/hrt.2007.125039

Dragsted C, Aagaard T, Ohrt-Nissen S, Gehrchen M, Dahl B. Mortality and health-related quality of life in patients surgically treated for spondylodiscitis. J Orthop Surg. 2017;25(2):230949901771606. https://doi.org/10.1177/2309499017716068

Gentile L, Benazzo F, De Rosa F et al. A systematic review: characteristics, complications and treatment of spondylodiscitis. Eur Rev Med Pharmacol Sci. 2019;23(2 Suppl):117–128. https://doi.org/10.26355/eurrev_201904_17481

Giordan E, Marton E, Scotton G, Canova G. Outcomes and risk factors for spontaneous spondylodiscitis: case series and meta-analysis of the literature. J Clin Neurosci. 2019;68:179–187. https://doi.org/10.1016/j.jocn.2019.06.040

Herren C, Jung N, Pishnamaz M et al. Spondylodiscitis: diagnosis and treatment options. Dtsch Arztebl Int. 2017;114(51-52):875–882. https://doi.org/10.3238/arztebl.2017.0875

Homagk L, Marmelstein D, Homagk N, Hofmann GO. SponDT (Spondylodiscitis Diagnosis and Treatment): spondylodiscitis scoring system. J Orthop Surg Res. 2019;14(1):100. https://doi.org/10.1186/s13018-019-1134-9

Kim BJ, Lee JW, Kim SJ, Lee GY, Kang HS. Diagnostic yield of fluoroscopy-guided biopsy for infectious spondylitis. AJNR Am J Neuroradiol. 2013;34(1):233–238. https://doi.org/10.3174/ajnr.A3120

Kutlu SS, Kutlu M, Tuzun T, Ozdemir K. Spondylodiscitis: a common complication of brucellosis. J Infect Dev Ctries. 2018;12(7):550–556. https://doi.org/10.3855/jidc.10557

Lee SA, Chiu CK, Chan CYW et al. The clinical utility of fluoroscopic versus CT guided percutaneous transpedicular core needle biopsy for spinal infections and tumours: a randomized trial. Spine J. 2020;20(7):1114–1124. https://doi.org/10.1016/j.spinee.2020.03.015

Lew DP, Waldvogel FA. Osteomyelitis. Lancet. 2004;364(9431):369–379. https://doi.org/10.1016/S0140-6736(04)16727-5

Mavrogenis AF, Megaloikonomos PD, Igoumenou VG et al. Spondylodiscitis revisited. EFORT Open Rev. 2017;2(11):447–461. https://doi.org/10.1302/2058-5241.2.160062

McNamara AL, Dickerson EC, Gomez-Hassan DM, Cinti SK, Srinivasan A. Yield of image-guided needle biopsy for infectious discitis: a systematic review and meta-analysis. AJNR Am J Neuroradiol. 2017;38(10):2021–2027. https://doi.org/10.3174/ajnr.A5337

Nasto LA, Fantoni M, Cipolloni V et al. A detailed analysis of clinical features and outcomes of patients with pyogenic spondylodiscitis presenting without axial back pain. Trop Med Infect Dis. 2021;6(2):54. https://doi.org/10.3390/tropicalmed6020054

Nickerson EK, Sinha R. Vertebral osteomyelitis in adults: an update. Br Med Bull. 2016;117(1):121–138. https://doi.org/10.1093/bmb/ldw003

Pandita N, Paul S, Yadav G, Kalia RB, Kandwal P. Evaluation of challenges in diagnosis of spontaneous subacute pyogenic spondylodiscitis in immunocompetent patients: experiences from a tertiary care center. Asian Spine J. 2019;13(4):621–629. https://doi.org/10.31616/asj.2018.0220

Pennington Z, Ahmed AK, Cottrill E et al. Intra- and interobserver reliability of the Spinal Instability Neoplastic Score system for instability in spine metastases: a systematic review and meta-analysis. Ann Transl Med. 2019;7(10):218–218. https://doi.org/10.21037/atm.2019.01.65

Petkova AS, Zhelyazkov CB, Kitov BD. Spontaneous spondylodiscitis-epidemiology, clinical features, diagnosis and treatment. Folia Med. 2017;59(3):254–260. https://doi.org/10.1515/folmed-2017-0024

Raghavan M, Lazzeri E, Palestro CJ. Imaging of spondylodiscitis. Semin Nucl Med. 2018;48(2):131–147. https://doi.org/10.1053/j.semnuclmed.2017.11.001

Segreto FA, Beyer GA, Grieco P et al. Vertebral osteomyelitis: a comparison of associated outcomes in early versus delayed surgical treatment. Int J Spine Surg. 2018;12(6):703–712. https://doi.org/10.14444/5088

Shenoy K, Singla A, Krystal JD et al. Discitis in adults. JBJS Rev. 2018;6(6):e6. https://doi.org/10.2106/JBJS.RVW.17.00104

Stolberg-Stolberg J, Horn D, Roßlenbroich S et al. Management of destructive Candida albicans spondylodiscitis of the cervical spine: a systematic analysis of literature illustrated by an unusual case. Eur Spine J. 2017;26(4):1009–1018. https://doi.org/10.1007/s00586-016-4827-3

Sur A, Tsang K, Brown M, Tzerakis N. Management of adult spontaneous spondylodiscitis and its rising incidence. Ann R Coll Surg Engl. 2015;97(6):451–455. https://doi.org/10.1308/rcsann.2015.0009

Taylor DG, Buchholz AL, Sure DR et al. Presentation and outcomes after medical and surgical treatment versus medical treatment alone of spontaneous infectious spondylodiscitis: a systematic literature review and meta-analysis. Glob Spine J. 2018;8(4_suppl):49S–58S. https://doi.org/10.1177/2192568218799058