Spinal Tuberculosis

Magnetic Resonance Imaging and Neurological Impairment

Robert Dunn, FCS(SA) Orth, MMed(Orth),* Ian Zondagh, FCS(SA) Orth, MMed(Orth),* and Sally Candy, FCRad(SA)†

Study Design. Retrospective descriptive study.

Objective. To evaluate the preoperative magnetic resonance imaging (MRI) findings in spinal tuberculosis and identify features that correlate with the neurologic status and outcome.

Summary of Background Data. MRI plays an important role in the diagnosis of spinal tuberculosis with a high specificity and sensitivity. It allows demonstration of bony, soft tissue and neural pathology; however, the clinical correlation is not clear.

Methods. MRI scans of 82 consecutively managed spinal tuberculosis patients over a 4-year period were studied. Data including age, gender, human immunodeficiency virus status, neurologic status were reviewed. This was correlated with preoperative MRI findings including level of involvement, percentage of vertebral body destruction, kyphotic angle, soft tissue involvement, cord size, and cord signal changes.

Results. Fifty-two percent of patients presented in a nonambulatory state, 21% mild neurologic deficit, and 27% were intact. Of those with neurologic deficit, significant recovery occurred in 92%, with 74% improving from nonambulatory to ambulatory status. The patients ambulant at presentation had a larger cord dimension than those who were not ambulatory. Cerebrospinal fluid persisting anterior to the cord at the apex of the deformity showed a trend to residual neurologic function. There was no significant correlation found between ambulatory status and the presence of an epidural abscess, kyphotic angle, or vertebral body destruction. There was no evidence of myelomalacia on the MRI scans, but cord signal changes on T2 images were present in 94% of patients presenting with neurologic deficit.

Conclusion. There is correlation between residual cord size, cerebrospinal fluid remaining anterior to the cord, presence of cord signal changes in the T2-weighted images, and neurologic deficit; however, none were predictive of outcome. There was no significant correlation found between ambulatory status and the presence of an epidural abscess, kyphotic angle, or vertebral body destruction.

Key words: tuberculosis, MRI, cord size, neurological status, spine.

Spine 2011;36:469–473

Tuberculosis (TB) remains a growing public health problem especially in developing countries. In South Africa, the World Health Organization reports the incidence of TB at 0.72% per year. Local experience suggests that this under reports the disease. This has been attributed to a detection of TB, lack of adequate primary health care facilities, poor sanitation, malnutrition, the presence of drug-resistant strains of mycobacterium tuberculosis, and the effects of human immunodeficiency virus. Bone and joint involvement develops in approximately 0.5% to 1% of patients with TB, and half of these affected patients will have TB of the spine.

The incidence of neurologic involvement in spinal TB is 10% to 47%. The spinal cord and cauda equina withstand the slow building pressure as occurs in TB epidural abscess. Compression of up to 76% of cord diameter can be tolerated with no neural deficit. However, when vascular or mechanical instability is present, paraplegia can be produced at lesser canal compromise.

Magnetic resonance imaging (MRI) has proven to be the most accurate radiologic investigation to diagnose and classify spinal tuberculosis, identifying early spinal cord changes.

The aim of this study is to correlate MRI findings with that of neurologic status and outcome in a cohort of TB spine patients undergoing surgical intervention.

MATERIALS AND METHODS

This retrospective descriptive study reviewed 82 consecutive patients with spinal tuberculous spondylitis that were managed in the spinal surgery unit between January 2002 and January 2006. All these patients underwent surgical intervention of some sort. In addition, patients were treated with 4 drug antituberculosis agents for a minimum of 9 months using the combination agent Rifafour, which contains Rifampicin, Isoniaztid, Ethambutol, and Pyrazinamide. Clinical response, normal ESR, and signs of radiographic healing

www.spinejournal.com 469

Copyright © 2011 Lippincott Williams & Wilkins. Unauthorized reproduction of this article is prohibited.
were used to determine when to stop medical treatment. The indications for surgery were to establish diagnosis, neurologic compromise, and axial instability. Surgery ranged from costotransversectomy to anterior debridement and reconstructions with allograft. This was decided on a case by case basis. All our patients had histopathologic and/or culture confirmation of tuberculous spinal infection.

A prospective database of demographics, neurologic status, laboratory findings, and surgical interventions is maintained. This was reviewed along with case notes, radiographs, and MRI findings. Specific clinical data evaluated included age, gender, human immunodeficiency virus status, duration of neurologic deficit, ambulatory status, motor and sensory neurologic status. The preoperative neurologic deficit was compared with the postoperative neurologic outcome, using the Frankel grading system.6

At presentation, 43 patients (52%) were nonambulatory and 22 patients (27%) had normal neurologic status, with the remaining 17 patients (21%) having mild neurologic deficit. The neurologic status before and after treatment was recorded using the Frankel grading system (Table 1). Of those with neurologic deficit, recovery occurred in 92%, with 74% improving from nonambulatory to ambulatory status. Only 8% showed no recovery at all. The Frankel A group went from 27 (33%) to only 3 (4%), whereas the Frankel E group changed from 23 (28%) to 62 (76%) after treatment (Figure 1). No patients were recorded as Frankel B, i.e., no motor but some sensation intact. Some of these may well be in the A group. As most of the patients are rural, and there are language and cultural difficulties when assessing subtle residual sensation, it is possible it could be missed. To allow for this possibility, analysis was done between ambulatory and nonambulatory, i.e., Frankel A, B, C versus D, E.

MRI was performed in all of our patients using a Siemens Symphony System (Magnetom) operated at 1.5 T in a supine position using spine surface coils, neck array coils, and head coils as needed. Contiguous 4-mm slices were obtained in the sagittal plane in T1 sequences (TR ± 500–650, TE ± 15), and T2 sequences (TR ± 4200, TE ± 110) and in the axial plane using T2 sequences (TR ± 4400, TE ± 90–100). Contrast was not used in any of the patients.

Only the sagittal MRI films were used for the purposes of the study as these are most useful in the clinical scenario in terms of decision making. The level of involvement,
RESULTS
The distribution of the spinal TB followed the expected pattern with 9 (11%) cervical spine, 54 (66%) thoracic spine, 5 (6%) thoracolumbar, 11 (13%) lumbar, and 3 (4%) sacral involvement. There were 12 patients (15%) who presented with noncontiguous spinal involvement, i.e., 2 separate sites, which were identified using whole spine MRI. Only 13 (16%) of our patients had posterior element involvement.

The relationship of neurologic impairment to the cord size was evaluated (Table 2).

In the nonambulatory groups (Frankel groups A–C), the average Apex/Average cord size ratio was 0.68, whereas in the ambulatory groups (Frankel D and E) it was 0.84. This was tested with a 2-tailed unpaired Student t test after confirmation of a normal distribution (Statistica 7), and found to be statistically significant (P = 0.005). Patients with lumbar and sacral spine involvement alone were excluded due to the cauda equina and not spinal cord involvement.

The presence of cerebrospinal fluid (CSF) anterior to the thecal sac cord in patients with cervical and thoracic disease was assessed (Figures 3, 4). Preservation of anterior CSF was found in only 11 patients (13%). The remaining 57 patients (70%) had none. The correlation of anterior CSF to ambulatory status in cervical and thoracic involvement using the Fisher exact test found a significant relationship of absent CSF to nonambulatory status (P = 0.0096) for preoperative status, but no relationship to prognosis.

Correlation of CSF found anterior to the cord at the apex of the deformity with our Apex/Average ratio, and neurologic status was made.

The average of the Apex/Average Ratio for the group of patients with CSF anterior to the cord (lumbar involvement excluded) was 0.89. The group without CSF remaining was only 0.67. We know that from the above-mentioned information that this does correlate with neurologic status.

<table>
<thead>
<tr>
<th>Frankel Grading Before</th>
<th>Frankel Grading After</th>
<th>Minimum Apex/Average Ratio</th>
<th>Maximum Apex/Average Ratio</th>
<th>Average Apex/Average Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A</td>
<td>0.4</td>
<td>0.83</td>
<td>0.56</td>
</tr>
<tr>
<td>A</td>
<td>C</td>
<td>0.33</td>
<td>1</td>
<td>0.66</td>
</tr>
<tr>
<td>A</td>
<td>D</td>
<td>0.43</td>
<td>0.92</td>
<td>0.63</td>
</tr>
<tr>
<td>A</td>
<td>E</td>
<td>0.18</td>
<td>0.86</td>
<td>0.57</td>
</tr>
<tr>
<td>C</td>
<td>C</td>
<td>0.8</td>
<td>1.2</td>
<td>0.93</td>
</tr>
<tr>
<td>C</td>
<td>D</td>
<td>0.73</td>
<td>0.77</td>
<td>0.75</td>
</tr>
<tr>
<td>C</td>
<td>E</td>
<td>0.5</td>
<td>0.86</td>
<td>0.68</td>
</tr>
<tr>
<td>D</td>
<td>D</td>
<td>0.92</td>
<td>0.92</td>
<td>0.92</td>
</tr>
<tr>
<td>D</td>
<td>E</td>
<td>0.43</td>
<td>1.17</td>
<td>0.76</td>
</tr>
<tr>
<td>E</td>
<td>E</td>
<td>0.57</td>
<td>1</td>
<td>0.85</td>
</tr>
</tbody>
</table>

Signal change on the T2-weighted images, indicating cord edema, was present in 56 patients (80%), and absent in the remaining 12 patients (20%). Of the 14 patients with lumbar and sacral involvement were also excluded here. Correlation of ambulatory status to cord signal changes was found to be significant. Of the 42 patients who were nonambulatory (Frankel A–C), all (100%) had cord signal changes present on T2-weighted images. Of the 26 patients who were ambulatory (Frankel D/E), only 14 had some cord signal changes on T2-weighted images. In the Frankel E group, 3 patients had cord signal changes. These 3 patients also had the smallest Apex/Average cord size ratio of the whole Frankel E group (0.57; 0.57; 0.6), which was much smaller than the average.
for the group (0.85). In the Frankel D group, 11 patients had cord signal changes and 3 did not despite having a neurologic deficit. In these, we found that the Apex/Average cord size ratio was at least equal to but mostly larger (0.66; 0.77; 1; 1) than the average size for the group (0.68). The morphology or size of signal change was not to be different between the different ambulatory function groups.

No MRI demonstrated a low intensity on T1-weighted images. Therefore, no evidence of myelomalacia was found.

Of the 36 patients with cord signal changes, only 5 patients showed no clinical recovery. There were no predictive features found for this on MRI; however, poor general health status was present in all these patients. Significant recovery from a nonambulatory (Frankel A–C) to ambulatory (Frankel D/E) status occurred in 31 of 42 (74%) patients. No patients deteriorated in neurologic function. In the 11 of 42 (26%) patients who remained nonambulatory, no predictive MRI features were found.

There was no significant correlation found between ambulatory status and the presence of an epidural abscess, the kyphotic angle, or percentage of vertebral body destruction.

**DISCUSSION**

The clinical outcome of TB spine patients is based on a multitude of factors such as general health status, extent of disease, etc. However, the MRI is frequently used in their assessment as it is an excellent tool for the evaluation of the pathology in spinal TB with neurologic complications, delineating pathology, and neural structures. Yet the clinical relevance is not always clear. This study attempts to give some insight into the correlation of these changes in relation to the neurologic outcome following surgical decompression.

Paraplegia in patients with active disease may be caused by mechanical pressure on the spinal cord by tubercular abscess, caseous granulation tissue, or debris. The localized pressure caused by internal gutter on the spinal cord or mechanical instability caused by pathologic subluxation or dislocation of vertebrae also may contribute to neurologic complications. Intrinsic changes in the spinal cord such as inflammatory edema or direct involvement of meninges and spinal cord by the tuberculous infection may lead to paraplegia. Infective thrombosis or endarteritis of spinal vessels leading to infarction of the spinal cord also may produce neurologic complications.

The spinal cord seems to have some physiologic reserve to withstand some pressure particularly when pressure develops slowly, as is the case with TB. Jain et al calculated canal encroachment on computed tomography scans in 15 patients with TB of the spine without neurologic complications from C3 to T12 and found that as much as 76% of spinal canal encroachment is compatible with an intact neural status. Our evaluation using MRI offers more detailed information regarding the exact size of the cord itself. We were able to directly visualize the cord and measure the mid sagittal dimension. This is a far more direct and accurate way of determining the cord compression.

In the nonambulatory groups, their average Apex/Average cord size ratio was significantly smaller (0.68) than the value in the ambulatory groups (0.84). There were few patients, only 10 of 82 with evidence of cord compression exceeding 50% of the expected dimensions. All of these except for 1 patient presented as a complete paraplegia. This been said though, due to the nature of the disease and favorable response to therapy, most of these patients had some neurologic recovery. This seems to indicate that cord compression alone is not solely responsible for prognosis. However, these data show that the cord is susceptible to pressure even if the disease process is slow and that previous values given are generous in their estimates. Our information shows us that at most, 40% of AP midsagittal cord compression is still possible without any neurologic implications.

We found no previous studies documenting the significance of CSF anterior to the cord. Our study shows a direct correlation with CSF anterior to the cord at the level of maximal involvement to the amount of cord compression, as may be expected. It is evident that those patients with CSF remaining anterior to the cord presented with far greater neurologic function and therefore a better outcome after treatment. The average of the Apex/Average Ratio for the group of patients with CSF anterior to the cord (lumbar involvement excluded) was 0.89. The group without CSF remaining was only 0.67. This correlates well with the Frankel groups as mentioned earlier when differentiating between the ambulatory and non-ambulatory groups.

Though the cord is known to be the target of the injury, surgical decompression does not invariably alleviate the neurologic fallout in tuberculous spondylitis. Correlation between cord signal changes and prognosis is expected, particularly the implications of both cord signal changes in T1- and T2-weighted images and their relation to neurologic prognosis. T2-weighted image signal changes correlate well with the state of neurologic involvement as all the patients with Frankel grades A to C had significant signal changes present. Even in those patients with mild involvement, it seems that T2 signal changes are sensitive for neurologic complications. Only 3 patients with mild neurologic deficit showed no evidence of cord edema on T2 images and in these patients had larger cord dimensions with CSF remaining anterior to the cord, possibly explaining the lack of cord changes present.

T1-weighted image cord changes indicating myelomalacia were universally absent. Myelomalacia is a phenomenon caused by long-standing compression and ischemia leading to significant cord damage and axonal loss with permanent loss of function and sometimes associated with the formation of a syrinx. The absence of this in our study can probably be explained but the fact that our patients were all treated in the active stage of the disease with a relatively short history.

**CONCLUSION**

MRI is mandatory in the evaluation and surgical management of spinal TB. Midsagittal cord size and CSF anterior to the cord correlate with neurologic deficit. Most cases have a favorable prognosis, which is understandable with the lack of...
T1 cord signal changes. No negative predictors of neurologic improvement were identified on MRI and these appear to be related to the general health of the patient.

Key Points

- MRI is an excellent tool to demonstrate pathology of TB of the spine.
- Residual cord size ratio, as measured on a mid-sagittal T2, correlates with neurologic status.
- The persistence of residual CSF anterior to the cord suggests preserved neurologic status.
- No significant correlation between ambulatory status and the presence of an epidural abscess, kyphotic angle, or vertebral body destruction.

References