Magnetic Resonance Imaging in Differential Diagnosis of Pyogenic Spondylodiscitis and Tuberculous Spondylodiscitis

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Summary

Background: Infectious spondylodiscitis is characterized by the involvement of two adjacent vertebrae and the intervening disc. Incidence rate of the disease is estimated at 0.4–2 cases per 100000 per year. Staphylococcus aureus is the most common infectious agent causing pyogenic spondylodiscitis. Non-pyogenic infections of the spine are most frequently caused by Mycobacterium tuberculosis, and fungi. Clinical symptoms are nonspecific. Early diagnosis and appropriate treatment can prevent unfavorable irreversible sequela for the patient.

Significant developments in techniques of imaging of pathological tissues raised expectations among the clinicians regarding possibility to distinguish between tuberculous spondylodiscitis and pyogenic spondylodiscitis on MR images. The aim of this study was to identify and differentiate between features of tuberculous and pyogenic spondylodiscitis on MR images.

Material/Methods: We performed retrospective analysis of MR images obtained from 34 patients with confirmed spondylodiscitis (18 with pyogenic spondylodiscitis, and 16 with tuberculous spondylodiscitis). Data acquisition was performed using 1.5 T MRI scanners where images were obtained using similar protocols. T2 TIRM and T1-weighted images with and without contrast enhancement were subject to assessment in coronal, axial and sagittal planes.

Results: Characteristic features of pyogenic spondylodiscitis include: involvement of the lumbar spine, ill-defined paraspinal abnormal contrast enhancement, diffuse/homogeneous contrast enhancement of vertebral bodies, low-grade destruction of vertebral bodies, hyperintense/homogeneous signal from the vertebral bodies on T2 TIRM images. Prevailing features of tuberculous spondylodiscitis included: involvement of the thoracic spine, involvement of 2 or more adjacent vertebral bodies, severe destruction of the vertebral body, focal/heterogeneous contrast enhancement of vertebral bodies, heterogeneous signal from the vertebral bodies on T2 TIRM images, well-defined paraspinal abnormal contrast enhancement, paraspinal and epidural abscesses, meningeal enhancement at the affected spine level.

Conclusions: Comparison of MR images of patients diagnosed with pyogenic spondylodiscitis and tuberculous spondylodiscitis allowed identification of individual characteristics for preliminary differentiation between TB and infectious spondylodiscitis and thereby enabling proper treatment.

MeSH Keywords: Bone Diseases, Infectious • Discitis • Magnetic Resonance Imaging • Spine • Tuberculosis, Spinal

PDF file: http://www.polradiol.com/abstract/index/idArt/899606
Background

Differential diagnosis of vertebral inflammatory lesions has always been a challenge to orthopedic surgeons and radiologists due to equivocal clinical course and unclear results of imaging studies. X-ray in particular being characterized by low specificity and relatively low sensitivity, especially at early stages of the disease.

Purulent/nonspecific/spondylitis is the most common inflammatory condition of the vertebra. It is rare in healthy individuals without clinical signs of immunosuppression, and most often develops as a result of penetrating trauma or surgical intervention/as a surgical complication.

In other cases of purulent spondylitis we should always suspect immunosuppression and presence of a primary inflammatory focus.

Prevalence of spondylitis is estimated at 0.4–2 cases per 100 000/year [1]. However, latest reports point to increasing incidence all over the world, particularly in the Southern Africa, where spondylitis is diagnosed in 11% of all patients reporting to the doctor due to back pain [2].

Two age peaks may be observed in the incidence of the disease – before the 20th year of life and between 50 and 70 years of age, with slight preponderance of men (M:X 1.5–2:1) [1].

Staphylococcus aureus is the most common cause of nonspecific spondylitis (20–84% of cases), followed by Enterobacteriaceae, Klebsiella, Staphylococcus epidermidis, Streptococcus viridans, Escherichia coli [3].

Pseudomonas aeruginosa and increasingly more common hospital strains of methicillin-resistant Staphylococcus aureus were identified among patients with infections due to intravenous injections (especially in the course of long-term hospital treatment) [4]. Treatment is particularly difficult in such cases, as those bacterial species are highly resistant to most antibiotics.

Atypical clinical course of spondylitis, where routine cultures yield negative results, may be indicative of tuberculosis, brucellosis, fungal, or parasitic infections [5–9].

Fungal infections are incredibly rare, being encountered almost exclusively among patients with profound immunosuppression (e.g. AIDS, leukemia, solid-organ transplantation, chemotherapy for neoplastic disease).

Spinal tuberculosis/Pott’s disease/constitutes about 50% cases of osteoarticular tuberculosis and 1–3% of all cases of tuberculosis; in the developing countries this proportion reaching as much as 10–15% [10].

Acquired immunosuppression due to, e.g. HIV infection, is an important factor increasing the incidence of tuberculosis. HIV-positive patients are at 20–37-fold higher risk of developing tuberculosis than individuals without the infection. Mycobacterium tuberculosis is the causative agent in Pott’s disease.

From a clinical point of view, the following factors indicate the nonspecific background of the inflammatory process: acute onset of the disease with hectic fever, surgical procedure on the abdomen immediately before the infection, significantly elevated inflammatory markers – CRP, ESR.

On the other hand, medical history often supports the tuberculous etiology of the disease: exposure to TB, insidious onset without significantly elevated temperature, lower CRP and ESR values, and positive tuberculin skin test.

X-ray is the first-line imaging study; it may demonstrate narrowing of intervertebral spaces and irregularity of vertebral marginal endplates [4]. These changes are visible only after several weeks of the pathological process.

Sclerosis of vertebral bodies, formation of bone blocks, destruction and collapse of vertebral bodies resulting in “gibbus deformity” (a deformation only observed in TB infections) may later develop.

Beside the above-mentioned features, CT examination reveals soft tissue edema and/or abscesses [11].

CT is more sensitive than X-ray in the diagnosis of moderately advanced lesions, but neither X-ray nor CT enable identification of early inflammatory process, or unequivocal differentiation between tuberculous and nonspecific etiology at later stages of the disease.

Before laboratory confirmation and final diagnosis is made based on the whole clinical picture, inflammatory process (particularly in case of specific lesions) may be so advanced, that treatment becomes difficult and prognosis unfavorable. Therefore, early diagnosis allows for implementation of proper treatment and protects the patient from irreversible sequelae: neurological disorders, vertebral deformation and resultant disability [12–21].

Significant progress in the imaging of tissue pathologies using MRI raised expectations among the clinicians with regard to the possibility to differentiate between nonspecific/purulent inflammation and spinal tuberculosis. In many cases, this imaging study was decisive for administration prolonged anti-mycobacterial treatment. Knowledge of the imaging features of nonspecific and specific spondylitis is of great clinical significance due to scarce or completely absent symptoms of tuberculosis.

Despite publishing of several dozen important clinical reports devoted to spondylitis over the past 20 years, only some of these publications contain comparative analysis of typical MRI characteristics of specific vs. nonspecific inflammation [12,22–25].

We attempted to identify distinguishing features for nonspecific/purulent and specific/tuberculous spondylitis in MR imaging.
Aim

The goal of this work was to identify the features distinguishing between nonspecific and specific spondylitis in MR imaging.

Material and Methods

Retrospective analysis of MR studies performed over the years 2011–2015 in 34 patients diagnosed with spondylitis (including 18 patients with nonspecific spondylitis – K:M=3:15, and 16 patients with TB spondylitis – K:M=7:9).

Age range of patients with purulent spondylitis was 47–74 years (median age 61.5 years); with TB spondylitis: 33–79 years (median age 52 years).

Among patients with nonspecific inflammation time from the onset of symptoms to MR imaging lasted from 3 months to one year, and from 5 months to one year among patients with TB infection.

Preliminary diagnosis of spondylitis was confirmed using microbiological studies, microscopy, and in some cases, based on positive response to implemented treatment.

MR studies, always preceded by x-ray imaging, were performed with 1.5T apparatuses using similar protocols.

T1-weighted, T2 TIRM, T1-weighted with contrast sequences in sagittal, transverse, and frontal planes were subject to assessment.

MRI studies were consulted independently by two radiologists with years of experience in the diagnostics of musculoskeletal system.

The following features were evaluated:
1. Level of lesions;
2. Number of involved vertebrae;
3. Vertebral body signal in T1-weighted imaging;
   - two vertebral bodies adjacent to the inflamed disc were assessed and compared to the signal from the remaining vertebral bodies;
   - signal was described as hypointense, hyperintense, isointense, heterogeneous (hypo- and hyperintense areas) with respect to the non-inflamed vertebrae;
4. Scope of signal in T1-weighted images;
   - two vertebrae adjacent to the inflamed disc were assessed;
   - scope of signal was described as 25%, 50%, 75%, or 100% of that from the unaffected vertebrae;
5. Vertebral signal in T2 TIRM images;
   - two vertebral bodies adjacent to the inflamed disc were assessed and compared to the signal from the remaining vertebrae;
   - signal strength was described as hypointense, hyperintense, isointense, fluid, heterogeneous (hypo-, hyperintense, fluid areas) in relation to the unaffected vertebrae;
6. Scope of signal in T2 TIRM images;
   - two vertebral bodies adjacent to the inflamed disc were assessed;
   - scope of signal was described as 25%, 50%, 75%, or 100% of that from the vertebral body;
7. Type of signal enhancement in T1-weighted images following administration of contrast and the scope of contrast enhancement;
   - two vertebral bodies adjacent to the affected disc were assessed;
   - it was described as diffuse/homogeneous, focal/heterogeneous, marginal, lack of signal enhancement;
   - scope of signal was described as 25%, 50%, 75%, or 100%;
8. Extent of vertebral destruction;
   - the most severely affected vertebra adjacent to the inflamed disc was assessed and compared to the unchanged vertebral bodies above and below the lesion;
   - degree of height reduction was described as follows: 0 – no height reduction, 1 – <25% reduction, 2 – 25–50% reduction, 3 – 50–75% reduction, 4 – >75% reduction;
9. Condition of the marginal endplate;
   - marginal endplate of the most severely affected vertebral body adjacent to the infected disc was assessed in T1-weighted images;
   - endplate was described as: unchanged, with erosions, complete destruction (endplate not visible);
10. Signal from the intervertebral disc;
    - inflamed discs were compared to the unaffected ones;
    - in T1-weighted images signal was described as isointense, hypointense, hyperintense, heterogeneous (hyper/hypo);
    - in T2 TIRM images it was described as isointense, hypointense, hyperintense, fluid, heterogeneous (hyper/hypo/fluid);
11. Contrast enhancement of the intervertebral disc in T1-weighted images;
    - described as diffuse, focal, marginal, lack of enhancement;
12. Extent of intervertebral disc destruction;
    - none – intervertebral disc height and signal are unchanged;
    - mild – height of the disc is unaffected, signal is changed, height is increased secondary to widening of intervertebral space;
    - moderate – disc height decreased by <50%, height of the disc is partly maintained and signal with minute fluid-filled area;
    - severe – height of the disc decreased by >50%;
    - complete destruction – disc abscess (fluid signal in T2 TIRM images without contrast enhancement), disc structures indistinguishable;
13. Areas of contrast enhancement in paravertebral soft tissues;
    - described as well-demarcated vs. poorly-demarcated regions of contrast enhancement;
14. Moreover, we assessed for the presence of an abscesses in paravertebral tissues, and meningeal enhancement at the affected vertebral segment (segment defined as two affected vertebral bodies and the intervertebral disc in between).
Results

The above-mentioned features/distractors/enabling differentiation between specific vs. nonspecific inflammatory disease were subject to statistical analysis. Tables 1–20 present these results. There is a clear relationship between the affected vertebral level and type of infection. The thoracic (Th) region is more characteristic for tuberculosis, while the lumbar (L) region is more specific for purulent spondylitis (Table 1).

Table 2 shows that the number of vertebral bodies not exceeding 2 suggests nonspecific inflammation, while larger number of affected vertebrae are indicative of tuberculosis.

Table 3 demonstrates lack of statistical dependence between the types of signal from the vertebral bodies in T1-weighted images and spondylitis etiology.

There was no statistical relationship between the scope of changed vertebral signal in T1-weighted images and type of inflammatory condition (Table 4).
### Table 3. Signal intensity from vertebral bodies on T1-weighted images.

| Variable                                | Diagnosis            | Total |
|-----------------------------------------|----------------------|-------|
| **Vertebrae – Signal intensity on T-weighted images** |                      |       |
| Hypointense                             |                      |       |
| Absolute number                         | 18                   | 14    | 32   |
| % in a column                           | 100.0%               | 87.5% | 94.1%|
| Standardized residuals                  | 1.5                  | -1.5  |      |
| Heterogeneous                           |                      |       |
| Absolute number                         | 0                    | 2     | 2    |
| % in a column                           | 0.0%                 | 12.5% | 5.9% |
| Standardized residuals                  | -1.5                 | 1.5   |      |
| Total                                   | Absolute number      | 18    | 16   | 34   |
| % in a column                           | 100.0%               | 100.0%| 100.0%|

**Result of statistical analysis**

- **Value**: 0.265
- **Level of significance (p-value)**: 0.122

**Statistical test**: Crammer's V

### Table 4. Scope of altered signal from vertebral bodies in T1-weighted images.

| Variable                                | Diagnosis            | Total |
|-----------------------------------------|----------------------|-------|
| **Vertebrae – Scope of T1-weighted signal** |                      |       |
| 25%                                     | Absolute number      | 2     | 0    | 2    |
| % in a column                           | 11.1%                | 0.0%  | 5.9% |
| 50%                                     | Absolute number      | 3     | 3    | 6    |
| % in a column                           | 16.7%                | 18.8% | 17.6%|
| 75%                                     | Absolute number      | 11    | 11   | 22   |
| % in a column                           | 61.1%                | 68.8% | 64.7%|
| 100%                                    | Absolute number      | 10    | 11   | 21   |
| % in a column                           | 55.6%                | 68.8% | 61.7%|
| Total                                   | Absolute number      | 18    | 16   | 34   |

**Result of statistical analysis**

- **Value**: 2.755
- **Level of significance (p-value)**: 0.600

**Statistical test**: chi-square (degrees of freedom=4)

### Table 5. Signal intensity from vertebral bodies in T2-weighted TIRM images.

| Variable                                | Diagnosis            | Total |
|-----------------------------------------|----------------------|-------|
| **Vertebrae – Signal intensity in T2 TIRM images** |                      |       |
| Hyperintense                            | Absolute number      | 16    | 5    | 21   |
| % in a column                           | 88.9%                | 31.3% | 61.8%|
| Standardized residuals                  | 3.5                  | -3.5  |      |
| Heterogeneous                           | Absolute number      | 2     | 11   | 13   |
| % in a column                           | 11.1%                | 68.8% | 38.2%|
| Standardized residuals                  | -3.5                 | 3.5   |      |
| Total                                   | Absolute number      | 18    | 16   | 34   |
| % in a column                           | 100.0%               | 100.0%| 100.0%|

**Result of statistical analysis**

- **Value**: 0.592
- **Level of significance (p-value)**: 0.001

**Statistical test**: Crammer's V
### Table 6. Scope of altered signal from vertebral bodies in T2 TIRM images.

| Variable               | Diagnosis               | Total |
|------------------------|-------------------------|-------|
|                        | Purulent infection      | Tuberculosis |
| Vertebrae – Scope of T2 TIRM signal |                        |       |
| Absolute number        | 1                       | 0     | 1 |
| % in a column          | 5.6%                    | 0.0%  | 2.9% |
| 25%                    |                         |       | |
| Absolute number        | 3                       | 1     | 4 |
| % in a column          | 16.7%                   | 6.3%  | 11.8% |
| 50%                    |                         |       | |
| Absolute number        | 9                       | 3     | 12 |
| % in a column          | 50.0%                   | 18.8% | 35.3% |
| 75%                    |                         |       | |
| Absolute number        | 14                      | 15    | 29 |
| % in a column          | 77.8%                   | 93.8% | 85.3% |
| 100%                   |                         |       | |
| Absolute number        | 18                      | 16    | 34 |
| % in a column          | -                       | -     | - |
| Total                  | Absolute number         | 18    | 16 | 34 |
| % in a column          | -                       | -     | - |

**Result of statistical analysis**

| Value | Level of significance (p-value) |
|-------|---------------------------------|
| 7.146 | 0.128                           |

### Table 7. Type of vertebral contrast enhancement.

| Variable               | Diagnosis               | Total |
|------------------------|-------------------------|-------|
|                        | Purulent infection      | Tuberculosis |
| Vertebrae – Contrast enhancement |                        |       |
| Absolute number        | 16                      | 6     | 22 |
| % in a column          | 88.9%                   | 37.5% | 64.7% |
| Homogeneous            |                         |       | |
| Standardized residuals | 3.1                     | -3.1  | |
| Absolute number        | 2                       | 10    | 12 |
| % in a column          | 11.1%                   | 62.5% | 35.3% |
| Heterogeneous          |                         |       | |
| Standardized residuals | -3.1                    | 3.1   | |
| Absolute number        | 18                      | 16    | 34 |
| % in a column          | 100.0%                  | 100.0%| 100.0% |
| Total                  |                         |       | |

**Result of statistical analysis**

| Value | Level of significance (p-value) |
|-------|---------------------------------|
| 0.537 | 0.002                           |

### Table 8. Scope of vertebral contrast enhancement.

| Variable               | Diagnosis               | Total |
|------------------------|-------------------------|-------|
|                        | Purulent infection      | Tuberculosis |
| Vertebrae – Scope of contrast enhancement |                        |       |
| Absolute number        | 2                       | 0     | 2 |
| % in a column          | 11.1%                   | 0.0%  | 5.9% |
| 25%                    |                         |       | |
| Absolute number        | 3                       | 2     | 5 |
| % in a column          | 16.7%                   | 12.5% | 14.7% |
| 50%                    |                         |       | |
| Absolute number        | 10                      | 9     | 19 |
| % in a column          | 55.6%                   | 56.3% | 55.9% |
| 75%                    |                         |       | |
| Absolute number        | 13                      | 12    | 25 |
| % in a column          | 72.2%                   | 75.0% | 73.5% |
| 100%                   |                         |       | |
| Absolute number        | 18                      | 16    | 34 |
| % in a column          | -                       | -     | - |
| Total                  | Absolute number         | 18    | 16 | 34 |
| % in a column          | -                       | -     | - |

**Result of statistical analysis**

| Value | Level of significance (p-value) |
|-------|---------------------------------|
| 2.041 | 0.728                           |
There is a relationship between type of signal from vertebral bodies in T2 TIRM images and the type of infection. Hyperintense signal is typical for purulent infection, while heterogeneous signal is typical for tuberculosis (Table 5).

Scope of altered signal from vertebral bodies in T2-weighted images is not associated with a specific type of infection (Table 6).

We demonstrated a relationship between type of contrast enhancement of vertebral bodies and type of infection. Homogeneous enhancement suggests purulent infection, while heterogeneous enhancement indicates tuberculous spondylitis (Table 7).

There is no statistically significant dependence between the scope of contrast enhancement of vertebral bodies and the type of inflammation (Table 8).

Table 9 shows that vertebral signal in T1-weighted images does not correlate with the type of inflammation. In Table 10 we demonstrated lack of statistically significant

| Variable | Diagnosis | Total |
|----------|-----------|-------|
| Disc – Signal in T1-weighted images | Purulent infection | Tuberculosis |
| | Absolute number | 15 | 16 | 31 |
| | % in a column | 83.3% | 100.0% | 91.2% |
| | Standardized residuals | −1.7 | 1.7 |
| Isointense | | |
| Hypointense | Absolute number | 3 | 0 | 3 |
| | % in a column | 16.7% | 0.0% | 8.8% |
| | Standardized residuals | 1.7 | −1.7 |
| Total | Absolute number | 18 | 16 | 34 |
| | % in a column | 100.0% | 100.0% | 100.0% |

Result of statistical analysis

| Statistical test: Crammer's V | .293 | 0.087 |

| Variable | Diagnosis | Total |
|----------|-----------|-------|
| Discs – Signal intensity in T2 TIRM images | Purulent infection | Tuberculosis |
| | Absolute number | 0 | 3 | 3 |
| | % in a column | 0.0% | 18.8% | 8.8% |
| | Standardized residuals | −1.9 | 1.9 |
| Isointense | | |
| Hyperintense | Absolute number | 7 | 3 | 10 |
| | % in a column | 38.9% | 18.8% | 29.4% |
| | Standardized residuals | 1.3 | −1.3 |
| Fluid | Absolute number | 7 | 6 | 13 |
| | % in a column | 38.9% | 37.5% | 38.2% |
| | Standardized residuals | .1 | −.1 |
| Heterogeneous | Absolute number | 4 | 4 | 8 |
| | % in a column | 22.2% | 25.0% | 23.5% |
| | Standardized residuals | −.2 | .2 |
| Total | Absolute number | 18 | 16 | 34 |
| | % in a column | 100.0% | 100.0% | 100.0% |

Result of statistical analysis

| Statistical test: Crammer's V | .367 | 0.206 |
### Table 11. Type of intervertebral disc contrast enhancement.

| Variable | Diagnosis                  | Total |
|----------|----------------------------|-------|
|          | Discs – Contrast enhancement |       |
|          | Absolute number             |       |
|          | % in a column               |       |
|          | Standardized residuals      |       |
| Diffuse  | Purulent infection          | 3     |
|          | 16.7%                       |       |
|          | 1.7                         |       |
|          | 8.8%                        |       |
|          | Tuberculosis                | 0     |
|          | 0.0%                        |       |
|          | −1.7                        |       |
|          | 3                           |       |
| Focal    | Purulent infection          | 2     |
|          | 11.1%                       |       |
|          | −.1                         |       |
|          | 11.8%                       |       |
|          | Tuberculosis                | 2     |
|          | 12.5%                       |       |
|          | .1                          |       |
|          | 11.8%                       |       |
|          | Marginal                    | 11    |
|          | 61.1%                       |       |
|          | .7                          |       |
|          | 55.9%                       |       |
|          | None                        | 2     |
|          | 11.1%                       |       |
|          | −1.8                        |       |
|          | 23.5%                       |       |
|          | Total                       | 18    |
|          | 100.0%                      |       |

**Result of statistical analysis**

| Value | Level of significance (p-value) |
|-------|---------------------------------|
| .398  | 0.146                           |

### Table 12. Severity of vertebral destruction.

| Variable | Diagnosis                  | Total |
|----------|----------------------------|-------|
|          | Vertebrae – Severity of destruction |       |
|          | Absolute number             |       |
|          | % in a column               |       |
|          | Standardized residuals      |       |
| None     | Purulent infection          | 3     |
|          | 11.1%                       |       |
|          | .9                          |       |
|          | 11.8%                       |       |
|          | Tuberculosis                | 1     |
|          | 6.3%                        |       |
|          | −.9                         |       |
|          | 11.8%                       |       |
| <25%     | Purulent infection          | 2     |
|          | 11.1%                       |       |
|          | .5                          |       |
|          | 8.8%                        |       |
|          | Tuberculosis                | 1     |
|          | 6.3%                        |       |
|          | −.5                         |       |
|          | 8.8%                        |       |
| 26–50%   | Purulent infection          | 10    |
|          | 55.6%                       |       |
|          | 2.6                         |       |
|          | 35.3%                       |       |
|          | Tuberculosis                | 2     |
|          | 12.5%                       |       |
|          | −2.6                        |       |
|          | 35.3%                       |       |
| 51–75%   | Purulent infection          | 2     |
|          | 11.1%                       |       |
|          | −1.8                        |       |
|          | 23.5%                       |       |
|          | Tuberculosis                | 6     |
|          | 37.5%                       |       |
|          | 1.8                         |       |
|          | 23.5%                       |       |
| > 75%    | Purulent infection          | 1     |
|          | 5.6%                        |       |
|          | −2.3                        |       |
|          | 20.6%                       |       |
|          | Tuberculosis                | 6     |
|          | 37.5%                       |       |
|          | 2.3                         |       |
|          | 20.6%                       |       |
| Total    | Purulent infection          | 18    |
|          | 100.0%                      |       |
|          | Tuberculosis                | 16    |
|          | 100.0%                      |       |

**Result of statistical analysis**

| Value | Level of significance (p-value) |
|-------|---------------------------------|
| .598  | 0.016                           |
dependence between type of signal from intervertebral discs in T2 TIRM images and the type of inflammation.

Table 11 shows lack of statistically significant relationship between type of contrast enhancement of the intervertebral discs and a type of inflammation.

Table 12 shows that degree of vertebral destruction below 50% is more characteristic for purulent infection, while destruction exceeding 50% is more tightly associated with TB infection.

Table 13 demonstrates that the degree of destruction of marginal endplates does not determine the type of inflammation. The extent of intervertebral disc destruction also does not correlate with type of spondylitis (Table 14).

| Variable | Diagnosis | Total |
|----------|-----------|-------|
| Endplates | | |
| Absolute number | | |
| % in a column | | |
| Standardized residuals | | |
| | | |
| [Insert Table 11 here] |
| [Insert Table 12 here] |
| | | |
| Total | | |
| Absolute number | | |
| % in a column | | |
| Standardized residuals | | |

| Result of statistical analysis | Value | Level of significance (p-value) |
|--------------------------------|-------|--------------------------------|
| Statistical test: Crammer's V | .246  | 0.561                          |

| Variable | Diagnosis | Total |
|----------|-----------|-------|
| Discs – severity of destruction | | |
| Absolute number | | |
| % in a column | | |
| Standardized residuals | | |
| | | |
| [Insert Table 13 here] |
| [Insert Table 14 here] |
| | | |
| Total | | |
| Absolute number | | |
| % in a column | | |
| Standardized residuals | | |

| Result of statistical analysis | Value | Level of significance (p-value) |
|--------------------------------|-------|--------------------------------|
| Statistical test: Crammer's V | .274  | 0.110                         |

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### Table 15. Enhancement of paravertebral tissues.

| Variable                          | Purulent infection | Tuberculosis | Total |
|----------------------------------|-------------------|--------------|-------|
| Additional features – enhancement of paraspinal tissues |                   |              |       |
| Absolute number                  | 1                 | 0            | 1     |
| % in a column                    | 5.6%             | 0.0%         | 2.9%  |
| Standardized residuals           | 1.0              | -1.0         |       |
| 1 Absolute number                | 17                | 16           | 33    |
| % in a column                    | 94.4%            | 100.0%       | 97.1% |
| Standardized residuals           | -1.0             | 1.0          |       |
| Total                            | 18                | 16           | 34    |
| % in a column                    | 100.0%           | 100.0%       | 100.0%|

Result of statistical analysis

| Value | Level of significance (p-value) |
|-------|----------------------------------|
| .164  | 0.339                            |

Statistical test: Crammer's V

### Table 16. Types of enhancement of paraspinal tissues.

| Variable                          | Purulent infection | Tuberculosis | Total |
|----------------------------------|-------------------|--------------|-------|
| Additional features – type of enhancement of paraspinal tissues |                   |              |       |
| Well- demarcated                 |                   |              |       |
| Absolute number                  | 4                 | 15           | 19    |
| % in a column                    | 23.5%             | 93.8%        | 57.6% |
| Standardized residuals           | -4.1              | 4.1          |       |
| Poorly demarcated                |                   |              |       |
| Absolute number                  | 13                | 1            | 14    |
| % in a column                    | 76.5%             | 6.3%         | 42.4% |
| Standardized residuals           | 4.1               | -4.1         |       |
| Total                            | 17                | 16           | 33    |
| % in a column                    | 100.0%            | 100.0%       | 100.0%|

Result of statistical analysis

| Value | Level of significance (p-value) |
|-------|----------------------------------|
| .710  | 0.000                            |

Statistical test: Crammer's V

### Table 17. Paraspinal abscess.

| Variable                          | Purulent infection | Tuberculosis | Total |
|----------------------------------|-------------------|--------------|-------|
| Additional features – paraspinal abscess |                   |              |       |
| Absolute number                  | 11                | 4            | 15    |
| % in a column                    | 61.1%             | 25.0%        | 44.1% |
| Standardized residuals           | 2.1               | -2.1         |       |
| 1 Absolute number                | 7                 | 12           | 19    |
| % in a column                    | 38.9%             | 75.0%        | 55.9% |
| Standardized residuals           | -2.1              | 2.1          |       |
| Total                            | 18                | 16           | 34    |
| % in a column                    | 100.0%            | 100.0%       | 100.0%|

Result of statistical analysis

| Value | Level of significance (p-value) |
|-------|----------------------------------|
| .363  | 0.034                            |

Statistical test: Crammer's V
In Table 15 it is shown that contrast enhancement of para-
vertebral structures does not differentiate between types of
inflammation.

In Table 16 we present a relationship between type of
enhancement of paravertebral structures and a type of
inflammation. Well-demarcated enhancement is typical for
TB, while poorly demarcated enhancement is suggestive of
purulent infection.

Table 17 shows that presence of a paravertebral abscess is
significantly more often indicative of tuberculous infection.

Meningeal enhancement is strongly associated with tuber-
culous spondylitis (Table 18). Presence of an epidural
abscess is considerably more often indicative of tubercu-
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culous spondylitis (Table 18). Presence of an epidural
abscess is considerably more often indicative of tubercu-
los infection (Table 19).
Table 20. Intervertebral disc abscess.

| Variable | Diagnosis | Total |
|----------|-----------|-------|
|          | Purulent infection | Tuberculosis | 25 |
| Additional features – intervertebral disc abscess | 12 | 13 | 25 |
| Absolute number | % in a column | Standardized residuals |
| 0 | 66.7% | 81.3% | 73.5% |
| 1 | 33.3% | 18.8% | 26.5% |
| Absolute number | % in a column | Standardized residuals |
| Total | 18 | 16 | 34 |
| % in a column | 100.0% | 100.0% | 100.0% |

Result of statistical analysis

| Value | Level of significance (p-value) |
|-------|---------------------------------|
| Crammer’s V | .165 | 0.336 |

Table 21. Compilation of differentiating characteristics. Discrimination of tuberculous spondylitis from pyogenic spondylitis. Differentiating features.

| Variable | Nonspecific infection | Tuberculous infection |
|----------|-----------------------|-----------------------|
| Involved spinal level | L | TH |
| Number of affected vertebrae | <2 | >2 |
| Severity of destruction of vertebral bodies | <50% | >50% |
| Areas of paraspinal enhancement | Well-demarcated | Poorly demarcated |
| Vertebral signal in T2 TIRM images | Hyperintense/homogeneous | Heterogeneous |
| Vertebral enhancement | Diffuse/homogeneous | Focal/heterogeneous |
| Paraspinal abscess | 39% of cases | 75% of cases |
| Epidural abscess | 11% of cases | 56% of cases |
| Meningeal enhancement at the affected vertebral level | 28% of cases | 75% of cases |

Figure 1. 68-year-old patient diagnosed with Pyogenic Spondylodiscitis (PS). Images (A) T1 sag., (B) T2 TIRM sag., (C) T1 sag. with contrast enhancement. Inflammatory process of the Th11 and Th12 vertebral body, abscess in the intervertebral disc Th11–Th12.
The following features were more common in tuberculous infections: thoracic spine involvement (75% vs. 22%), involvement of >2 vertebral bodies (25% vs. 0%), more severe vertebral destruction, focal/heterogeneous contrast enhancement of vertebral bodies (63% vs. 11%), heterogeneous signal from vertebral bodies in T2 TIRM sequences (69% vs. 11%), well-demarcated contrast enhancement of paravertebral tissues (94% vs. 24%), presence of a paravertebral abscess 75% vs. 39%), meningeal enhancement at a level of the affected spinal segment (75% vs. 28%), epidural abscess (56% vs. 11%), (Figures 5A–5C, 6A–6D, 7A, 7B).

The majority of publications devoted to MR imaging of nonspecific and specific spondylitis describe similar symptomatology [10,20,21,22,23].

MR imaging did not show significant differences between nonspecific and specific inflammatory conditions with regard to the vertebral signal in T1-weighted images, or with respect to the extent of changes affecting vertebral bodies in T1-weighted and T2 TIRM images.

We also failed to observe significant difference with respect to the scope of vertebral contrast enhancement. Isointense signal from the intervertebral discs in T1-weighted images predominated in both types of inflammation.
T2 TIRM images demonstrated greater variability of signal from the intervertebral discs in cases of tuberculous infections (both isointense, as well as hyperintense, hypointense, and heterogeneous) among all examined patients irrespective of the phase of the disease.

We did not detect significant differences with respect to the pattern of contrast enhancement of the intervertebral discs or the degree of disc destruction. We showed similar prevalence of intervertebral disc abscesses in both types of inflammatory process. We did not observe a statistical relationship between the severity of marginal endplate destruction and a type of infection.

Several publications appeared in the recent years attempting to differentiate between nonspecific and tuberculous spondylitis based on MR imaging [12,22–25], as well as some review patients on these two disease entities [3,26–29].

Na-Young Jung et al. indicated the following features as the most differentiating between those two types of inflammation: presence of well-demarcated contrast enhancement areas in paravertebral soft tissues in tuberculosis, greater prevalence of abscesses in tuberculosis, involvement of several vertebral bodies in tuberculosis, thoracic spine involvement in tuberculosis [12].

Ming-Chau Chang et al. observed greater extent of vertebral destruction in tuberculous infection, heterogeneous signal from vertebral bodies following contrast administration in tuberculosis, and homogeneous contrast enhancement in purulent inflammation [22]. Likewise, Souza et al. emphasized the significance of vertebral enhancement pattern as a differentiating feature [22,23].

Moreover, in our work we demonstrated greater predilection of nonspecific inflammations to the lumbar spine region, which was previously described in numerous scientific reports concerning spondylitis – both review papers [3,26], as well as clinical studies [22]. However, Jung et al. failed to observe that predilection of nonspecific inflammations to the lumbar region of the vertebra [12].

Based on the results of clinical studies (Harada Y. et al. [25], Chang et al. [22]) Kyu Yeol Lee [3] published a review paper describing more frequent occurrence of epidural abscesses and meningeal spreading of inflammatory infiltration in TB infection. Sharif considered meningeal spreading rare in nonspecific inflammation [26].

We also observed greater frequency of occurrence of epidural abscesses and meningeal enhancement in spondylitis of tuberculous etiology.

Na-Young Jung et al., Souza et al., Griffith et al. [12,23,30] demonstrated involvement of several vertebral bodies as more characteristic for tuberculosis. Lee presented the same observation in his review article [3]. In our material...
we also observed more frequent involvement of several vertebral in tuberculous spondylitis.

Many reports published to date indicate sparing of intervertebral discs in tuberculous spondylitis [23,24,31,32], which was linked to the fact that mycobacteria do not produce proteolytic enzymes. In our study intervertebral disc destruction was similar in both types of inflammation, which might be due to longer disease duration before MR imaging. A study by Jung et al. also did not demonstrate the differences in disc involvement by the inflammatory process [12].

Unlike Chang et al., who underscored the increased incidence of intervertebral disc abscesses in nonspecific inflammation, in our study the incidence of abscess was similar in both types of inflammation [22].

Moreover, we also observed differences in the signal from vertebral bodies in T2 TIRM images. In both types of
inflammation – hyperintense/homogeneous in nonspecific, and heterogeneous in tuberculous infection.

Cited clinical studies did not indicate such characteristic as important for differentiation between types of inflammation. Jung et al., described only higher incidence of high signal from the inflamed vertebrae in T2-weighted images in tuberculous spondylitis; however, he did not not observe signal heterogeneity in those vertebral bodies [12].

Conclusions

Comparison of MR images in patients diagnosed with spinal tuberculosis and nonspecific spondylitis allowed to identify individual characteristics for preliminary differentiation between these two disease entities and establishing direction for further management.

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