Imaging of the spine in patients with malignancy

David MacVicar
Royal Marsden NHS Foundation Trust, Downs Road, Sutton, Surrey, SM2 5PT, UK

Corresponding address: Dr David MacVicar, FRCP, FRCR, Consultant Radiologist, Royal Marsden NHS Foundation Trust, Downs Road, Sutton, Surrey, SM2 5PT, UK. E-mail: david.macvicar@rmh.nhs.uk

Abstract

This contribution presents an approach to the diagnosis of symptoms referable to spinal pathology in patients with known malignancy. Pain and neurological disturbance are distressing and disabling symptoms, which in patients with cancer may be a result of bony metastases, paraspinal soft tissue disease and meningeal and intra-axial spinal metastases. Imaging studies are pivotal, and typical and atypical imaging features are presented.

Keywords: Spinal pathology; malignancy; imaging.

Introduction

Spinal pathology and its neurological sequelae in patients with known malignant disease appear to be increasing in frequency. It is possible that this is simply a result of more effective treatment resulting in prolonged survival, allowing more metastases to develop at all sites. Alternatively it is possible that the central nervous system (CNS) acts as a sanctuary site for malignant cells from common solid tumours[1]. The effects of metastatic disease on the CNS can be severely disabling. The spinal cord is enclosed in bone and relatively small volume disease can have a disproportionately damaging effect. The CNS lacks lymphatics so that oedema and biological detritus are difficult to remove. In a patient with known malignancy, there are a variety of ways in which metastatic disease can affect the spine, and the clinical presentation may be complex. Many patients present to general hospitals rather than specialist neurology units, and physicians and oncologists may lack a complete understanding of the mechanisms of disease. The oncological radiologist needs full clinical information and an understanding of patterns of disease to guide the patient towards the correct imaging technique. Magnetic resonance imaging (MRI) remains the principal investigative tool. However, multi-detector CT (MDCT) and isotope studies have a place in investigation of the spine.

Detection of bony metastases to the spine

In patients with known malignancy and back pain, isotope bone scanning is an appropriate initial study which has the advantage of including the entire skeleton at a single investigation. False positive findings may need further investigation, and there is a small but important false negative rate which may be attributed to deposits which are confined to the bone marrow. In these circumstances MRI is more sensitive than isotope scintigraphy[2]. T1-weighted spin-echo imaging gives good contrast between tumour and normal bone marrow in the adult. Normal red marrow returns a low signal which may be confused with tumour. However the pattern of marrow within the vertebral body is repeated throughout the spine, and low signal tumour is asymmetrical within the vertebral body marrow cavity. T2-weighted spin-echo imaging and gadolinium-enhanced T1-weighted spin-echo imaging tend to reduce tumour contrast, and the short tau inversion recovery (STIR) sequence is more useful in highlighting the presence of bony metastatic disease to the spine. The role of positron emission tomography-computed tomography (PET-CT) in the diagnosis of bony metastatic disease remains under evaluation.
Figure 1  T2-weighted sagittal sequence demonstrating metastases in several vertebrae. There is complete collapse of the vertebral body at T6 with retropulsion onto the course of the anterior spinal artery. A syndrome of cord compression resulted with dense paraplegia.

Epidural spinal cord compression

This important complication of bony metastatic disease is frequently associated with primaries in breast, lung, prostate and kidney. It is also a well-recognised complication of lymphoma and multiple myeloma, although any primary tumour may be responsible. Local or radicular pain is the most frequent and earliest clinical symptom with subsequent loss of power and sphincter dysfunction; numbness or sensory loss are present in the majority of patients by the time the diagnosis is made. An appreciation of the anatomy of the spinal cord is useful. The most catastrophic effect of cord compression is paraplegia, and the main motor pathways are the lateral cortico-spinal (pyramidal) tract, which is a crossed structure lying in the lateral part of the cord but inside the sensory fibres; the anterior or ventral cortico-spinal tract, carrying direct (uncrossed) fibres, and the anterior reticulo-spinal tract lie anteriorly in the cord. The blood supply of the cord depends on the anterior spinal artery which runs at the anterior end of the ventral median fissure. This artery runs the length of the cord and is fed by the anterior radicular arteries which are branches of the vertebral arteries, posterior intercostal arteries or lumbar arteries depending on the level. The position of the anterior spinal artery makes it vulnerable to direct invasion by tumour in the vertebral body, and mechanical compressive effects if the vertebral body collapses (Fig. 1). Interruption of the anterior spinal artery will cause infarction of the cord resulting in the classical clinical presentation of power loss with upper motor neurone signs, sphincter disturbance and a sensory level. However, tumour growth in the posterior elements may compress from a lateral or posterior direction, resulting in a less obvious clinical presentation. Breast and prostate deposits not infrequently expand the posterior elements, impinging first on the lateral spino-thalamic and spino-radicular tracts, which carry sensory fibres. A high index of suspicion is necessary to detect the signs of lateral compression of the cord on sagittal scans (Fig. 2). Apparent widening of the cord at the midline sagittal images is a sign suggesting lateral compression. The neural foramina and peripheral sagittal slices should always be positively scrutinised and if any abnormality is suspected, a set of axial images should be obtained.

When imaging the patient with suspected cord compression, sagittal images of the entire spine should be obtained using T1-weighted spin-echo sequences. This sequence is sufficiently sensitive to detect the majority of bony deposits. The level of cord compression predicted by clinicians is frequently inaccurate, and the whole spine should always be included. If the patient is in severe pain, T1-weighted sagittal images should be obtained first. If the patient’s clinical condition allows, T2-weighted spin-echo sagittal images of the whole spine are frequently helpful (or T2*-weighted gradient-echo images if preferred). Foramen magnum and sacrum should be included, and skin markers may be necessary to ensure adequate overlap. It should be remembered that compression of the nerve roots of the cauda equina in the lumbar region will result in lower motor neurone signs. These will obscure the upper motor neurone signs of true cord compression higher up. In addition, acute interruptions of the cortico-spinal tracts may abolish the spinal reflexes subserved by segments below the lesion (‘spinal shock’). It may take a few days for typical upper motor neurone signs of cord compression to develop, so even if typical signs are absent, a significant compression may still exist.

Paraspinal and epidural soft tissue disease

Soft tissue masses in the paraspinal and epidural spaces may cause back pain and neurological syndromes including cord compression. Bony changes may be subtle or absent, and the pain at presentation is often less severe. Soft tissue extension of tumour (in a ‘dumbbell’ fashion) may occur with a variety of tumours including lymphoma, neurofibroma, neuroblastoma, malignant thymoma, mesothelioma and lung cancer. Neurofibroma
Figure 2  (a) T2-weighted sagittal sequence of thoraco-lumbar spine. There is abnormal signal in all bones displayed, due to infiltration by metastatic prostate carcinoma. At T10 (arrow) there is apparent widening of the cord in the midline sagittal plane. This finding should precipitate orthogonal plane imaging. (b) Axial T2-weighted imaging at T10 demonstrates a metastasis infiltrating the vertebral body and expanding the posterior elements so that there is some mechanical distortion of the cord from a lateral direction.

and neuroblastoma are the classic dumbbell tumours, but are uncommon. MRI or MDCT with multiplanar reformat can be used for diagnosis (Fig. 3). Bronchial carcinoma can penetrate the intervertebral foramen while causing little bony destruction, particularly in superior sulcus tumours. Malignant thymoma and mesothelioma may also spread through the neural foramen by means of soft tissue extension. One of the most important dumbbell tumours is lymphoma in the posterior mediastinum, retrocrural region and retroperitoneum. The incidence of spinal cord compression by lymphoma reported in the literature varies between 1% and 7%. Epidural masses may be small and subtle, but symptomatology such as back pain with even minimal neurology should be vigorously investigated, since early treatment should result in a favourable response (depending on the overall prognosis of the disease). However, if symptoms are neglected and paraplegia is allowed to develop, it is unlikely to recover. Current practice will usually result in back pain in patients with lymphoma being investigated with MRI. Scrutiny of the neural foramina is necessary to pick up early signs of invasion into the epidural spaces. However, early manifestations of soft tissue spread of disease through the neural foramen can be appreciated on staging CT scans in patients with lymphoma. Subtle signs such as the obliteration of the fat planes in the neural foramen may be detected, and the epidural spaces should be regarded as a ‘check area’ on staging CT scans in lymphoma[4] (Fig. 4).

Figure 3  MDCT coronal reformat demonstrating recurrent neuroblastoma (arrows) in a child aged 3 years. The tumour penetrates two neural foraminae in the lower thoracic region, and extends cranio-caudally within the spinal canal covering almost four segments.
Figure 4  Axial CT scan of a patient with lymphoma and poorly localised back pain. There is soft tissue tumour in the neural foramen (arrows) obliterating the fat plane normally found. Such epidural disease is not rare, and may be found in any type of lymphoma.

Figure 5  Sagittal T1-weighted MRI following gadolinium shows enhancing nodules throughout the spinal meninges consistent with meningeal metastatic disease.

Meningeal metastatic disease

Meningeal carcinomatosis is increasingly recognised, and can be detected by MRI. The presentation differs from cord compression, although back pain, which tends to be poorly localised, is frequent. Isolated peripheral neuropathies and root lesions at various levels combine to produce what is often a confusing clinical presentation. Meningeal disease within the cranial cavity may co-exist and cause headache, cranial neuropathies and cognitive abnormalities, and the presence of such a combination should precipitate a search for meningeal disease. Even with the most up-to-date equipment, MRI is far from 100% sensitive in the detection of meningeal disease. The key sequences are sagittal T1-weighted spin-echo images before and after intravenous gadolinium. Any enhancement of the spinal meninges should be considered abnormal, and primary tumours such as lung, breast and melanoma may produce isolated enhancing lumps or sheets of nodular enhancement in the spinal meninges. Previous intracranial or spinal surgery, radiotherapy to the spine, lumbar puncture and intrathecal chemotherapy can give rise to meningeal enhancement, but the presence of enhancing meningeal masses allows confident diagnosis of metastases (Fig. 5).

Figure 6  (a) T2-weighted sagittal image in a patient suspected of having cord compression on clinical grounds. At T8 there is an area of slightly altered signal in the cord (arrow) with high signal cranially and caudally. This was interpreted as a limited syrinx, and precipitated administration of gadolinium in an attempt to confirm intra-axial spinal cord deposits. (b) Following gadolinium there is an enhancing mass in the cord at T8 (arrow). Further small enhancing nodules are present in the upper thoracic and cervical region and also in the cerebellum (metastatic breast carcinoma).

Meningeal recurrence is a well-recognised phenomenon in acute leukaemias in patients in remission following chemotherapy. Meningeal leukaemia and lymphoma are particularly difficult to detect using MRI, with a sensitivity as low as 5–10% in some series. However, this may improve with state-of-the-art machines, and if MRI is negative, CSF cytology can be undertaken subsequently.
The recommended protocol is T1-weighted sagittal images of the whole spine before and after intravenous gadolinium. If meningeal disease is suspected, gadolinium administration is obligatory. T2-weighted sagittal images may be helpful (before gadolinium) if time allows, and axial images of suspected lesions also provide useful information. However a very important factor in diagnosis is prior recognition of the possibility. Meningeal metastases are rarely found in the absence of metastases elsewhere but are very occasionally the first clinical manifestation of metastatic breast carcinoma or melanoma.

**Intra-axial spinal cord deposits**

Tumour deposits may be found throughout the neuraxis. Brain deposits are seen relatively frequently, but the same process of haematogenous metastatic spread may result in spinal cord lesions. They may be more frequent than previously recognised, and MRI is becoming increasingly sensitive at picking up such lesions. The clinical presentation is similar to that of meningeal metastatic disease, and a high index of suspicion helps in diagnosis. Neurological symptoms and signs cannot be unified to a single anatomical site. In a patient being investigated for suspected spinal cord compression, the T2-weighted sequence may show high signal within the cord. Sometimes this is the result of a true syrinx, seen cranial to and occasionally caudal to the tumour deposits. Oedema around a deposit may give a similar appearance and recognition of this phenomenon should precipitate administration of gadolinium. As with meningeal metastatic disease, the presence of an enhancing small mass or nodule within the cord should allow confident diagnosis (Fig. 6). Carcinoma of breast and lung and malignant melanoma are the commonest primary tumours associated with this phenomenon[7].

**Conclusion**

Investigation of spinal pain and neurological symptoms in the cancer patient requires good clinical information to maximise the diagnostic potential of modern imaging. MRI remains the principal investigative technique, but MDCT with multiplanar reformat and isotope studies may also yield important information.

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