MR IMAGING FEATURES OF IDIOPATHIC THORACIC SPINAL CORD HERNIATIONS USING COMBINED 3D-FIESTA AND 2D-PC CINE TECHNIQUES

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SUMMARY

Idiopathic thoracic spinal cord herniation (TISCH) is a rare cause of surgically treatable progressive myelopathy. The authors report 3 cases of TISCH diagnosed based on conventional T1- and T2-weighted Spin-Echo (SE) MR images in one case, and T1- and T2-weighted SE images combined with 3D-FIESTA (Fast Imaging Employing Steady state Acquisition) and 2D-Phase-Contrast Cine MR imaging in 2 cases. Conventional MRI findings usually provided the diagnosis. 3D-FIESTA images confirmed it, showing the herniated cord in the ventral epidural space. Moreover, in combination with 2D-Phase Contrast cine technique, it was a sensitive method to for the detection of associated pre- or postoperative cerebrospinal fluid spaces abnormalities.

Key words: spinal cord herniation, idiopathic, magnetic resonance imaging, Brown-Séquard syndrome.

RÉSUMÉ

Aspects IRM des hernies medullaires idiopathiques thoraciques avec les séquences 3D-Fiesta et 2D Ciné-PC

La hernie médullaire idiopathique thoracique (HMIT) est une cause rare, chirurgicalement curable, de myélopathie chronique. Les auteurs rapportent 3 cas de HMIT dont le diagnostic a été porté par IRM sur des séquences pondérées T1 et T2 Spin-Echo pour un cas, et associées à des séquences 3D-FIESTA (Fast Imaging Employing Steady state Acquisition) et 2D Phase-Contrast Ciné dans 2 cas. Les séquences conventionnelles orientaient fortement le diagnostic. La séquence 3D-FIESTA le confirmait, en montrant la moelle herniée dans l’espace épidural antérieur. Son association avec la séquence ciné 2D-Phase-Contrast était sensible pour la détection des anomalies associées pré- et post-opératoires au niveau des espaces sous-arachnoïdiens.

Mots-clés : hernie médullaire, idiopathique, imagerie par résonance magnétique, syndrome de Brown-Séquard.

INTRODUCTION

Idiopathic thoracic spinal cord herniation (TISCH) is a rare but increasingly recognized cause of surgically treatable progressive myelopathy. Since its first description by Wortzman et al. [24] in 1974, 72 cases have been reported in the English literature [1, 2, 11, 22]. Idiopathic spinal cord herniation can be defined as a spontaneous herniation of the spinal cord, always at the thoracic level, through an anterior dural defect. Conventional MRI (magnetic resonance imaging) studies usually provide the diagnosis by demonstrating anterior displacement of the spinal cord and enlargement of the dorsal subarachnoid space [3, 7, 11, 23]. We report three cases of TISCH whose diagnosis of transdural herniation was based on the combined findings of conventional, 3D-FIESTA (Fast Imaging Employing Steady state Acquisition) and 2D-phase-contrast cine MR imaging (2D-PC cine imaging). We discuss the added value of combined 3D-FIESTA and 2D-PC cine techniques in the management of patients with TISCH.

CASE REPORTS

Case 1

A 70-year-old man presented with an 18-months history of progressive gait disturbance. He denied any history of spinal trauma. Neurological examination revealed weakness in his left lower limb, bilateral hyperreflexia, and decreased pin-prick and tactile sensation on the left below T12. He had no sphincter disturbance.

MRI of the thoracic spine, including sagittal and axial Spin-Echo (SE) T1- and T2-weighted images, showed a ventral deviation of the spinal cord and enlargement of the dorsal subarachnoid space at T10-T11 level (figure 1). These findings were consistent with a TISCH. A T10-T11 laminectomy was performed and the dura was opened dorsally. Herniation of the spinal cord through a ventral dural defect was identified and gently reduced. A patch of artificial dura was slipped between the dural defect and the spinal cord, and biological glue was placed to prevent its migration.

The postoperative course was remarkable for rapid improvement of both sensory and motor functions. Postoperative MR at 9 and 17 months, including sagittal FIESTA (7.4/3.6/3) (TR/TE/excitations),
and retrospective gated 2D sagittal and axial phase contrast sequence with parameters of 80/11.8/2, flip angle of 15° and velocity encoding of 2.5cm/s showed the spinal cord tethered to the ventral dura mater and dorsal arachnoiditis (figure 2). At 2-years follow-up, the patient has remained stable with no further progression of his deficits.

Case 2

A 75-year-old woman presented with a 12-months history of gait disturbance. She had no history of spinal trauma. Neurological examination revealed a left Brown-Séquard syndrome below T10 without sphincter disturbance.

MRI of the thoracic spine, including sagittal Turbo Spin Echo T1- (520/12.1/3) and T2-weighted (3740/107.4/3) images as well as sagittal FIESTA (7.4/3.6/3) and retrospective gated 2D sagittal and axial phase contrast sequence with parameters of (80/11.8/2), flip angle of 15° and velocity encoding of 5cm/s images, showed a spinal cord herniation at T5-T6 level (figure 3). A laminectomy was performed at T5-T6. The herniated cord was reduced intradurally and the dural defect repaired with a patch of artificial dura. Postoperatively, the patient disclosed deterioration of her neurological status and examination revealed a paraparesis. MRI performed 9 days after surgery showed the spinal cord realignment while it was focally thickened and tethered to the dorsal dura mater. At 5 months follow-up, the patient complained of some dysfunction of bladder control. The last assessment at one year postoperatively revealed no significant change in her neurological status while sagittal T1- and T2-weighted, sagittal FIESTA and sagittal and axial PC cine MR images showed a widened spinal cord and a cyst located in the ventral epidural space (figure 4).

FIG. 1. – Case 1: preoperative MRI. Sagittal T2-weighted image showed at T10-T11 an acute angular distortion anterior to the spinal cord and a tethering of the spinal cord extending less than one vertebral segment. It showed also a widened dorsal CSF (cerebrospinal fluid) space and a disappearance of the ventral CSF space over the herniated segment.

FIG. 1. – Cas 1 : IRM préopératoire. La coupe sagittale T2w montre en T10-T11 une angulation aiguë antérieure de la moelle et un accolement de la moelle sur une hauteur inférieure à un segment vertébral. Elle montre aussi un élargissement de l’espace sous arachnoïdien postérieur et la disparition de l’espace sous arachnoïdien antérieur en regard du segment hernié.

FIG. 2. – Case 1: postoperative MRI. On sagittal FIESTA image (a), spinal cord was adherent to ventral dura mater. Arachnoiditis was visible on dorsal CSF space. b: Systolic phase axial image PC imaging (white areas correspond to caudocranial flow). Velocity images showed out of phase CSF pulsatile flow on right dorso-lateral CSF space, without intensity abnormality. This aspect was consistent with a communicating arachnoid pouch rather than a cyst.

FIG. 2. – Cas 1 : IRM postopératoire. Sur l’image sagittale FIESTA, la moelle adhérait à la dure-mère antérieure. L’espace sous arachnoïdien postérieur était le siège d’arachnoïdité. L’étude vélocimétrique (b: coupe axiale de la séquence ciné-PC à la phase systolique) montrait, dans l’espace sous arachnoïdien postéro-latéral droit, un flux pulsatile de même intensité mais déphasé par rapport aux autres espaces sous arachnoïdiens. Cet aspect était plutôt en faveur d’une poche arachnoïdienne communicante que d’un kyste arachnoïdien.
FIG. 3. – Case 2: preoperative MRI. Sagittal (a) and axial (b) reformatted 3D-FIESTA images showed a ventral angular distortion of spinal cord at T5-T6 level, with a widened dorsal CSF space. On axial image, the ventral part of the spinal cord was clearly visualized in the ventral epidural space.

FIG. 3. – Cas 2 : IRM pré-opératoire. Les coupes reconstruites FIESTA sagittale (a) et axiale (b) montraient une angulation antérieure de la moelle en T5-T6, avec un élargissement de l’espace sous arachnoïdien postérieur. Sur la coupe axiale, une partie de la moelle était visualisée en avant de la dure mère.

FIG. 4. – Case 2: One year postoperative MRI. The sagittal T2-weighted image (a) showed intramedullary signal abnormalities better than FIESTA (b), except for the intramedullary cavity. 3D-FIESTA showed enlargement of ventral epidural space and dorsal tethering. The axial cine-PC imaging (c: diastolic phase image) showed a pulsatile flow in the front of the cord and the dura, and no flow behind the spinal cord, consistent with dorsal tethering.

FIG. 4. – Cas 2 : IRM post-opératoire à 1 an. La coupe sagittale pondérée T2 (a), montrait mieux les anomalies de signal intramédullaires que les reconstructions FIESTA (b) sauf pour la cavité intramédullaire. La séquence FIESTA, montrait mieux le décollement épidural antérieur et l’accolement postérieur. La séquence axiale ciné-PC (c: image de la phase diastolique) montrait un flux pulsatile en avant de la moelle et de la dure mère, et une absence de flux en arrière de la moelle en rapport avec l’accolement postérieur.
Case 3

A 48-year-old woman presented with a 4-years history of burning pain in her left leg. She had no history of spinal trauma. Neurological examination revealed decreased pin-prick, touch, and temperature sensation on the right below T6, without other abnormality.

MRI examination included sagittal T1- and T2-weighted, sagittal FIESTA and sagittal and axial PC cine images. It revealed a spinal cord herniation at T5-T6 (figure 5). Numerous conversations regarding surgical management have been shared with the patient. Finally, she elected to continue a course of conservative management and she received analgesic treatment with gabapentine. At one year follow-up, her neurological condition was stable with symptomatic improvement.

DISCUSSION

TISCH is a rare but reversible cause of thoracic spinal cord dysfunction that typically occurs in middle-aged patients (mean, 50 years) with a female-to-male ratio of 1.7 to 1 [1, 11, 21]. Neurological symptoms progress slowly with a range of 1-12 years although it may occur in a stepwise fashion or more suddenly [11, 21]. The most common presentation is a complete or incomplete Brown-Séquard syndrome [9].

The pathogenesis of TISCH remains unclear and controversial, and a number of hypotheses have been put forward to explain the ventral dural defect. On the basis of the chronicity and evolution of symptoms, it is speculated that it is an acquired condition with predisposing factors. Definitive proof was recently provided by Ewald et al. [5], in a case in which TISCH developed despite the appearance of normal anatomy on a previously obtained MRI study. These factors may include congenital extra-or intradural cysts [12], duplication of the dura [7, 10, 22], degenerative disc prolapse with transdural rupture of calcified disc material [7, 13], and a ventral dural defect stemming from an unrecognized remote history of minor spinal trauma [24]. Interestingly, in all reported cases, the thoracic cord was involved, usually between T2 and T10 [2, 7, 11]. Pathologically, the anterolateral funiculus is the most typically involved, a fact presumably caused by the tethering and strangulation of the spinal cord along the dural edges [10, 12]. The laterally placed spinothalamic tract seems to be involved early and, as the herniation increases, the corticospinal tracts are affected [10, 12].

Conventional T1- and T2-weighted MRI studies usually provide the diagnosis of spinal cord herniation by demonstrating ventral displacement of the spinal cord, with a sharp angle within a few segments, and enlargement of the dorsal subarachnoid space [3, 7, 11, 23].

Fig. 5. – Case 3. The scoliosis impeded the visualization of the spinal cord on conventional sagittal T2-weighted images (a). The spinal cord herniation was better depicted on reformatted sagittal FIESTA images (b) at T4-T5 level. The axial cine-PC images (c: diastolic phase image) showed no flow ventral to the cord and normal pulsatile flow in the enlarged dorsal CSF space.
Typically, the spinal cord is tethered by herniation rather than compressed by a dorsal mass. Nevertheless, association of TISCH with a dorsal arachnoid cyst has been reported [8, 15, 19]. Also, dorsal arachnoid cyst alone was the most common erroneous radiological diagnosis [18]. Radiological demonstration of a coexisting arachnoid cyst may be difficult. Indeed, their signal intensity is the same as cerebrospinal fluid (CSF) on both T1- and T2-weighted MR images, and the cyst walls are usually not visible on these sequences.

Our patients had 3D-FIESTA MR examination. It is a gradient-echo technique using steady-state free precession with fully refocused transverse magnetization [16], as Constructive Interference in Steady State (CISS) imaging [17]. The steady-state imaging permits a myelographic-like imaging with excellent CSF-to-nervous tissue contrast. It is useful in neuroradiology to study cranial nerves, especially acoustic and vestibular nerves [20], inner ear structures, epidermoid cyst, to research craniobasal CSF fistulas [4], or to visualize basal arachnoidal structures [6]. For spine imaging, it is useful to study brachial plexus injuries, arachnoiditis, syringomelia [17], or to classify sacral meningeal cysts [9]. The systematic multiplanar reconstructions provided an excellent visualization of the spinal cord herniation in the sagittal plane as well as the herniated cord in the ventral epidural space and the cord through the dura in the axial plane. 3D-FIESTA images allowed a better analysis of the perimedullary spaces than conventional MR images in showing no subarachnoid space ventral to the herniated cord while the dorsal subarachnoid space was widened, without cyst wall. According to some authors [3, 14], 2D-PC cine imaging is a valuable technique for assessing the presence or absence of a dorsal arachnoid cyst. In our cases, qualitative analysis of 2D-PC cine imaging was helpful in demonstrating an absence of CSF flow ventral to the herniated cord and a normal CSF flow pattern dorsal to the spinal cord, thus excluding the coexistence of a compressive dorsal arachnoid cyst.

Three-dimensional-FIESTA in combination with PC cine sequences is a very sensitive method for the detection of associated abnormalities such as a dural duplication [1] or an arachnoid cyst [3]. We believe that this combination of sequences can replace computed tomographic myelography for diagnosis and surgical planning choice, thus avoiding the use of a more invasive imaging technique.

The current management of symptomatic TISCH is based on surgery. The goals of surgery are to reduce the herniation, return the spinal cord to the normal position, and prevent the recurrence of herniation [2, 11, 21]. Repair of the ventral dural defect can be accomplished by primary closure [10], fascia or muscle grafts [3, 12], or artificial dural graft as in our cases. Some authors [15, 22] have proposed to enlarge the dural defect to facilitate safe reduction with minimal cord manipulation. About two-thirds of patients are improved after surgery [11]. We observed a postoperative worsening of symptoms in our second patient, which may reflect the difficulty in executing the reduction or the irreversible nature of the damaged spinal cord. The natural history is variable and non progressive in some cases [11] so it may be appropriate to treat such cases expectantly, as for our patient 3.

Postoperative MRI usually shows realignment of the spinal cord and reappearance of the ventral subarachnoid space [2, 3, 23]. Postoperative 3D-FIESTA images showed better CSF-spaces abnormalities than conventional T2-weighted images, as tethering or arachnoiditis in our two surgically-treated cases. On the other hand, spinal cord abnormalities such as atrophy, signal abnormality, or tethering do not seem to be correlated with a poor functional outcome [10, 23]. However, in case of clinical postoperative deterioration, 3D-FIESTA sequences eliminated a recurrence of TISCH, showing the spinal cord behind the ventral dura mater, even if tethering existed. Phase-Contrast-Cine imaging could differentiate arachnoiditis with pouch from cyst (case 1), and confirm tethering of the spinal cord. In TISCH postoperative follow-up, this combined techniques showed CSF spaces abnormalities better than conventional images, whereas cord signal abnormalities were better visualized in T2-weighted images.

CONCLUSION

TISCH is a rare entity, which is getting more attention with the increasing availability of MRI. Conventional MR studies usually afford the diagnosis by showing a sharp ventral displacement of the thoracic spinal cord. 3D-FIESTA and 2D-PC cine imaging combination is very helpful for assessing the presence or the absence of a pre- or postoperative dorsal arachnoid cyst. This is a curable cause of progressive myelopathy that can be managed successfully with microsurgical techniques. Further studies are needed to evaluate the long-term outcome of these patients and the postoperative CSF-spaces abnormalities, which are better analysed with these combined techniques.

RÉFÉRENCES


