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Infections of the spinal column — Spondylodiscitis


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KEYWORDS
Spinal column; Infection; Conventional radiography; MRI; Interventional radiology

Abstract  Infectious spondylodiscitis is an infection of the intervertebral disc and the adjacent vertebral bodies due to the introduction of a pyogen, usually by the haematogenous route. Plain film radiography (which is usually normal in the early stages) shows blurring of the vertebral endplates and a loss of disc height that progresses quickly. MRI is the examination of choice, as it detects oedema within the trabecular bone very early, before the onset of destruction. Injection of a contrast medium with fat signal saturation improves detection and visualisation of the spread of infection in the soft tissue and epidural space. Imaging can also be used to guide a needle aspiration to investigate the infective agent.
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Epidemiological and microbiological data

The annual incidence of cases of spondylodiscitis in France, estimated based on data from the French hospital discharge database (PMSI), is in the order of 2.4 per 100,000 people [1], a figure that is comparable to that of other Western nations. The sex ratio is around 1.5 men to 1 woman, and the mean age of incidence is 59 years (1—98 years). Children and those under the age of 20 only account for 3% of patients, with no difference in distribution by sex. After the age of 20, there is clear predominance in men. Spondylodiscitis is the result of haematogenous infection, direct introduction or contiguous contamination. Haematogenous infection is the leading cause in young children (60—80% of cases) because the discs are highly vascularised, but it is less common in adults. Spondylodiscitis can be due to an infection in a distant site (endocarditis, abscess, urinary tract infection, lung or pelvis infection), arise following a surgical intervention in a distant site (pelvic, urinary, vascular, cardiac or internal organ surgery) complicate a local infection that becomes systemic, or result from IV use of illicit drugs. Direct introduction (15—40% of cases) develops in response to a local contaminating event affecting the discs or vertebrae: puncture,

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infiltration, diskography, laminectomy, discectomy, laser therapy, or surgery to the spinal column. Contiguous introduction from an infection in an adjacent structure, such as an abscess or an infected aortic graft, is much more rare (approximately 3% of cases). The potential agent responsible varies depending on initial contamination route (haematogenous, direct, or contiguous) and geographical location (area where tuberculosis is endemic or where brucellosis is present). Table 1 summarises the infectious agents that may cause spondylodiscitis by frequency.

### Imaging

#### Diagnosis and initial assessment

The role of imaging is threefold:

- to assist with early diagnosis and define the precise area affected by spondylodiscitis as well as disease spread to the vertebrae, discs, epidural space, or soft tissue;
- to identify the infective agent and guide percutaneous discoveertbral needle aspiration in order to direct the choice of antibiotic therapy;
- to detect any neurological complications (compression) or infectious complications (abscess) that could benefit from surgical or percutaneous intervention.

#### Plain film radiography

Although plain film radiography is often the first examination ordered, it is not particularly sensitive for early diagnosis as it is frequently normal for the first 2 to 3 weeks of the course of the disease. Radiography assessment must include at least anteroposterior and lateral views of the painful segment of the spine, potentially also with views focusing on the suspicious area. Signs on radiology vary in how long they take to appear depending on the agent of infection (they can be seen earlier in non-tuberculous spondylodiscitis compared to tuberculous spondylodiscitis) and only when bone destruction exceeds 30% as a minimum [2,3]. If there has been a particularly long delay in diagnosis (mainly in cases of tuberculosis), abnormalities can then be seen on radiography in over 90% of cases. Abnormalities on radiography (Fig. 1) during the course of the disease are as follows [4]:

- the cortical strip of the vertebral endplate appears blurred and poorly defined;
- the anterior corner of the vertebral endplate is eroded, and this finding is even more suspicious if this is mirrored;
- overall loss of disc height that progresses quickly (in under a month), a finding which can be seen if anterior views are available;
- a fusiform tumefaction of the soft tissue identified on the anteroposterior view, pointing to paravertebral thoracic spine involvement;
- displacement of the airway or digestive tracts near the cervical spine, visible on a lateral view.

It should be noted that although it is the lumbar spine that is most often the site of spondylodiscitis, abnormalities of the soft tissue in this area are more difficult to visualise on conventional imaging; nonetheless clinicians should look at the edge of the psoas for blurring and a convex appearance. In later stage disease [3,4], erosion spreads to the entire vertebral endplate, then subchondral geodes appear and there is secondary involvement of the centromeres. All of these lesions combined may lead to significant osteolysis and vertebral compression. If the affected discs are aggra-vated then disorders of spinal deformity may arise. Later, there are signs of bone reformation comprising peripheral sclerosis, osteophytosis, and a build-up of osteolytic lesions. These vary when they occur, depending on the causative agent (in non-tuberculous infectious spondylodiscitis they progress more quickly). Bone consolidation can only be confirmed by consistent radiology findings on repeated imaging. It is clear that normal radiography must under no circumstances lead the clinician to eliminate spondylodiscitis and more sensitive imaging modalities are called for where there is strong clinical suspicion. Finally, clinicians should always bear in mind that radiography only provides minimal

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**Table 1** Microorganisms causing spondylodiscitis in France by frequency [1].

<table>
<thead>
<tr>
<th>Microorganism</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not known</td>
<td>34</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>15</td>
</tr>
<tr>
<td>Other staphylococci</td>
<td>10</td>
</tr>
<tr>
<td>Streptococci</td>
<td>9</td>
</tr>
<tr>
<td>Enterobacteria</td>
<td>4</td>
</tr>
<tr>
<td>Brucella</td>
<td>0.4</td>
</tr>
<tr>
<td>Mycobacterium tuberculosis</td>
<td>21</td>
</tr>
<tr>
<td>Two microorganisms combined</td>
<td>1.5</td>
</tr>
<tr>
<td>Candida</td>
<td>0.3</td>
</tr>
<tr>
<td>Aspergillus</td>
<td>0.2</td>
</tr>
<tr>
<td>Other microorganisms</td>
<td>7</td>
</tr>
</tbody>
</table>

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**Figure 1.** Spondylodiscitis on a lateral view radiograph of the lumbar spine. Loss of disc height combined with erosion to the vertebral endplates, giving the cortical bone a blurred appearance.
CT

Because it is readily available, it offers the option of views in multiple planes, and it is more sensitive, CT scanning is useful, especially to study areas that are difficult to analyse on standard radiography such as the dorsolumbar spine or lower cervical spine. Abnormalities on computed tomography are visible from the first 2 weeks of infection in half of all patients. An assessment of signs will look for early disc involvement that manifests as reduced bone density [5]. Areas of osteolysis, bone erosion, or vertebral endplate geodes can be easily identified (Fig. 2). CT scanning also allows the clinician to make a much more precise assessment of the extent of bone destruction (especially in the posterior vertebral arch), as well as being able to detect involvement of the vertebral canal, which is not visible on standard radiography. When the soft tissue is involved, this leads to paravertebral thickening with a loss of peripheral fat planes. The fact that this thickening is circumferential and not focal makes it a useful sign to differentiate infection from a tumour. Intravenous injection of an iodine-based contrast medium shows wall enhancement of any paravertebral or epidural abscesses, as well as phlegmons. Furthermore, CT scanning is the best technique that is currently available for visualising bone sequestra within the canals, residual calcification, and the presence of gas within an abscess. But in spite of these clear advantages, CT scanning does not allow for a full assessment of the extent of abscess within the canals, of whether there are lesions in the dural tube, or of perispinal nerve structures. MRI is more reliable for investigating these signs.

MRI

MRI is the examination of choice for diagnosing spondylodiscitis because it is sensitive and specific [6]. The acquisition classically required includes views in the sagittal and axial planes on T2-weighted sequences with fat signal suppression and T1-weighted sequences, before and after the injection of a contrast medium with fat signal saturation. Irrespective of the agent causing the infection, the characteristic findings in spondylodiscitis are high signal intensity from the discs on T2-weighted images, low signal intensity on T1 and high signal intensity on T2-weighted images from the two adjacent vertebrae, as well as thickening of the paravertebral soft tissue and/or involvement within the vertebral canals [6–9] (Fig. 3). In the vertebral body, the inflammatory reaction leads to an increase in the extracellular component of trabecular bone, resulting in the normal high signal intensity from the vertebral bodies being replaced by low signal intensity on T1-weighted images [10]. The age of the patient must be taken into account because in young patients red bone marrow remains predominant and the high signal intensity on T1 that it produces could mask

**Figure 2.** CT scan of tuberculous spondylodiscitis. Sagittal plane reconstruction: there is a centrosomatic geode.

**Figure 3.** Characteristic signs of spondylodiscitis on a sagittal plane MRI: a: on T1-weighted sequences the vertebral endplates present low signal intensity; b: on T2-weighted sequences there is high signal intensity from the disc; c: on T1 Fat Sat after gadolinium injection the vertebral endplates and the degenerated intervertebral disc show enhancement.
that of the inflammation [6]. High signal intensity on T2 is visualised even more clearly when fat saturation sequences are used (T2 Fat Sat or STIR) [11].

A contrast medium must be used because it shows the often diffuse enhancement of the subchondral bone and the disc. It is rare to see no enhancement (less than 5%) [11]. Other signs can be seen in the vertebral body: in more than two-thirds of cases, there is cortical bone loss in the vertebral endplates, which is a characteristic finding and is better visualised on T1-weighted sequences [7], or involvement of the posterior arch, which is more common in tuberculous spondylodiscitis [12]. Intervertebral disc involvement is characterised by a loss of disc height producing high signal intensity on T2 (present in between 50 and 90% of cases, with 95% sensitivity) (Fig. 4) and low signal intensity on T1 [7,9]. It is very common to find contrast uptake in the intervertebral disc, seen in between 70 and 100% of cases.

When the soft tissue is affected, this is visualised as thickening of the paravertebral soft tissue appearing with low signal intensity on T1, high signal intensity on T2, and it is contrast enhancing [4,9]. Contrast uptake is homogenous where there is pleurisy, while peripheral and ring-enhancement is seen in abscesses, as only the capsule takes up gadolinium (Fig. 5).

Authors differ in their assessment of how common soft tissue involvement is in spondylodiscitis, but it is always in excess of 50% of cases. Disease spread to more than three superior vertebral bodies is suggested to be an important diagnostic finding suggestive of tuberculosis (seen in 85% of cases as against 40% in pyogenic spondylodiscitis) [11], as is an abscess with thin walls (Fig. 6). Finally, in almost three-quarters of cases there is spinal epiduritis, which can be identified very easily when a contrast medium is used, but it can be missed when unenhanced T1 and T2-weighted sequences are used because its signal is similar to that of cerebrospinal fluid [11]. Table 2 brings together the MRI findings that have greatest sensitivity for diagnosing spondylodiscitis.

<table>
<thead>
<tr>
<th>Table 2 Value of MRI signs.</th>
<th>Sensitivity</th>
</tr>
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<tbody>
<tr>
<td>Signs on MRI</td>
<td></td>
</tr>
<tr>
<td>1 Inflammation of the soft tissue (high T2 signal intensity and contrast uptake)</td>
<td>98%</td>
</tr>
<tr>
<td>2 Disc enhancement (contrast uptake)</td>
<td>95%</td>
</tr>
<tr>
<td>3 High T2 signal intensity from the disc or fluid-like signal</td>
<td>93%</td>
</tr>
<tr>
<td>4 Loss of intradiscal space</td>
<td>84%</td>
</tr>
<tr>
<td>1+2</td>
<td>100%</td>
</tr>
<tr>
<td>2+3</td>
<td></td>
</tr>
<tr>
<td>3+4</td>
<td></td>
</tr>
<tr>
<td>1+3</td>
<td></td>
</tr>
<tr>
<td>1+ destruction of the vertebral endplates</td>
<td></td>
</tr>
</tbody>
</table>
Specific and misleading forms

Some forms of spondylodiscitis need to be discussed here either because of the infective agent or the age of the patient at disease onset.

Tuberculous spondylodiscitis

In France, over 75% of cases of tuberculous spondylodiscitis are found in the immigrant population. Clinically, the infection is often sub-acute at onset, with inconsistent presentation of inflammatory signs on laboratory tests and concomitant visceral tuberculosis. On imaging, there are three signs clinicians should be aware of:

- spinal cord compression is common (Fig. 7);
- centrosome geodes, often mirrored in another part of the intervertebral disc and often visible at multiple levels of the spine (Fig. 8), sometimes combined with lesions of the posterior arch;
- bi-lobed epidural abscesses that are often large, with distinct margins and that remain localised under the anterior longitudinal ligament (Fig. 9). Due to these voluminous abscesses, carrying out frontal plane MRI views or coronal plane CT reconstructions is justified.

It is worth remembering that infectious spinal lesions caused by tuberculosis can result in images showing the ivory vertebra sign or vertebra plana.

Brucellar spondylodiscitis

This condition is very rare in France outside of a specific professional context. Serology usually points towards this diagnosis. Imaging usually shows destructive lesions that are less aggressive than in other forms of spondylodiscitis and that may be accompanied by bone proliferation [13]. On MRI clinicians should be aware of the following suspicious findings: early disc involvement, involvement predominantly of the superior endplate underlying the pathological disc, and a lower incidence of epidural abscesses.

Forms in children and newborn babies

Although the clinical picture is often nonspecific (the classic presentation is that of a child who refuses to sit down),
Infections sequences is newborn indicated phy and weighted mon signs in (Fig. 10). Repeated radiography shows loss of disc height and erosion to one or two vertebral endplates. If a MRI is carried out early, it is essential to look for the common "degenerative" type appearance, which is principally indicated by a disc producing low signal intensity on T2-weighted sequences (Fig. 11). At a later stage, inflammatory signs are usually found (high signal intensity on T2-weighted sequences from the vertebral endplates and contrast uptake in the trabecular bone and disc peripheries) combined with loss of intervertebral disc height. In some cases, sonography can contribute to early diagnosis of spondylodiscitis in newborn babies.

Other specific circumstances

Here we would draw attention to:
- spondylodiscitis that occurs in immune suppressed territories, in which there are often only moderate signs of inflammation in the trabecular bone, or they may even be absent altogether;
- suspected spondylodiscitis at a very early stage, in which MRI can show an isolated, subtle lesion to the vertebral body opposite the vertebral endplate; at this stage, the disc may be normal and clinicians need to look for specific abnormalities in the areas of the ligaments.

Differential diagnosis

The differential diagnoses of spondylodiscitis consist essentially of certain inflammatory or mechanical pathologies that can mimic spondylodiscitis, especially on MRI. Inflammatory spondylarthropathy and some degenerative disc diseases (Fig. 12) of atypical severity (erosive disc disease, microcrystalline disc disease, disc disease in patients on dialysis, etc.) can lead to abnormalities of suspicious appearance, with clear enhancement of the disc and bands of enhancement in the vertebral endplates [14].

Clinicians must also set out to investigate any findings suggestive of a non-septic cause:
- concomitant presence of involvement in several areas of the spine;
- cortical bone of the endplates is preserved, condensation in the endplates;
- absence of fluid collection in the disc or perivertebral area, presence of gas within the discs;
- absence of disease progression between two consecutive imaging examinations.

Other diagnoses may also sometimes be discussed: recent vertebral compression fracture in which the abnormal signal is localised to the vertebral endplates while the disc is preserved; a multifocal tumoural pathology (metastases, myeloma, lymphoma) that could be difficult to distinguish

Figure 9. Tuberculous spondylodiscitis. Gadolinium-enhanced T1-weighted sagittal plane MRI with Fat Sat. Bi-lobed epidural abscess (asterisk) in a classical position under the anterior longitudinal ligament (arrows).

Figure 10. Spondylodiscitis in a newborn baby. Lateral view radiography carried out on day one (a) and day 30 (b). Changes on radiology, especially a reduction in disc height, arise quickly.
Figure 11. Spondylodiscitis in a child: a: sagittal plane T2-weighted MRI: the disc has the appearance of degenerative disease, essentially low signal intensity on T2-weighted sequences; b: gadolinium-enhanced T1-weighted sequences with Fat Sat: no notable enhancement after contrast medium injection.

from tuberculosis affecting the vertebral body with no associated disc lesion.

The role of imaging in identifying the bacterial cause of spondylodiscitis

Taking specimens for microbiology assessment in order to identify the infective agent causing spondylodiscitis as quickly as possible can be considered to be an emergency procedure. Very often it is delayed and carried out after empirical antibiotic therapy has been started, with the microorganism still remaining unidentified.

A percutaneous discovertebral aspiration should only be considered if other microbiology examinations (blood cultures, urinalysis, intradermal reaction and specimens for Koch bacillus (KB) testing, brucella serology, etc.) are negative. If the patient has had intradiscal surgery, recourse to discovertebral aspiration or biopsy should be swifter, as blood cultures are almost always negative [15]. Depending on the clinician’s preference, this intervention can be guided by fluoroscopy or CT [16]. The approach routes vary, but the most reliable ones must be prioritised: postero-lateral and transpedicular approach for the lumbar spine [17,18], and the inter costotransverse approach for the thoracic spine. Ideally, seven samples should be taken: four specimens from the bone (two from the superior endplate and two from the inferior endplate), two specimens from the disc (one for microbiology and another for pathology) and finally one specimen at the end of the intervention after lavage of the disc space using normal saline solution, with the fluid then being aspirated for microbiological analysis. Microbiology (three or four specimens) and histology examinations (two specimens) are essential, and PCR (polymerase chain reaction) may potentially also be carried

Figure 12. Sagittal (a) and frontal plane (b) computed tomography reconstructions. The presence of air within the disc (arrow head), mirrored areas of sclerosis (asterisk) and distinct sites of erosion (arrows) must tip the balance in favour of the diagnosis of erosive degenerative disc disease.
out (one specimen) [19]. Most authors also suggest that blood cultures should routinely be carried out immediately after the intervention (within 4 hours), which seems to encourage blood transfer of microorganisms.

This means that if blood cultures are negative, discovertebral aspiration and biopsy can lead to diagnosis of spondylodiscitis based on microbiology and identify the microorganism responsible in around two thirds of cases [20]. The result is usually negative in two specific situations: if the specimens are not of sufficient quality and/or quantity; if antibiotics prescribed before the intervention compromised a positive result on biopsy, which can happen in around 25 to 75% of cases [21–23]. Moreover, no study provides information on the minimum time required between stopping antibiotics and carrying out the aspiration and biopsy. Three specific contexts must be highlighted:

• tuberculous spondylodiscitis, in which there are often perispinal abscesses of significant volume. Taking a specimen from an abscess is often easier and is sufficient to establish diagnosis based on microbiology [24];
• postoperative spondylodiscitis, in which blood cultures are much less often positive [15] so recourse to discovertebral aspiration or biopsy should be routine;
• brucellar spondylodiscitis, in which the clinical context is more often suspicious and serology will lead to diagnosis in the vast majority of cases, without needing recourse to an invasive intervention [15,25,26].

Methods for monitoring spondylodiscitis

Good clinical progress usually rests on reduced spinal pain, inflammation resolving, a return to apyrexia, and normalised CRP.

The use of imaging to monitor spondylodiscitis remains controversial. It is recommended that radiography should be carried out once treatment has finished in order to look for any problems of spinal deformity. There is no indication for CT scanning in monitoring. MRI criteria for recovery appear later, from the 15th week of disease progression, but it is still indicated where patients do not respond well to treatment. It is nonetheless important to note that not all MRI signs follow the same pattern of progression. For example, paravertebral abscesses, epidural space involvement, oedema of the vertebral endplates, and intradiscal high signal intensity seem to resolve sooner than other signs do, and this may be suggestive of a more favourable progression.

Conclusion

Spondylodiscitis is an infection of a disc and the two adjacent vertebrae. When this diagnosis is put forward and suggested on radiography, though more easily visualised on MRI, blood cultures must be carried out and if these are negative, a discovertebral aspiration and biopsy or fine-needle aspiration of the disc must be carried out. In order to make a diagnosis based on microbiology, the way in which the intervention is carried out, its quality criteria, the process of taking of the specimen, and the use that is made of it must all be optimised. Finally, the use of imaging to monitor spondylodiscitis is only considered when clinical progress is poor or laboratory results are unsatisfactory.

**TAKE-HOME MESSAGES**

Standard radiography can be used to look for eroded vertebral endplates or loss of disc height.

MRI can contribute very early on by detecting oedema of the vertebral endplates and intervertebral disc, with contrast uptake in the disc and subchondral bone.

MRI is the examination of choice for analysing the extent of the infection in the soft tissue and epidural space, as these are contrast enhancing.

Imaging can play a role in guiding an intervention for biopsy to investigate the infective agent.

Clinical case study

An 88-year-old man presented a recent history of cervical spine pain accompanied by a slight fever; CRP levels were
200 mg/L. Computed tomography (Fig. 13) and an MRI scan (Figs. 14–16) were carried out.

Questions

1. Describe the abnormal signs on computed tomography.
2. Describe the abnormal signs on the MRI scan.
3. What are the findings that go against a diagnosis of infectious spondylodiscitis of the cervical spine?
4. What diagnosis would you suggest for this patient?
5. What are the various radiological findings to look for to point you towards this diagnosis?
6. Is a biopsy essential?

Answers

1. Loss of disc height in multiple areas, accompanied by multiple sites of erosion and sclerotic regions in the vertebral bodies.
2. High signal intensity from the vertebral bodies on STIR sequences. Low signal intensity from the discs on T2-weighted sequences. Strong contrast uptake in the vertebrae and soft tissue, but with no identifiable perispinal fluid collection.
3. Low signal intensity from the disc on T2-weighted sequences. Multiple sites are involved and there is no abscess in the soft tissue.
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4. Articular chondrocalcinosis. Although chondrocalcinosis of the cervical spine is relatively rare, it is important to be aware that isolated presentations can mimic infectious spondylodiscitis.

5. Involvement of more than three sites. Vacuum phenomena are common. Possible ligament involvement (yellow, periodontal, interspinal and supraspinal ligaments). Highly marked sclerosis of the vertebral endplates.

6. Progression to destruction of the spaces between the vertebral bodies, especially in the cervical spine. Spondylolisthesis of the facet joints is common.

7. No. Radiology investigations are carried out (knees, wrists, pubic symphysis) to look for calcifications, which would add further weight to diagnosis.

References


