VIDEO OF ORTHOPAEDIC TECHNIQUE

Thoracic Endoscopic-Assisted Mini-Open Surgery for Thoracic and Thoracolumbar Spinal Cord Compression

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Intervertebral disc herniation is a common cause of spinal cord compression, especially for the thoracic and thoracolumbar spinal cord, which has limited buffer space in the spinal canal. Spinal cord compression usually causes decreased sensation and paralysis of limbs below the level of compression, urinary and fecal incontinence, and/or urinary retention, which brings great suffering to the patients and usually requires surgical intervention. Thoracotomy or abdomin thoracic surgery is usually performed for the thoracolumbar cord compression caused by hard intervertebral disc herniation. However, there is high risk of trauma and complications with this surgery. To reduce the surgical trauma and obtain good visibility, we designed thoracic endoscopic-assisted mini-open surgery for thoracic and thoracolumbar disc herniation, and performed this procedure on 10 patients who suffered from hard thoracic or thoracolumbar spinal cord compression. During the procedure, the thoracic endoscopy provided clear vision of the surgical field with a good light source. The compression could be fully exposed and completely removed, and no nerve root injury or spinal cord damage occurred. All patients achieved obvious recovery of neurological function after this procedure. This technique possesses the merits of minimal trauma, increased safety, and good clinical results. The aim of this study is to introduce this thoracic endoscopic-assisted mini-open surgery technique, and we believe that this technique will be a good choice for the thoracic and thoracolumbar cord compression caused by hard intervertebral disc herniation.

Key words: Intervertebral disc herniation; Mini-open; Spinal cord compression; Thoracic endoscopy

Introduction

Thoracic and thoracolumbar spinal cord compression is usually caused by intervertebral disc herniation, fracture, kyphosis, and ossification of ligaments, which result in spinal stenosis and the gradual deterioration of spinal cord function. Thoracic and thoracolumbar spinal cord compression needs to be treated with surgery once it leads to neurological compromise^{1–3}. Thoracic and thoracolumbar intervertebral disc herniation is relatively rare and is usually combined with cartilaginous nodes (vertebral posterior marginal intraosseous cartilaginous nodes), endplate irregularities, wedging of vertebra, atypical Scheuermann disease, or ligamentum flavum ossification. Because of the hardness of the thoracic intervertebral disc herniation and the limited buffer capacity of the thoracic spinal canal, the thoracic spinal cord is vulnerable, and it

is difficult and dangerous to remove the compression. Thoracotomy or abdomin thoracic surgery is usually performed for the thoracic and thoracolumbar cord compression caused by intervertebral disc herniation, which can cause great surgical trauma^{4–9}. To reduce trauma and to expose the compression and spinal cord clearly, we perform thoracic endoscopic-assisted mini-open surgery for the thoracic intervertebral disc herniation, and investigate the feasibility, result, and advantages and disadvantages of this technique.

Technique

Typical Case

We describe here a typical case of hard thoracolumbar cord compression. A 52-year-old woman presented with weakness

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Fig. 1 The preoperative sagittal (A) lumbar and (B) thoracic magnetic resonance imaging showed that the T₁₂–L₁ disc protruded backwards and severely compressed the spinal cord.

in the right lower extremity and right foot drop. Weakness of the right lower extremity first occurred 1 year prior to presentation, and was not treated systematically. One month prior to presentation, right hallux and ankle dorsiflexion were weak, with numbness and hypoesthesia of the right foot dorsum. Physical examination showed paravertebral deep tenderness on the thoracolumbar junction level. The strength of the right hallux and ankle dorsiflexion were both grade II. Hypoesthesia was present in the right medial crus and in the back of the foot. The knee and Achilles tendon reflexes were present bilaterally, and the bilateral Babinski sign was negative. The bilateral straight leg raising test results were negative (80°). The Patrick sign was negative bilaterally.

The preoperative lumbar and thoracic magnetic resonance imaging (MRI) showed that the T₁₂–L₁ disc protruded backwards and compressed the spinal cord (Fig. 1). The cross-sectional computed tomography (CT) scans showed ossification of T₁₂–L₁ disc protrusion and ligamentum flavum (Fig. 2). Disc protrusion was clear on the image, and the symptoms and signs were consistent with the lesion. Conservative treatment had achieved poor results, and the

Fig. 2 The preoperative cross-sectional computed tomography scans showed ossification of the T₁₂–L₁ disc protrusion and ligamentum flavum.

daily activities of the patient were seriously affected. The indications for surgery were clear.

Because the spinal cord was severely compressed by disc herniation anteriorly and ossification of ligament flavum posteriorly, one-stage posterior and anterior decompression surgery was planned, including laminectomy and pedicle fixation through a posterior approach, and thoracic endoscopic-assisted mini-open surgery through an anterior approach.

Surgical Technique

After the general anesthesia, the patient was placed in a prone position. The T₁₂–L₁ intervertebral space was located and marked under a C-arm fluoroscope. After routine disinfection and draping, a 10-cm longitudinal incision was made along the posterior. The subcutaneous tissue and deep fascia was incised and bleeding was controlled by bipolar coagulation. The paraspinal muscle was distracted from the spinous process to expose the puncture sites of T₁₂ and L₁ vertebral pedicles (shape crest). The positioning needle was placed with the angle and depth adjusted under the C-arm fluoroscope. Then, pedicle tapping was performed before the vertebral pedicle screws were inserted. The posterior decompression was performed at T₁₂L₁ level by removing supraspinous and interspinous ligaments, partial spinous process and lamina of T₁₂ and L₁. Laminectomy was performed with a high-speed burr. The hyperplastic ossifying ligamentum flavum was carefully removed and the cord was decompressed. The spinal cord achieved a good expansion after the posterior compression was removed. Suitable rods were inserted and tightened to connect screws. The incision was irrigated with sterile saline solution and sutured.

The patient was placed in a right lateral position. After routine disinfection and draping, a 12-cm incision was made along the 11th rib. The subcutaneous tissue, deep fascia and latissimus dorsi were incised and the 11th rib was separated and resected partially for bone grafting. Tissue separation was further performed along the extrapleural space to expose the T₁₂–L₁ intervertebral disc. The thoracic endoscopy was inserted through the incision. The annulus fibrosus was cut, and the disc material in the intervertebral space was removed. The posteroinferior corner of the T₁₂ vertebral body and the posterosuperior corner of the L₁ vertebral body were removed with a high-speed burr. The ossification and herniation were isolated by removing the posterior vertebral wall peripherally, then the ossification was carefully separated from the spinal cord and removed (Fig. 3A). With thoracic endoscopy, the compression and spinal cord were exposed clearly, so the decompression was performed easily with minimal invasion of the spinal cord. Sufficient decompression and good pulsation of the spinal cord could be observed (Fig. 3B). The resected rib was trimmed to an appropriate size and inserted to support the intervertebral space (Fig. 3C). The field was irrigated with sterile saline solution and a drainage tube was inserted; the incision was sutured routinely.

Fig. 3 The intraoperative view showed that (A) the ossification was carefully separated from the spinal cord and removed, (B) sufficient decompression and good pulsation of the spinal cord could be observed, and (C) the resected rib was trimmed to an appropriate size and inserted to support the intervertebral space.

Outcomes

The patient experienced obvious relief of symptoms after the operation, with significant recovery of strength of her right lower extremity, and the strength of her right hallux and ankle dorsiflexion recovered to grade 4 in 6 h. The drainage was removed in 24 h, and she ambulated with thoracolumbar brace. Postoperative lumbar X-ray and CT at 1 month follow-up showed that the internal fixation was in a good position with no loose or breakup of instrument, and the herniation and ossification was completely removed (Fig. 4).

From December 2014 to February 2016, we performed thoracic endoscopy-assisted mini-open surgery for thoracic and thoracolumbar spinal cord compression for 10 patients. Among these patients 7 had ossifying intervertebral disc herniation and ossification of ligamentum flavum, 2 had old vertebral burst fractures and kyphosis, and 1 patient had tuberculosis. Levels T₆ to L₁ were involved. Mini-open surgery was performed through extrapleural space in 8 cases at the thoracolumbar level, and mini-open thoracotomy was performed in 2 cases with lesions at T₆ and T_{8,9} level. The compression and spinal cord were well exposed and decompressed in all the patients. They did not cause dura mater or cord damage, nerve root disorders, or any other unwanted phenomena. Each patient experienced obvious recovery of neurological function.

Discussion

Characteristics of Thoracic and Thoracolumbar Spinal Cord Compression

Thoracolumbar spine is the junction of the kyphotic thoracic spine and the lordotic lumbar spine, which supports

concentrated stress. The incidence of intervertebral disc herniation is relatively high in thoracolumbar spine, and it is reported that 75% of thoracic disc herniation occurs at T₈–L₁ level^{3,4}.

It is reported that 75% of thoracic disc herniation occurs at T₈–L₁ level^{3,4}. The thoracic and thoracolumbar spinal cord is vulnerable, with limited buffer space of the spinal canal, so surgery is needed once symptoms of spinal cord damage develop.

Surgical Approaches

A variety of surgical approaches have been applied for thoracic and thoracolumbar spinal cord compression. Procedures involving resection of the anterior compression through posterior total laminectomy have abandoned because of the high rate of spinal cord traction injury^{3,4}. A posterior transpedicular approach can expose the lateral side of the disc by resection of the pedicle and facet joint, reducing the potential for spinal cord traction injury. It can be used for lateral and soft herniation without extensive calcification, but it is not a good choice for central and hard herniation. A costotransverse approach or a posterolateral extrapleural approach can increase the exposure of the spinal ventral side through removal of the partial rib, transverse process, vertebral pedicle, and facet joints; however, the exposure of the ventral side of the spinal cord is difficult, and likelihood of trauma with this approach is great, including injury to the segmental nerve root and Adamkiewicz artery. An anterior trans-thoracic approach can expose the ventral side of the dura, with direct and complete decompression. However, visibility of the compression and the

Fig. 4 The postoperative lumbar X-ray (A) showed that the internal fixation was in a good position with no loose or breakup of instrument, and computed tomography (B,C) showed that the herniation and ossification was completely removed.

spinal cord is poor with the naked eye, and sometimes it is necessary for the surgeon to touch the ventral side of the dural sac with their fingers to confirm sufficient decompression. With conventional thoracotomy with a large incision there is high risk of trauma, lung injury, and postoperative pain³⁻⁹.

In this study, thoracic endoscopy-assisted mini-open surgery was performed for thoracic and thoracolumbar spinal cord compression. The surgery was successfully completed. The thoracic endoscopy can provide a good light source, and good exposition of the compression protruding into the spinal canal, as well as the ventral side of the dural sac. The surgical field is clear under the thoracic endoscopy, with increased accuracy of decompression and less invasion of the spinal cord; adequate hemostasis can be achieved with the good visibility. The technique takes full advantage of mini-open surgery and thoracic endoscopy. The postoperative CT showed adequate decompression and significant improvement of neurological function.

Technical Points

The thoracic and thoracolumbar spinal cord is vulnerable, with limited buffer space in the spinal canal, so any interference may lead to spinal cord injury, or even irreversible injury. Hence, unnecessary intervention to the spinal cord should be avoided. The use of a rongeur may lead to further

compression of the spinal cord and aggravate the spinal cord injury, so a high-speed burr was used in the decompression. The corners of the adjacent vertebral body were removed to obtain enough working space. The periphery vertebral wall was removed to isolate the herniation and ossification, and then it was isolated from the spinal cord dura gradually, and removed. For patients with severe anterior and posterior compression from ossification of ligamentum flavum, posterior decompression of laminectomy was first performed to release the spinal cord, and then anterior decompression was performed until sufficient decompression was obtained.

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Video Image

Additional video images may be found in the online version of this article. Visit <http://onlinelibrary.wiley.com/doi/10.1111/os.12281/supinfo>.

References

1. Chen ZQ, Sun CG. Clinical guideline for treatment of symptomatic thoracic spinal stenosis. *Orthop Surg*, 2015, 7: 208–212.
2. Durbhakula MM, Cassinelli E. Thoracic disc herniation. *Contemp Spine Surg*, 2005, 6: 77–82.
3. Qi Q, Chen ZQ, Liu ZJ, et al. Surgical treatment and approaches selection of thoracolumbar disc herniations. *Zhongguo Ji Zhu Ji Sui ZaZhi*, 2006, 16: 133–137 (in Chinese).
4. Ding WY, Li BJ, Shen Y, et al. Thoracic disc herniation treated with posterolateral transpedicular approach operation. *Zhong hua Gu Ke Za Zhi*, 2006, 26: 39–42 (in Chinese).
5. Bartels RH, Peul WC. Mini-thoracotomy or thoracoscopic treatment for medially located thoracic herniated disc? *Spine (Phila Pa 1976)*, 2007, 32: E581–E584.
6. Ayhan S, Nelson C, Gok B, et al. Transthoracic surgical treatment for centrally located thoracic disc herniations presenting with myelopathy: a 5-year institutional experience. *J Spinal Disord Tech*, 2010, 23: 79–88.
7. Ohnishi K, Miyamoto K, Kanamori Y, Kodama H, Hosoe H, Shimizu K. Anterior decompression and fusion for multiple thoracic disc herniation. *J Bone Joint Surg Br*, 2005, 87: 356–360.
8. Anand N, Regan J. Video-assisted thoracoscopic surgery for thoracic disc disease, classification and outcome study of 100 consecutive cases with a 2-year minimum follow-up period. *Spine (Phila Pa 1976)*, 2002, 27: 871–879.
9. Wang P. Safety operation for thoracic spinal canal stenosis. *Zhongguo Xian Dai Shen Jing Bing ZaZhi*, 2004, 4: 273–275 (in Chinese).