Anterior thoracic foraminotomy through mini-thoracotomy for the treatment of giant thoracic disc herniations

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Abstract

Study design A retrospective review of a case series.

Objectives Giant thoracic disc herniations remain a surgical challenge and historically have been associated with significant complications. While neurological outcomes have improved with the abandonment of decompressive laminectomy, the attempt to minimize surgical complications and associated morbidities continues through less-invasive approaches. With the current study, we describe a surgical technique to treat giant thoracic disc herniations while minimizing approach-related morbidity.

Methods Demographic and radiographic data; clinical outcome and perioperative complications were retrospectively analysed for patients with single-level giant thoracic disc herniations who underwent mini-thoracotomy and selective microsurgical anterior spinal cord decompression without instrumented fusion.

Results Between 2007 and 2012, 7 consecutive patients with giant thoracic disc herniations were treated (average age of 53 years; range 45–66 years). The average canal encroachment was 73.2 % (range 40–92 %) with 5 grossly calcified discs of which 3 had transdural components. All patients had gradual myelopathic progression. The average Nurick grade was 3.5 (range 2–5). All patients were successfully treated with anterior microsurgical decompression without instrumentation. Uninstrumented fusion with rib graft was performed only in one patient with advanced degenerative changes. Average time of surgery was 337.8 min (range 220–450 min). The average length

of hospital stay was 7.4 days (range 6–11 days). The average neurological status at follow-up (average 23.5 months; range 9–36 months) using the modified Nurick grading scale was 1.28. No vertebral collapse or loss of spinal alignment developed. There were no neurological complications. One patient developed an acute headache and diplopia, 10 days after surgery, following sneezing associated with a post-operative thoracic cerebrospinal fluid leakage requiring revision. Two patients suffered an approach-related complication in form of intercostal neuralgia; one was persistent.

Conclusions Anterior decompression using a mini-trans-thoracic approach provides sufficient exposure for microsurgical decompression of giant thoracic disc herniations without disrupting the stability of the spine. Microsurgical decompression without instrumentation does not appear to lead to vertebral collapse or spinal malalignment.

Keywords Giant thoracic disc herniation · Less-invasive surgery · Transthoracic approach · Spinal cord compression · Spinal microsurgery

Introduction

Thoracic disc herniation is a relatively uncommon spinal condition with an incidence of 1 case per million population per year. Symptomatic thoracic disc herniation is a rare occasion and only comprises 0.15–1.80 % of all surgeries performed for all disc herniations. Seventy-five percent of thoracic disc herniations occur below T8, and the most commonly affected level is T11–T12. Male and female individuals are equally affected and the condition occurs commonly between the third and fifth decades of life. Signs and symptoms can vary from obscure thoracic or

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abdominal pain to severe myelopathy with bowel/bladder dysfunction. Progression of the spinal cord compression can result in bowel and bladder dysfunction, gait disturbance, variable sensory and/or motor dysfunction in the lower extremities, and paraplegia. Surgical treatment is indicated in patients with signs of myelopathy or severe radiculopathy that is nonresponsive to conservative treatment [1–3]. The subgroup of patients with giant thoracic disc herniations has unique presentations, pathological entities, surgical considerations, and outcomes. According to Hott et al., giant herniated thoracic disc are those occupying 40 % or more of the diameter of the spinal canal based on preoperative CT myelography, MR imaging, or both. There is scant literature on the clinical characteristics, treatment options, and outcome of patients with giant thoracic disc herniations [4].

Several approaches have been reported in the literature to treat thoracic disc herniations. There is no gold standard approach and each technique has unique advantages and disadvantages [5–8]. These approaches include transpedicular, transfacet pedicle-sparing approaches, costotransversectomy, transthoracic transpleural approach, thoracoscopic approach [9–14]. This report describes a less-invasive approach to treat giant thoracic disc herniations. It allows the surgeons to perform standard anterior discectomy through a less-invasive approach with the advantages, which include performing the procedure under direct vision, and less potential peri-operative and post-operative morbidity compared with the literature.

Our purpose in the current study is to describe the early results of the mini-thoracotomy approach for symptomatic giant thoracic disc herniations.

Materials and methods

Patients who underwent surgery for giant thoracic disc herniation between 2007 and 2012 were included in this study. Patients who presented with radiculopathy or myelopathy due to a giant thoracic disc herniations were considered candidates for this surgery. All patients had preoperative magnetic resonance imaging (MRI) scan of the entire spine (Figs. 1, 2). Patient's data included level, clinical presentation, blood loss, length of surgery, and peri-operative complications. Clinical outcomes were measured using the Modified Nurick grading score before and after the surgery (Table 1). All data were collected, retrospectively (Tables 2, 3, 4).

Surgical technique

The side of the approach was primarily chosen according to the laterality of the prolapse (left 1 case, right 6 cases).

Where the prolapse was located centrally, the thoracotomy was favoured on the right side to avoid any necessity of retracting the aorta. Single lung ventilation was used in those patients with adequate pulmonary function. Side supports were utilized to rigidly fix the chest and pelvis in a true lateral position and prevent any motion of the spine during surgery. The alignment of the coronal plane perpendicular to the floor was confirmed under fluoroscopy and appropriate adjustments made through minor tilting of the operating table. The projection of the target level on the lateral chest wall was marked under fluoroscopy by counting the levels up from the lumbosacral junction. A standard mini-thoracotomy, as previously described by H. M. Mayer (15), was performed centered over the posterior edge of the targeted disc space. Latissimus dorsi and serratus anterior muscles layers were split in all cases and not transected. In 5 cases, the thoracotomy was performed with resection of approximately 10 cm of rib to reduce the force of distraction on the ribs after one patient (patient 6) had developed ongoing intercostal pain. A standard Finochetto retractor with small blades was used in all cases. The pleura was split longitudinally over the targeted disc and adjacent vertebrae, and a marker placed into the disc. After radiographic confirmation of the level, a malleable retractor was placed between the pleura and anterior border of the vertebral bodies adjacent to the target disc and taped to the retractor.

The head of the rib was removed and the borders of the adjacent pedicles identified. Under the surgical microscope a 5- to 6-mm wide groove was cut into the posterior third of the vertebral body using a high-speed burr parallel to the endplate on either side of the targeted disc up to the posterior wall, and to a depth of approximately half of the vertebral diameter (Fig. 3). Subsequently, the exposed endplates and disc portion were removed. The exposed posterior wall was carefully burred down using a diamond burr. Sparing resection of the pedicles was performed with Kerrison rongeurs, exposing dura above and below the disc herniation. Using curettes and dissectors, the prolapse was delivered away from the dura into the cavity previously created by resection of the endplates and adjacent vertebral bone. Soft disc herniations were easily separated from the dura, whereas calcified hernias were found to be firmly attached to the dura in three cases. In two cases the dura was regionally too adherent to be separated without dural defect, and in one case (case 1) the hernia was indistinguishable from dura and required resection of the dura for removal. Dural repair with Tachosil patch (Takeda Pharmaceuticals International GmbH, Thurgauerstrasse, Zurich, Switzerland) was necessary in these three cases. In case 1 a double-layered patch was applied one from inside of the dura, one from outside sandwiching the dural edges between the patch layers. In this case an additional layer of

Fig. 1 Pre- and post-operative scans demonstrating giant thoracic disc from our series. Patient 1 (a–f); patient 2 (g–m); patient 3 (n–q); patient 4 (r–v); patient 5 (w–y) (preoperative images only—the patient improved from surgery, but refused follow-up MRI)

fibrin glue and Spongistan covering the defect was applied. Haemostasis was accomplished through bone wax for seepage from exposed bone and with bipolar cautery and

Floseal (Baxter Deerfield, IL, USA) for epidural venous bleeding. Pleural closure consisted of a running vicryl suture and a large tachosil patch in all cases. The thoracotomy was

Fig. 2 Pre- and post-operative scans demonstrating giant thoracic disc from our series. Patient 6 (a–d); patient 7 (e–h)

Table 1 Modified Nurick Grading Scale [37]

Grade 0	No root or cord symptoms
Grade 1	Signs or symptoms of root involvement only (no spinal cord symptoms)
Grade 2	Signs of spinal cord involvement—nomal gait
Grade 3	Mild gait abnormality—does not prevent employment
Grade 4	Gait abnormality prevents employment
Grade 5	Only able to walk with assistance
Grade 6	Chair bound or bedridden

closed after placing a chest drain with standard Prolene and vicryl sutures. The operations were performed under normotension without routine intraoperative cortisone use. Lumbar drains were placed in cases 1 and 5.

Results

Seven patients (3 males and 4 females) were enrolled in this study. The average age of patients at presentation was 53 years (range 45–66 years). The average follow-up period was 23.5 months (range 9–36 months). The disc herniation was at the following levels: T5–6 ($n = 2$), T7–8 ($n = 2$), T8–9 ($n = 1$), T9–10 ($n = 2$) (Table 2). The average operation time was 337.8 min (range 220–450 min). The mean blood loss was 800 mL (range 400–1,500). The mean duration of hospitalization was 7.4 days (range 6–11 days) (Table 3). One patient had a pre-operative

lumbar drain inserted, due to the high probability of having CSF leak due to the herniation to be transdural and calcified. One patient (case 1) had a lumbar drain inserted after the revision thoracotomy for a recurrent CSF leak. Average canal encroachment was 73.2 % (range 40–92 %) with 5 grossly calcified discs of which 3 had transdural components (Table 4).

Clinical outcomes

The mean pre-operative average Nurick score was 3.5 (range 2–5), and improved to 1.28 at an average follow-up of 23.5 months. No patient had neurological deterioration. All patients had subjective improvement of motor power and gait.

Complications

One patient (50-year-old male with progressive myelopathy—case 1) developed an acute onset of headache and diplopia (abducens nerve palsy) following sneezing 10 days after surgery. An MRI of the brain revealed a subdural collection that did not require any neurosurgical intervention. CSF leakage into the thoracic cavity was diagnosed and a surgical revision was performed with re-sealing of the dural defect with fibrin glue and collagen sponge layers. A lumbar drain was placed for 5 days. Diplopia resolved over 3 months. Two patients developed intercostal neuralgia (1 persistent). None of the patients had

Table 2 Patient demographic and clinical data

Patient	Age (years)	Sex	Symptoms	Duration of symptoms (months)	Myelopathy (Nurick scale)	Post-op (Nurick scale)	Level	Follow-up (months)
1	50	M	Back pain, leg disaesthesia, leg weakness	12	3	1	T9–T10	36
2	66	F	Genital paraesthesia, progressive right leg disaesthesia	6	2	1	T7–T8	11
3	53	M	Progressive leg weakness, ataxic gait, leg disaesthesia	5	4	2	T7–T8	9
4	45	F	After fall: bilateral leg paraesthesia, back pain, bladder hesitancy, leg weakness	8	5	1	T9–T10	24
5	51	F	Urinary incontinence, leg weakness, T10 sensory level paraesthesia, ataxic gait	7	4	2	T8–T9	26
6	59	F	Progressive leg dysaesthesia, ataxic gait, salturary episode of urinary incontinence, thoracic back pain	18	3	1	T5–T6	41
7	45	M	Progressive leg weakness, ataxic gait, leg paraesthesia, salturary urinary incontinence	8	4	1	T5–T6	18

Table 3 Perioperative data

Patient	Length of stay (days)	Blood loss (ml)	Operative time (min)	Post-operative intercostal neuralgia	Pleural effusion
1	7 (8)	500	350	No	Yes
2	11	1,500	340	Yes	No
3	6	400	420	No	No
4	6	1,400	345	No	No
5	8	900	450	No	No
6	9	500	240	Yes (permanent)	No
7	5	400	220	No	No

Table 4 Thoracic disc features and procedural data

Patient	Canal encroachment (%)	Calcified	Transdural	CSF leak	Right/left thoracotomy	Resection of rib	Lumbar drain	Rib graft
1	92	Yes	Yes	Yes (revised)	Right	No	No (yes)	No
2	70	Yes	No	Yes	Right	Yes	No	Yes
3	85	Yes	No	No	Right	Yes	No	No
4	90	No	Yes	Yes	Left	Yes	No	No
5	90	Yes	Yes	Yes	Right	Yes	Yes	No
6	41	Yes	Not	No	Right	No	No	No
7	45	No	No	No	Right	Yes	No	No

vertebral body collapse, thoracic spine malalignment or axial thoracic pain at the latest follow-up. The overall complication rate was 42.8 %. No patient had neurological deterioration.

Discussion

The thoracic spine and spinal cord have several unique features that make them vulnerable to anterior compression.

The thoracic spine is normally kyphotic and the spinal cord runs close to the posterior elements of the vertebral bodies. In addition to its close proximity to anterior pathology, tethering of the spinal roots by the dentate ligaments also limits the mobility of the spinal cord to drift away from anterior impingement. The thoracic spinal cord is approximately 6.5 mm deep and 8.0 mm wide, whereas the thoracic spinal canal is approximately 16.8 mm deep and 17.2 mm wide. The canal does widen distally, and as a result, there is a

Fig. 3 Illustration showing skin incision (*red line*); anterior thoracic foraminotomy (*blue and red circle*) and 5–6 mm vertebral body groove cut into the posterior third of the vertebral body using a high-

speed burr parallel to the endplate on either side of the targeted disc up to the posterior wall and to a depth of approximately half of the vertebral diameter (*red square*)

minimal clearance space of 9.2 mm laterally, whereas there is 10.3 mm of clearance in the AP direction leaving less room for spinal cord in case of stenosis [16]. Finally, the thoracic spinal cord is vulnerable to ischaemic injury due to the presence of an anatomic area of poor blood supply called the “watershed zone.” In contrast to cervical and lumbar disc herniations, thoracic disc herniations are more frequently centrally located. In addition, they are known to calcify more frequently. They may be adherent to and even erode through the dural sac over time. The development of clinical symptoms is attributed to local vascular compromise leading to spinal cord dysfunction. Doppman and Girtan [17] demonstrated in an experimental animal model that neurological deficits can recover, even in the presence of spinal cord distortion, if the normal circulation is restored; whereas the deficit usually persists if the normal hemodynamics cannot be restored.

Giant thoracic disc herniations are challenging surgical lesions. These discs are often densely calcified and tend to erode the dura mater. Calcified giant thoracic disc herniations tend to incorporate the dura into the calcified mass. Choosing the appropriate surgical approach is, therefore, critical in patients with giant thoracic disc herniations. 70 % of giant thoracic discs are transdural. In 50 %, the calcified disc penetrated the intradural space, leaving no remnant of dura behind [4].

The operative treatment of thoracic disc herniations was initially performed via thoracic laminectomy in which the disc was excised. The first authors to report clinical data for this treatment were Mixter and Barr in 1934 [18]. Their results and the results of other series reporting the use of a standard laminectomy approach were disappointing, yielding major morbidity rates of 18–75 % and mortality rates up to 50 % [19]. As a result, a number of alternative surgical approaches were developed, including the

transpedicular, transfacet pedicle sparing, costotransversectomy, lateral extracavitary, and transthoracic approaches [9–14]. Each of the aforementioned surgical approaches is associated with a specific set of complications. Several theories exist to explain the poor results associated with standard laminectomy approach. It is thought that the manipulation required for removal of the disc ventral to the spinal cord may produce mechanical injury and also potentially interfere with the spinal cord blood supply. There is also evidence that even minor kyphotic deformities produced by laminectomy can cause tethering of the spinal cord over incompletely removed disc or osteophyte and, in turn, lead to neurological deficit [5]. The costotransversectomy approach was described by Hulme [20] in 1960, who reported decreased procedural morbidity and improved patient outcomes. But this approach has drawbacks, including access limitations to the contralateral disc without spinal cord retraction, a limited working window to perform osteotomies or broader decompressions for large or highly calcific thoracic disc herniations [11, 20]. An inadequate working corridor forces the surgeon to retract the spinal cord to some degree. This experience led to the adoption of a transthoracic approach during the late 1960s, recognized for its utility in midline and transdural thoracic lesions [21]. Morbidities associated with thoracotomy, led to the development of thoracoscopic techniques [22–25]. Although giant thoracic disc herniations can be resected via thoracoscopy, these procedures are considerably more complex than open thoracotomy; gentle dissection of the dura from ossified disc and dural reconstruction is significantly more difficult and risky to perform thoracoscopically [26]. Anand and Regan [22] reported 21 % complication rate in a series of >100 patients. Fifteen percent of the complications was pulmonary related. McAfee et al. [27] reported perioperative complications in 78 patients

who had video-assisted thoracic surgery (VATS) (41 for thoracic disc herniation); the most common complications were intercostal neuralgia (8 %) and atelectasis (6 %) sufficient enough to delay discharge.

We believe that the transthoracic approach is the gold standard to treat thoracic disc herniations. However, standard thoracotomy carries significant risk of perioperative morbidity to the patient, therefore, a modification of a less-invasive thoracotomy approach has been developed [1, 15, 23, 26] to minimize the perioperative complications associated with conventional thoracotomy. The mini-thoracotomy approach, originally described by H. M. Mayer [15] combined with the use of a surgical microscope represents a middle-ground alternative between endoscopic and open-approach procedures especially for the treatment of giant thoracic disc herniations. It utilizes direct visualization, magnification, and adequate working field. The working field, while smaller than that for classic thoracotomy, has the advantage of allowing the surgeon simultaneous control of the pathology and the essential anatomical structures. This approach also allows decompression of the pathology under direct vision. With the use of the microscope, it provides adequate visualization to carry out the conventional procedure with a special light source that provides excellent illumination. Instead of manipulating the spinal cord, we prefer to create a working corridor that functionally expands the spinal canal, removing a 5- to 6-mm wide groove of the posterior third of the vertebral body using a high-speed burr. In our experience, the anterior approach allows the disc to be taken away from the cord ventrally, thus minimizing manipulation of the cord, an important goal for the patient with myelopathy. Second, giant thoracic discs tend to be centrally based in their position ventral to the spinal cord, and only anterior approaches allow direct visualization of the dissection plane between the dura and disc. Finally, giant thoracic disc herniations are often adherent to, or in some cases penetrating through, the ventral dura, and anterior approaches facilitate careful dissection [28–30]. This approach should disrupt only the middle column of the thoracic spine, following Denis' three-column theory. The intact anterior and posterior columns should thus stabilize the thoracic spine [31]. In the literature, the mean blood loss in open procedures was 562.9 ml (range 295–870 ml) in 203 patients, with a mean operative time of 229.3 min (range 150–305 min) in 128 patients and an average length of stay of 8.6 days (range 5.4–16.5 days) in 134 patients. A literature review on minimally invasive approaches for thoracic disc herniations showed mean blood loss of 307.1 ml (range 33–732 ml) in 293 patients, operating time of 199.8 min (range 93.75–216 min), and length of stay of 3.8 days (range 2.5–6.5 days) in 265 patients [26].

Results in the current study, based solely on giant thoracic disc herniations, showed 800 ml of mean blood loss, 337.8 min of mean operating time, and 7.4 days of average length of stay. Overall complication rate in the current study was 42.8 %. Overall complication rates for open approaches in the literature averaged 36.7 % (range 0–82 %) in 357 patients, and those for minimally invasive approaches averaged 28.4 % (range 0–92.3 %) in 466 patients. Minimally invasive reoperation average was 5.9 % (range 0–13.3 %) in 369 patients and open reoperation average of 4.3 % (range 0–33.3 %) in 231 patients [26]. In the context of open thoracotomy, post-thoracotomy pain syndrome has been reported in as many as 50 % of patients in the early post-operative period, with approximately 30 % continuing to experience the syndrome 4–5 years after surgery [32]. Substantial incisional pain or intercostal neuralgia was experienced in 2 of our cases (28.5 %) of which one (14.2 %) was persistent.

In the current series, the clinical outcome scores of the patients improved early on and maintained at the latest follow-up. No major complications were observed. The present series is limited by the fact of the small patient group and lack of control group. However, we believe that the novelty of our series is the giant size of the discs that were treated microsurgically with a non-instrumented approach while allowing excellent exposure.

In only a few contemporary large series the authors described the surgical management of thoracic disc herniations [5, 10, 13, 22, 29, 33–36]. In these reports, however, investigators included all subgroup of herniations not stratifying the discs based on size. There is scant literature on the clinical characteristics, treatment options, and outcome of patients with giant thoracic disc herniations. Hott et al. [4] have defined giant thoracic disc herniations as those occupying 40 % or more of the diameter of the spinal canal based on pre-operative CT myelography, MR imaging, or both. They concluded that the most important tenets for the surgical treatment of giant thoracic disc are ample exposure and an appropriate working corridor to deliver the extensive disc material. They recommended a two-level corpectomy to minimize retraction of the spinal cord, and to provide sufficient space to deliver the disc fragments into the sizable osseous cavity that was created, which was after reconstructed by placing interbody bone grafts and fixated with instrumentation. Conversely, we have proven that even a giant thoracic disc herniations can be removed safely with a microsurgical access and without need of performing corpectomy. Although some authors [1, 4, 26, 30] favour routine instrumented fusion using a variety of cage and plating systems, this was not typically necessary in our series. The average pre-operative canal encroachment in our series was 73.2 % (range 41–92 %), therefore even larger than those described in the literature as giant.

Nonetheless we did not have any post-operative vertebral collapse, spinal malalignment or neurological deterioration with the technique described here.

Conclusions

Giant thoracic disc herniations are challenging, high-risk surgical lesions. They are associated with more severe neurological deficits and worse functional recoveries than small and medium thoracic disc herniations. When a tailored, thoughtful surgical approach is executed, however, these lesions can be removed safely and myelopathy can be arrested and even improved. In our hands, the optimal surgical approach for giant thoracic disc herniations is a microsurgical thoracotomy without instrumented fusion.

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