Introduction

Thoracic myelopathy secondary to degenerative disease is uncommon. However, if prompt diagnosis and management is not initiated, significant morbidity and functional deterioration results [1–4]. Following diagnosis, however, management can also be technically challenging. As such is it crucial that the neurosurgeon has an understanding of effective management for these patients. Here we present the clinical features, principles of diagnosis, and management options for this important neurosurgical condition (see Figure 1).

Epidemiology, Background, and Aetiology of Thoracic Myelopathy

Epidemiology

Estimation of incidence and prevalence of thoracic myelopathy is difficult as it is likely there is significant underdiagnosis [5]. Compression can be anterior due to thoracic disc herniation, with reported incidence of clinically significant disc herniation as 1 per 1 million people, representing 0.25% of all herniated discs [6, 7]. Posterior compression from ligamentum flavum thickening and facet joint hypertrophy are also important causes of myelopathy, representing 64% and 46% of causes in one study, respectively [8]. Surgical intervention, a surrogate of a likely highly conservative marker for the true prevalence of thoracic myelopathy, is reported as 0.9% per 100 000 in a Japanese study [9]. Of note is that this prevalence is less than 10% of the reported intervention for cervical myelopathy, and in reality, a true global incidence of prevalence is currently unclear [9, 10].

Background

The less-known incidence of thoracic myelopathy is likely due to underdiagnosis but also due to natural protection of the thoracic spine from degenerative changes. This is the result of limited movement in the thoracic spine due to the stabilising effect of the rib cage with consequently most degeneration occurring in the most mobile region below T8 [11, 12].

However, it is well appreciated that the thoracic spinal cord is highly sensitive to external insult. This is perhaps the result of relative poor vascularity especially at cranial and caudal vascular watershed areas and underlying individual cellular and genetic vulnerability [5, 13]. It thus follows that when the thoracic cord is subject to external compression, such as from degenerative disease, stenosis, or disc, or both, thoracic myelopathy ensues. As such, when thoracic myelopathy does occur, surgical intervention is usually required in a timely

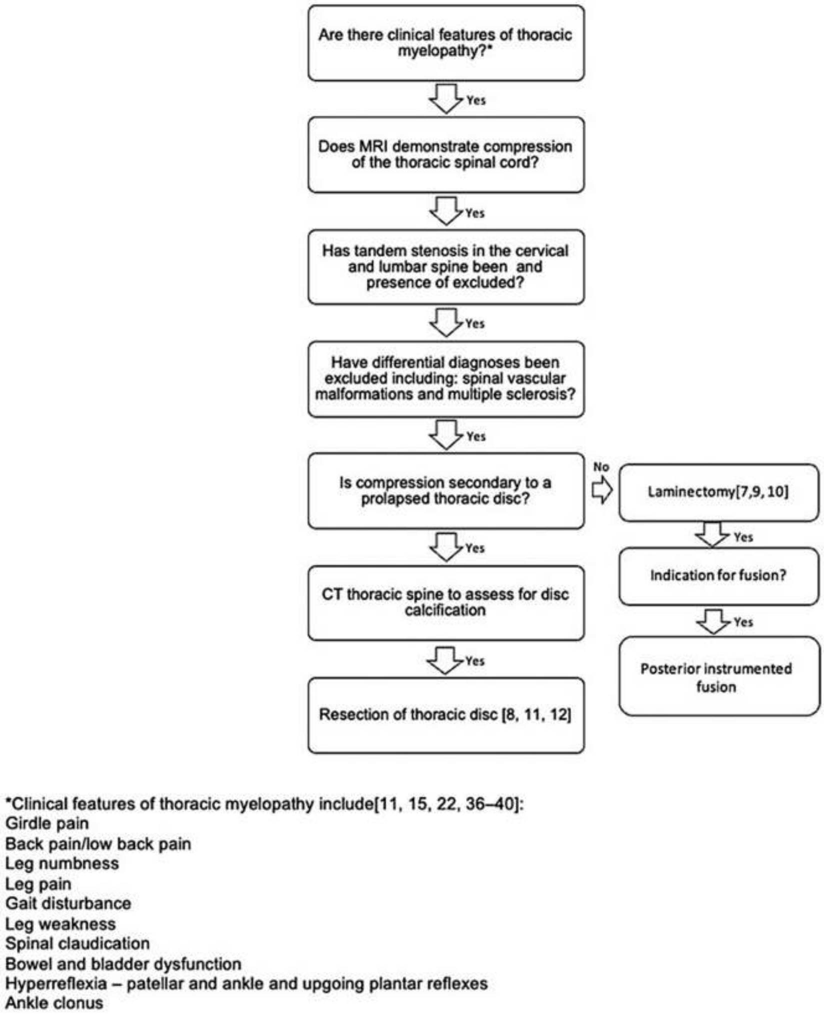

Figure 1 Algorithm for the management of degenerative spinal cord compression.

manner, due to clinical progression and poor outcomes associated with conservative management [1–4].

Aetiology

The aetiology of degenerative thoracic myelopathy varies depending on populations. In Western populations, thoracic disc herniation is often reported as the commonest overall cause (95.7%), with ossified ligamentum flavum and ossified posterior longitudinal ligament (OPLL) less common at 3.6% and 0.5%%, respectively [13, 14]. The most common locations of disc herniations are caudal to T8 and at T11-12 [6, 15]. In Eastern populations, notably Japan, OPLL makes up a much larger cause (45%), with fewer thoracic disc herniations (2.1%) [16]. Interestingly, in the authors' experience, ligamental and facet hypertrophy are the most common causes of symptomatic thoracic myelopathy, particularly in patients over the age of 60 years, with thoracic discs representing a smaller proportion of cases [8].

Clinical Presentation of Thoracic Myelopathy

Diagnosis of thoracic myelopathy may be challenging, not least due to overlap of myelopathy or radiculopathy symptoms from cervical or lumbar spinal regions. Symptoms include lower limb and girdle pain, lower back pain, motor and sensory deficits, and bowel, bladder, and sexual dysfunction [11, 17]. Naturally, this overlap with other pathological spinal regions may delay diagnosis and thus increase morbidity [13, 18]. It is also of importance that thoracic cord pathology is occasionally confused with cardiac, pulmonary, or even abdominal pathology [19, 20].

Presentation may vary based on the site of compression. Radicular symptoms such as dermatomal chest wall discomfort or band-like pain result from posterolateral compression [10].

Central compression typically results in myelopathic features with long tract signs such as lower limb weakness, hypertonia, hyperreflexia, upgoing plantars, and clonus, with positive Rhomberg's sign and sometimes also sensory alteration. If severe, features of loss of bowel or bladder control with a sensory level in the trunk and incomplete/complete paraplegia may manifest [13, 17, 18].

Principles of Diagnosis, Diagnostic Pitfalls, and Role of Imaging

Sagittal and axial T2-weighted MRI is the initial imaging modality of choice for evaluation of spinal cord compression. It is also useful to perform MRI of the whole spine as this enables avoidance of missing cervical myelopathy, which can be a common pitfall (Figure 2) [13, 18, 21, 22]. MRI of whole spine also enables identification of the number of vertebrae, and appearance of any lumbarised or sacralised segments [21, 22]. This latter point is important if surgical treatment is subsequently indicated, to enable localisation of the correct operative level.

In cases of thoracic disc herniation, CT is necessary to assess the level of calcification as this pathology is often poorly appreciated on MRI (Figure 3) [21–24]. CT is also naturally useful in rare cases of OPLL-causing stenosis. For completeness, evaluation of sagittal balance in the form of standing lateral (and

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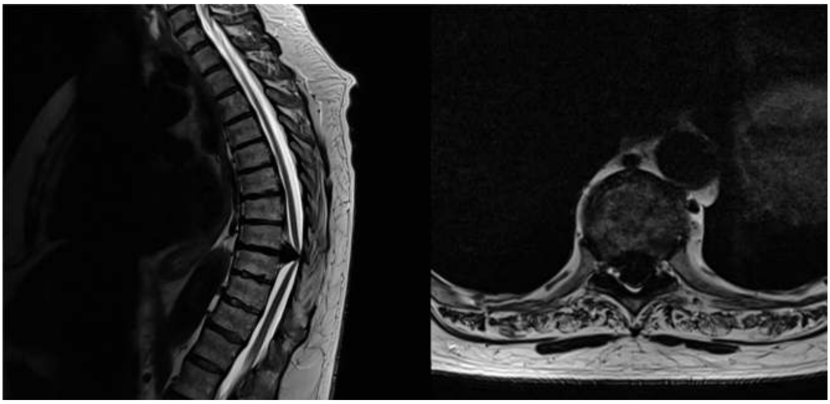

Figure 2 Sagittal and axial T2-weighted MRI demonstrating spinal cord compression from a large thoracic disc at the T8-9 level.

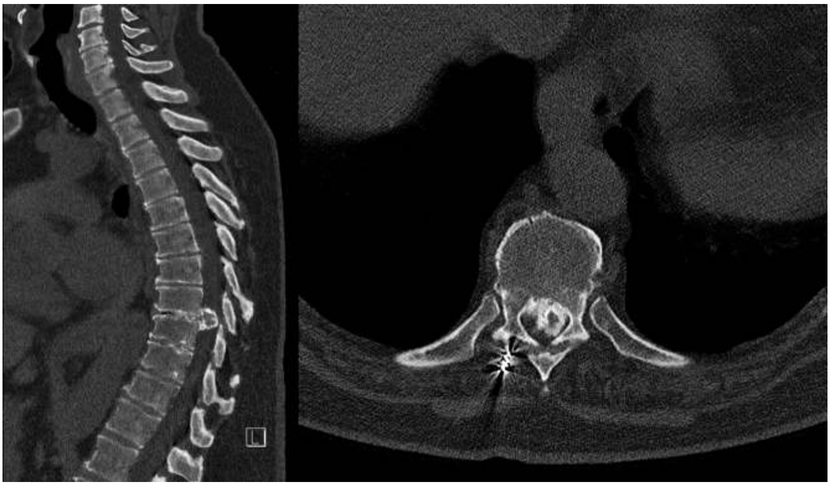

Figure 3 Sagittal and axial CT of the same patient imaged in Figure 1, demonstrating calcification of thoracic disc prolapse at T8-9. This emphasises the importance of pre-op CT evaluation as calcification is much better appreciated on CT than on MRI. Note also the presence of a pedicle marker on the axial image to aid swift intraoperative level localisation.

AP) X-ray of the thoracic spine is also useful prior to consideration of surgical fixation to prevent thoracic kyphosis progression [25].

The authors also advocate for the use of preoperative placement of CT-guided pedicle marker to avoid a common pitfall of operating at the incorrect level (Figure 3) [26]. This involves the placement of a radiopaque marker, such as an coil, in the pedicle of the intended operative level as guided by the CT. This enables quick, accurate localisation of the correct operative level and avoids time-consuming and increased radiation exposure of counting spinal levels using fluoroscopy from cervical or lumbar regions [27, 28].

Management Strategies

Management of thoracic canal stenosis from ligamental and bony thickening or OPLL is non-controversial as conservative management of symptomatic degenerative thoracic myelopathy is associated with poor neurological outcome. Hence, surgical management is frequently indicated [8, 10, 29]. Once cervical and lumbar pathologies have been excluded, surgical approach is based on the location of compression. Surgery necessitates a posterior decompression at the appropriate involved spinal level. Compared to the traditional laminectomy in the rest of the spine, laminectomy at the thoracic level can be more challenging given the increased sensitivity of the thoracic spinal cord with greater risk of neurological complications. If there is concern regarding instability due to interruption of the posterior tension band or need for a wider decompression with facetal removal, posterior instrumented fusion may be indicated.

However, the optimal management and approach for thoracic disc herniation is the subject of much debate with the description of several broad categories of approach, including anterior transthoracic, posterolateral, lateral extrapleural [30], and more recently the endoscopic approach [31, 32]. However, the antero lateral approach remains the gold standard.

Anterior approaches include traditional open thoracotomy or mini-variants and also thoracoscopic [30]. Posterolateral approaches include transfacetal, transpedicular, as well as minimally invasive tubular oblique paraspinal and endoscopic transforaminal approaches [30]. Lateral extrapleural approaches include tubular oblique retropleural and traditional open lateral extracavitatory approaches [30]. The authors' experience concur with the reported morbidity associated with traditional approaches, not least large incisions, rib resections, and blood loss [33–35].

As such we favour a minimally invasive direct lateral retropleural approach utilising mini-thoracotomy (approximately 5 cm). This combined with a tubular retractor system otherwise used in cases of lumbar extreme lateral interbody fusion XLIF® (NuVasive, San Diego, CA, USA) and the operative microscope enables effective access and visualisation to enable thoracic disc resection.

Due to the lack of evidence regarding optimum technique of thoracic disc resection, the authors recommend utilisation of techniques familiar to each institution. The authors also strongly advocate the use of intraoperative spinal monitoring.

Figure 4 Post-operative sagittal and axial CT of the same patient in Figures 1 and 2 demonstrating resection of the thoracic disc prolapse with resection of the posterior aspects of T8 and T9 vertebral bodies. This procedure was performed via a minimally invasive direct lateral retropleural approach utilising mini-thoracotomy.

Recommendations

- The thoracic spinal cord is the least common region affected, but least resilient region to compression from degenerative disease thus resulting in thoracic myelopathy.
- Prompt diagnosis and exclusion of other sites of spinal cord compression, for example cervical, are crucial to enable prompt surgical management.
- Degenerative compression in Western populations is most likely due to thoracic disc prolapse and ligamental hypertrophy.
- Management of acute thoracic myelopathy secondary to degenerative disease is challenging.
- Thoracic discs are frequently calcified, thus preoperative CT evaluation is essential.

Management of thoracic disc prolapse is resection of the thoracic disc and management of ligamental thickening is laminectomy.

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