Neural arch tuberculosis: radiological features and their correlation with surgical findings

NAIM-UR-RAHMAN, A. JAMJOOM, Z. A. B. JAMJOOM & A. M. AL-TAHAN

Abstract
Radiological features of 17 cases of neural arch tuberculosis (NAT), treated surgically by the authors, are reviewed and correlated with the operative and histopathological findings. The diagnostic accuracy of different imaging modalities in the evaluation of this rare, atypical form of spinal tuberculosis was found to be very low. Thus, the initial diagnosis was in error in 15 out of 17 of our cases. Recognition of the radiological diagnostic features of NAT is important, not only because they may mimic primary or metastatic spinal neoplasms, but also because of the surgical implications. Computed tomography (CT) and magnetic resonance imaging (MRI) features correlated most closely with the surgical findings, whereas plain spinal radiographs and myelograms were found to be non-specific and non-diagnostic.

Key words: Spinal compression, spinal computed tomography, spinal magnetic resonance imaging, spinal radiology, spinal tuberculosis.

Introduction
Tuberculosis of the spine, in its typical form, is a disease of two adjacent vertebral bodies with the destruction of the intervening intervertebral disc, with or without a paravertebral or a psoas abscess.1,2 A tuberculous process affecting the neural arch only, with complete sparing of the vertebral bodies and intervertebral discs, is rare,1 constituting less than 6% of all the cases of spinal tuberculosis.1 This atypical form of spinal tuberculosis, although previously reported,1,2 has not been sufficiently described in the medical literature. To our knowledge, this is the first report to include the MRI features of the neural arch tuberculosis (NAT). Since the advent of CT and MRI, more patients with NAT are being recognized; but they still pose diagnostic problems because they can be easily confused, on imaging studies, with primary or metastatic spinal tumours. To better understand the radiological features of NAT we have tried to correlate the imaging features with the surgical and histopathological findings.

Patients and methods
Seventeen patients with NAT (defined as a tuberculous process affecting the neural arch alone with complete sparing of the vertebral bodies and intervertebral discs) were treated surgically by the authors during last 20 years (Table I). All patients were referred to the neurosurgical unit with signs and symptoms of spinal cord compression, ranging from paraesthesias, and increasing weakness of the extremities to paraplegia and loss of sphincter control. None of them showed visible or palpable spinal deformity or the typical radiological appearance of spinal tuberculosis, i.e. destruction of the intervertebral disc and two adjoining vertebral bodies. All the 17 patients had spinal radiographs and myelograms, 11 had spinal CT and MRI of spine was carried out in five patients. Radiological and preoperative diagnosis was a tumour of the vertebral arch in 15 cases. In one patient the correct diagnosis was suspected because of the presence of tuberculosis elsewhere. All patients had surgical decompression and biopsy by posterior (laminectomy) approach and antitubercular chemotherapy as soon as the diagnosis was established. Complete resolution of neurological deficits was obtained in all the patients.

Results
Details of the patients (age, sex, clinical features), anatomic location of the lesion, imaging features, as well as operative and histological findings are summarized in Table I.
TABLE I. Summary of 17 cases of NAT

<table>
<thead>
<tr>
<th>Patient no.</th>
<th>Age (years)</th>
<th>Clinical features</th>
<th>Anatomic site of lesion</th>
<th>Radiographic findings</th>
<th>Myelographic findings</th>
<th>CT findings</th>
<th>MRI findings</th>
<th>Operative findings</th>
<th>Histological findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>43/M</td>
<td>Brachialgia, paraparesis</td>
<td>D1: S + L + T + P</td>
<td>BD</td>
<td>MB/EDM at D1</td>
<td>BD + FR + PPM</td>
<td>BD + EDM + PPM + SCC + PPA</td>
<td>BD + PPM + PPA + EDM</td>
<td>TBG + Pus + AFB</td>
</tr>
<tr>
<td>2</td>
<td>28/M</td>
<td>Tetraparesis, suboccipital mass</td>
<td>C1: PA + LM</td>
<td>NBL</td>
<td>MB/EDM at C1</td>
<td>BD + FR + PPM</td>
<td>BD + PPM + SCC</td>
<td>BD + PPM + EDM</td>
<td>TBG + AFB</td>
</tr>
<tr>
<td>3</td>
<td>28/M</td>
<td>Paraparesis, brachialgia</td>
<td>D1: S + L + T + P</td>
<td>BD</td>
<td>MB/EDM at D1</td>
<td>BD + FR + PPM + EDM</td>
<td>ND</td>
<td>BD + EDM</td>
<td>TBG + AFB</td>
</tr>
<tr>
<td>4</td>
<td>30/M</td>
<td>Suboccipital mass, tetraparesis</td>
<td>C1: PA + LM</td>
<td>NBL</td>
<td>EDM at C1/2</td>
<td>BD + FR + PPM</td>
<td>BD + PPM + SCC</td>
<td>BD + PPM + EDM</td>
<td>TBG + AFB</td>
</tr>
<tr>
<td>5</td>
<td>37/M</td>
<td>Limb spasticity</td>
<td>C1: PA + LM</td>
<td>BD</td>
<td>EDM at C1/2</td>
<td>BD + FR + PPM</td>
<td>BD + PPM + SCC</td>
<td>BD + PPM + EDM</td>
<td>TBG + AFB</td>
</tr>
<tr>
<td>6</td>
<td>9/F</td>
<td>Limb spasticity, ataxia</td>
<td>C2: S + L</td>
<td>NBL</td>
<td>EDM at C2</td>
<td>ND</td>
<td>ND</td>
<td>BD + EDM</td>
<td>TBG + AFB</td>
</tr>
<tr>
<td>7</td>
<td>30/F</td>
<td>Occipital pain, tetraparesis</td>
<td>C2: L</td>
<td>NBL</td>
<td>EDM at C2</td>
<td>ND</td>
<td>ND</td>
<td>BD + PPM</td>
<td>TBG + AFB</td>
</tr>
<tr>
<td>8</td>
<td>35/M</td>
<td>Brachialgia, paraparesis</td>
<td>C7: S + L</td>
<td>NBL</td>
<td>MB/EDM at C7</td>
<td>BD + FR + PPM</td>
<td>BD + EDM + PPM + SCC</td>
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<td>TBG + AFB</td>
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<td>9</td>
<td>18/M</td>
<td>Brachialgia, paraparesis</td>
<td>C7: S + L</td>
<td>BD</td>
<td>MB/EDM at C7</td>
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<td>ND</td>
<td>BD + EDM</td>
<td>TBG + AFB</td>
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<tr>
<td>10</td>
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<td>D1: S + L + P</td>
<td>BD</td>
<td>MB/EDM at D1</td>
<td>BD + FR + PPM</td>
<td>ND</td>
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<td>TBG + AFB</td>
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<tr>
<td>11</td>
<td>26/F</td>
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<td>D1: S + L + P + T</td>
<td>BD</td>
<td>MB/EDM at D1</td>
<td>BD + FR + PPM</td>
<td>BD + EDM + PPM + SCC</td>
<td>BD + PPM + EDM</td>
<td>TBG + AFB</td>
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<tr>
<td>12</td>
<td>40/M</td>
<td>Paraparesis</td>
<td>D2: L + T</td>
<td>NBL</td>
<td>MB/EDM at D2</td>
<td>ND</td>
<td>ND</td>
<td>BD + EDM</td>
<td>TBG</td>
</tr>
<tr>
<td>13</td>
<td>65/M</td>
<td>Paraparesis</td>
<td>D2: L</td>
<td>NBL</td>
<td>MB/EDM at D2</td>
<td>ND</td>
<td>ND</td>
<td>BD + EDM</td>
<td>TBG + AFB</td>
</tr>
<tr>
<td>14</td>
<td>33/M</td>
<td>Paraparesis</td>
<td>D9: P</td>
<td>BD</td>
<td>MB/EDM at D9</td>
<td>BD + FR</td>
<td>ND</td>
<td>BD + EDM</td>
<td>TBG</td>
</tr>
<tr>
<td>15</td>
<td>13/F</td>
<td>Paraparesis</td>
<td>D10: P</td>
<td>BD</td>
<td>MB/EDM at D10</td>
<td>ND</td>
<td>ND</td>
<td>BD + EDM</td>
<td>TBG + AFB</td>
</tr>
<tr>
<td>16</td>
<td>30/M</td>
<td>Paraparesis</td>
<td>L5-S1: L</td>
<td>NBL</td>
<td>MB/EDM at L5</td>
<td>ND</td>
<td>ND</td>
<td>BD + EDM</td>
<td>TBG + AFB</td>
</tr>
<tr>
<td>17</td>
<td>39/M</td>
<td>Incontinence</td>
<td>S1-2: L</td>
<td>NBL</td>
<td>MB/EDM at S1</td>
<td>ND</td>
<td>ND</td>
<td>BD + PPM</td>
<td>TBG</td>
</tr>
</tbody>
</table>

AFB: acid fast bacilli; BD: bone destruction; EDM: extradural mass; FR: bone fragmentation; L: lamina; LM: lateral mass of atlas; MB: myelographic block; MB-EDM: myelographic block due to extradural mass; NBL: no bony lesion; ND: not done; P: pedicle; PA: posterior arch of atlas; PPA: posterior paraspinal abscess; PPM: posterior paraspinal mass; S: spine; SCC: spinal cord compression; T: transverse process; TBG: tubercular granuloma.

Natural arch tuberculosis.
Radiographic findings

Of the 17 patients with NAT, nine showed no bony lesion on plain spinal radiographs and eight had bone destruction involving various parts of the vertebral arch (Table I). None had the characteristic radiographic findings compatible with spinal tuberculosis, i.e. destruction of the adjacent vertebral bodies and the intervening intervertebral disc, or gibbus deformity.

Myelographic findings

Myelogram in all the 17 cases accurately showed a myelographic block/extradural mass at the level of the lesion (Table I) compression, flattening, and deviation of the dural tube and spinal cord from the posterior or posterolateral aspect was noted in all 17 patients.

CT findings

Computed tomography combined with myelography, carried out in 11 patients, confirmed and more accurately defined the myelographic findings of extradural mass lesion located behind the flattened, deviated and compressed dura and spinal cord (Fig. 2). Additionally, CT showed a posterior paraspinal soft tissue mass in all 11 cases. However, a more specific CT finding, seen in all cases, was the characteristic bone destruction and fragmentation involving various elements of the neural arch (Figs 4 and 6). No CT abnormality of vertebral bodies or discs was seen in any case.

MRI findings

Only one (case 1) of the five patients with NAT who underwent MRI showed a posterior paraspinal cyst-like lesion consistent with an abscess or aneurysmal bone cyst (Fig. 3). In the remaining four patients, the posterior paraspinal mass was solid and tumour-like. Gross epidural extension with compression of the spinal cord from behind was clearly demonstrated in all the cases (Fig. 3). Thin cortices of the vertebral arch undergoing destruction and definition of the bony fragments could not be seen on MR images. No abnormality of the discs or vertebral bodies could be seen in any patient (Fig. 3).

Operative findings

All the 17 patients had laminectomy at the level of the myelographic block or spinal cord compression as shown by MRI. Operative findings included varying degrees of erosion of different parts of the neural arch (Table I), and their replacement by solid, grey, friable, tumour-like mass which invaded the muscles of the back and extended intraspinally to compress the spinal cord. A posterior paraspinal abscess was found in one case only (case 1).

Biopsy findings

Histological study of the surgical specimens removed at the time of decompression surgery showed typical, large tubercular granulomas in all the 17 cases. Abscess was found in one case (case 1). Acid fast bacilli (AFB) were isolated or cultured from the biopsy specimens of 14 cases.

Outcome

Follow-up period ranged from 6 months to 3 years. Operative decompression resulted in rapid improvement and ultimate resolution of neurological deficits in all the cases.

Illustrative case reports

Case 1

This 43-year-old man presented with a 3-month history of increasing pain in the back of the root of the neck with radiation down the ulnar side of the left arm. Two months prior to admission, he developed severe paraesthesia and clumsiness of movements in the left hand and arm as well as stiffness in the legs. Examination revealed weakness of the small muscles of the left hand, hypoesthesia along medial side of arm along with brisk tendon jerks in both lower limbs. Plain radiographs of the spine (Fig. 1) showed evidence of bone destruction involving spinous process, laminae, and transverse process of T1. Computed tomography with myelography (CTM) (Fig. 2) showed destruction and fragmentation of spinous process, lamina and left transverse process of T1 along with a posterior paraspinal and intraspinal extradural mass with cord compression. MRI (Fig. 3) showed destruction of the left pedicle, transverse process, lamina and spinous process of T1 along with a soft tissue mass which was mainly iso-intense on T1-weighted images and very bright on T2-weighted images with an irregular contrast enhancing wall. MRI also demonstrated compression and flattening of the cord from back to front and from left to right. Anterior elements of the spine, both vertebral bodies and discs, were normal on plain radiographs, CT and MRI (Figs 1–3). In view of the cystic nature of the lesion an abscess was suspected but aneurysmal bone cyst could not be ruled out. At operation, an abscess and a large tubercular granuloma with posterior epidural extension was removed. Bone fragments were seen within the abscess and the soft tissue posterior paraspinal mass. Histology revealed typical tubercular granuloma from which Mycobacterium tuberculosis was isolated and cultured. The postoperative period was marked by rapid resolution of neurological symptoms and signs.
Case 2

A 28-year-old man was admitted with increasing occipital pain and spastic tetraparesis. Examination revealed a firm mass in left suboccipital region and upper motor neuron signs in all limbs. Plain radiographs of skull and cervical spine were reported to be normal. CT (Fig. 4) however, showed bony destruction of the posterior arch and lateral mass of the atlas with a solid mass encasing the fragments of destroyed bone. MRI (Fig. 5) showed a large solid mass involving the left half of the atlas. Intraspinal extension of the mass causes extradural compression of the cord from left side (Fig. 5A). This soft tissue mass was iso-intense on T1-weighted images and showed enhancement after contrast. Preoperative radiological diagnoses included chordoma, chondrosarcoma and nasopharyngeal carcinoma. At operation, a solid, tumour-like mass had replaced the left lateral mass and adjacent posterior arch of the atlas. Decompression and debridement resulted in rapid and complete recovery of neurological deficits and symptoms. Biopsy revealed tuberculous granulation tissue with acid-fast bacilli.

Case 3

A 28-year-old man was admitted with a 3-month history of severe pain and paraesthesias in the right arm and increasing weakness of both legs. Two days prior to admission, he was unable to stand or walk and had urgency of micturition. Examination revealed spastic paraparesis and a sensory level just below the nipples. Plain radiographs of the spine showed erosion of the spine, lamina and right pedicle of T1. A myelogram showed a complete block and cord compression by an extradural mass at the first dorsal vertebra. CT (Fig. 6) at this level showed destruction and fragmentation of the spinous process, lamina and transverse process on the right side along with a soft tissue mass in the posterior paraspinal region. Preoperative diagnosis was a
Fig. 3. MRI of the spine, sagittal image showing destruction of the vertebral arch of T1 and normal vertebral bodies and discs. Note the oval soft tissue mass (arrow) which is very bright on T2W1, with an irregular contrast enhancing wall. Note the epidural extension of the mass causing compression of the cord from back to front (arrow).

Fig. 4. CT scan showing fragmentation of the left lateral mass and adjacent posterior arch of atlas. Note the bony fragments embedded in the soft tissue mass (arrow).

“Pancoast tumour”. At operation, a grey, friable, tumour-like mass was found to be invading posterior paraspinal muscles. The right half of the neural arch of T1 was invaded and destroyed by the “tumour” that extended intraspinally to compress the dural tube and invade the roots of brachial plexus. Operative diagnosis was a “sarcoma”, but histology revealed tubercular granulation tissue and acid-fast bacilli were found in it. Rapid recovery of neurological symptoms and deficit followed operative decompression.

Discussion
The neural arch or vertebral arch includes the spinous process, the laminae, the transverse processes and the pedicles, as well as the lateral masses of the atlas, as embryologically they are equivalent to the neural arch.
of other vertebrae. A tuberculous process localized to these posterior elements of the spine is extremely rare. Thus, none of the 587 cases of spinal tuberculosis reported by Hodgson showed involvement of the neural arch alone. Our series includes 17 such cases. Similarly, the vertical distribution of NAT was atypical (Table I). Classical spinal tuberculosis most commonly affected the lumbo-dorsal junction, whereas NAT was most common in the cervical and upper dorsal spine. Thus, in 13 out of 17 cases (76.5%), NAT affected the cervical and upper dorsal spine, with maximal incidence at the cervico-dorsal junction. A search of the literature was made to find an explanation for this unusual distribution of tuberculous disease of the spine, where it was confined to the neural arch alone with complete sparing of the vertebral bodies and discs. It is now generally accepted that infection gains access to the spine via the venous pathway suggested and described by Batson and others. The posterior external venous plexuses of the vertebral veins are placed on the posterior surfaces of the laminae and around the spinous, transverse and articular processes. They anastomose freely with the anterior venous plexuses of the vertebral veins and constitute the final pathway for infection to reach the neural arch in this atypical form of spinal tuberculosis.

Pathological reaction to M. tuberculosis was also atypical in NAT. Thus, abscess formation was rare; only one out of 17 patients had a posterior paraspinal abscess. The remaining 16 patients had a solid soft tissue mass in the posterior paraspinal and extradural location. Compression of the spinal cord was from back to front as opposed to the anterior compression caused by the classical spinal tuberculosis. Characteristic fragmentation of the neural arch, with bony fragments embedded in the soft tissue mass, was seen in all the 17 cases. This was best shown on CT and helped to differentiate NAT from tumours affecting the vertebral arch. Histologically, these bony fragments consisted of mature bone and not soft tissue calcifications, as is sometimes believed.

Of the four imaging techniques used to evaluate 17 cases of NAT, plain spinal radiographs were reported normal in nine patients. In the remaining eight, plain radiography was helpful in showing the level of spinal involvement and destruction of various elements of the neural arch. A posterior paraspinal soft tissue mass was not shown on plain radiographs in any patient. On plain radiography, bone destruction was indistinguishable from that caused by primary or secondary tumours of the vertebral arch. None of the 17 patients showed any radiographic abnormality of the intervertebral discs, adjacent vertebral bodies, vertebral collapse, paraspinal abscess or gibbus deformity—features characteristic of the classical spinal tuberculosis. Distinguishing features of NAT on CT included bony destruction localized to the vertebral arch with characteristic flake-like bony fragments embedded in the posterior paraspinal soft tissue mass. Despite the fact that the total number of patients examined with MRI was small (five patients), there were important distinguishing features for NAT on MRI. Thus, MRI demonstrated bony destruction and extradural cord compression from posterior and posterolateral aspects (Fig. 3). Solid tubercular granulomas showed enhancement after contrast, and encroached on the spinal canal in front of the laminae and on the posterior and posterolateral aspects of the cord, as opposed to the classical spinal tuberculosis or malignant extradural metastasis, where the cord compression is from the front or circumferential. When a cystic lesion with contrast enhancing wall replaces the destroyed neural arch (Fig. 3), tuberculosis should be suspected, although an aneurysmal bone cyst can give similar cyst-like appearance. Although we do not have a formal study to prove it, it is our impression that ischaemic cord lesions, shown by increased signal intensity on T2-weighted images, were more common in anterior cord compression caused by the classical spinal tuberculosis, possibly due to encroachment on the anterior spinal artery. These lesions were rarely seen in NAT. Because of the predominance of thin cortical bone in vertebral arch, CT was superior in showing bony destruction and fragmentation, whereas soft tissue mass and abscess were well demonstrated in MRI.

Complete recovery of neurological deficits, even in advanced cases, was the rule following posterior surgical decompression and debridement in all the cases. As opposed to the typical spinal tuberculosis and malignant extradural metastasis, where anterior cord compression more often leads to permanent neurological deficits due to anterior spinal artery...
involvement and cord ischaemia, NAT with posterior cord compression has a much better prognosis. For these reasons, early radiological diagnosis is crucial in the management of NAT.

Conclusion
As opposed to the classical spinal tuberculosis, the imaging features of NAT are non-specific. For this reason, patients with NAT are often misdiagnosed and mistreated as primary or secondary spinal tumours. This retrospective study identifies some imaging criteria that would help to distinguish this atypical form of spinal tuberculosis. Briefly, the characteristic radiological features of NAT included a predilection for the cervico-dorsal junction of the spine and flake-like fragmentation of the neural arch best shown on the CT, along with a posterior paraspinal soft tissue mass or abscess best shown on MRI.

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References