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ORIGINAL ARTICLE

## Minimally invasive costotransversectomy for the resection of large thoracic dumbbell tumors

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### ABSTRACT

**Background:** Due to their important size and complex localization, the management of thoracic dumbbell tumors is challenging, frequently requiring the need for an anterior approach. Our study aims to first report the feasibility and safety of a single-stage posterior minimally invasive procedure in achieving complete resection of voluminous thoracic dumbbell tumors.

**Methods:** We retrospectively reviewed the medical records of five consecutive patients, who underwent the minimally invasive resection of a type III thoracic dumbbell tumor in our institution between March 2007 and March 2012. There were two men and three women, with a mean age at diagnosis of 57 years (range 41–68 years). After the placement of a non-expandable tubular retractor under fluoroscopic control, a costotransversectomy was achieved. By moving the retractor in all directions, the tumor was largely exposed and resected with the cavitron ultrasonic surgical aspirator. Clinical and radiological monitoring was performed before discharge, at 6 months, 1 year and 2 years.

**Results:** No major intraoperative complication was reported. Gross total resection was achieved in four patients. The mean operative time was 219 mins (range 75–540 mins) and the mean estimated blood loss was 230 ml (range 50–500 ml). No postoperative complication was reported. The mean length of hospital stay was 3.6 days (range 2–6 days) and all patients were discharged home. Histological analysis confirmed the diagnosis of grade 1 schwannoma in four patients and revealed a hemangiopericytoma in one patient. No tumor recurrence was noted with a mean follow up period of 46 months (range 32–54 months).

**Conclusion:** Thoracic dumbbell tumors can be safely and completely resected using a single-stage minimally invasive procedure. The costotransversectomy can be performed through a non-expandable retractor allowing sufficient access to all parts of the tumor.

### ARTICLE HISTORY

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### KEYWORDS

Schwannoma; dumbbell tumor; costotransversectomy; minimally invasive

### Introduction

Primary spinal tumors are relatively uncommon and account for 15% of the whole central nervous system tumor, 10% being intramedullary, 80% intradural – extra medullary and 10% extradural.<sup>1–3</sup> Among all extra medullary tumors, 40% are nerve sheath tumors (schwannomas, neurofibromas), 40% are meningiomas and 15% are ependymomas of the filum.<sup>3</sup> Clinical presentation is related to compression of the spinal cord or the nerve roots. Thus, patients may present with back or neck pain, radiculopathy and myelopathy of varying distribution and severity depending on the tumor size and location. Surgery remains the mainstay of treatment with the aim to achieve gross total resection without causing neurological impairment. It is widely recognized that this aim can be achieved through a single posterior approach for intradural tumors or extradural tumors that are confined to the spinal canal. Although, posterior laminectomy provides a good exposure of the spinal canal and its relevant anatomy, this procedure is associated with significant morbidity and can lead to spinal instability especially when partial or complete facetectomy is required.<sup>4–9</sup> With the recent advances in minimally invasive techniques and instrumentations, some

surgical teams demonstrated that these particular tumor types could be safely resected through a non-expandable retractor, thus limiting the surgical approach morbidity and preserving spinal stability.<sup>10–13</sup> A minority subgroup of tumors exhibits contiguous intraspinal, foraminal and extraforaminal components. A bony constriction at the foramen gives them an hourglass shape, being described as dumbbell tumors.<sup>14</sup> Due to their rarity, these tumor types have not been methodologically addressed in the current literature, making it difficult to establish optimal surgical strategies for their treatment. As thoracic dumbbell tumors frequently harbor significant paraspinous extension, an anterior approach is often considered necessary,<sup>15–17</sup> with the drawback of requiring a second surgical step and increasing the patient's overall morbidity. Minimally invasive techniques have been increasingly used in recent years for the management of thoraco-umbro spine tumors, to overcome the drawbacks of open procedures. As many teams, we previously reported our experience in a case series that involved patients included in the present study.<sup>11</sup> However, this study that focuses on thoracic dumbbell tumors, aims both to precise the technical aspects of their management and to assess the ability of minimally invasive approaches in achieving tumor control with a long-term follow-up.

## Materials and methods

### Inclusion criteria

We included in our study all consecutive patients who underwent the resection of a voluminous thoracic dumbbell tumor through a non-expandable retractor, in our institution between March 2007 and March 2012. We included only patients who harbored grade 3 or grade 4 tumors according to the Eden's classification<sup>18</sup> (Table 1). No patient had neurological deficit at initial evaluation. Patients with a history of thoracic surgery or spinal surgery at the thoracic level were excluded. Patients with suspected or confirmed neurofibromatosis were also excluded. There were two men and three women, with a mean age at diagnosis of 57 years (range 41–68 years). Main demographical data are summarized in Table 2.

### Decision-making

All patients underwent an MRI of the whole spine and a chest CT scan, which confirmed the presence of a large tumor that extended into the vertebral canal. The cases were discussed with the radiologists of our institution, and given the characteristic aspect of the tumors, a biopsy was not considered suitable in any case. The different treatment options have been systematically discussed with patients. Surgical treatment was preferred for patients in good general condition who were considered to have an extended life expectancy. After having been clearly informed of the benefits and risks of each surgical procedure, all patients gave their informed consent for undergoing a one-stage minimally invasive procedure.

### Surgical procedure

Under general anaesthesia, patient was positioned prone on a radiolucent Jackson table, allowing AP and lateral fluoroscopy. Using fluoroscopic control, a 2.5 cm longitudinal skin incision was made ~3–5 cm lateral to the midline, ipsilateral to the tumor. The incision was made from skin to fascia and a guide wire was inserted to the bone under fluoroscopic control. Then, a 24 mm-diameter non-expandable Spotlight tubular retractor (Depuy Spine, Raynham, MA) was placed over serial dilators and fixed in place using a table-mounted arm (Figure 1). After confirming the correct placement of the working tube, the relevant anatomy was exposed using an operating microscope (Carl Zeiss, Brighton, MI). The interlaminar space, the adjacent laminae, the transverse process and the two adjacent ribs were exposed after removing the remaining soft tissues. The transverse process, the edge of superior and inferior ribs and lateral aspect of the superior facet were systematically resected using a high-speed diamond drill

(Midas Rex Legend, Medtronic) and Kerrison rongeurs to widen the operating field. When larger exposure was required, bony resection was enlarged 'on demand', by moving the retractor medially, cranially, and caudally. The tumor capsule was exposed and widely opened to collect pathological specimens. Then with the small tip cavitron ultrasonic surgical aspirator (CUSA), tumor excision was carried out in standard microsurgical fashion (started in the tumor centre and extended to the edges) until a gross total resection was achieved or until it was unsafe to continue without compromising neural or other surrounding structures (pleura and diaphragm). The tumor capsule ensured a safe interface, and was dissected and removed from the parietal pleura at the end of the procedure. Finally, the integrity of the nerve root and the decompression of the spinal canal were verified and the operative field was irrigated with normal saline. After removing the tubular retractor, the fascia was approximated with sutures, and the skin was closed in two layers. Operative parameters were prospectively collected including, operative time, estimated blood loss and any intraoperative complication.

### Clinical and radiological follow-up

During the postoperative course, neurological status, pain, length of hospital stay and complication were systematically reported. All patients benefited from a postoperative MRI (with gadolinium enhancement) within the first 48 h to assess the resection. A chest X-ray was also performed to ensure the absence of pleural effusion.

The follow up visits were scheduled at 8 weeks, 6 months and 1 year and 2 years, postoperatively. During these visits, our evaluation included: physical and neurological examination, VAS, return to work and Mac Nab modified criteria<sup>19</sup> (Table 3). MRI follow-up were performed at 6 months, 1 year and 2 year to confirm the absence of tumor recurrence (Figure 1).

## Results

### Operative parameters

The mean operative time was 219 mins (range 75–540 mins) and the mean estimated blood loss was 230 ml (range 50–500 ml). No patient required blood transfusion during or after surgery. No major complication occurred during the procedures. For the second patient, the inferior part of the tumor was adherent to the pleura and the diaphragm. An incidental opening of the pleura occurred during the dissection that was repaired with sutures. The dissection was stopped and a subtotal resection was performed leaving a small part of the tumor, far from the neural structures. No related complication was reported postoperatively.

### Postoperative course

Patients were mobilized the day after surgery. No patient worsened his neurological condition postoperatively. No other

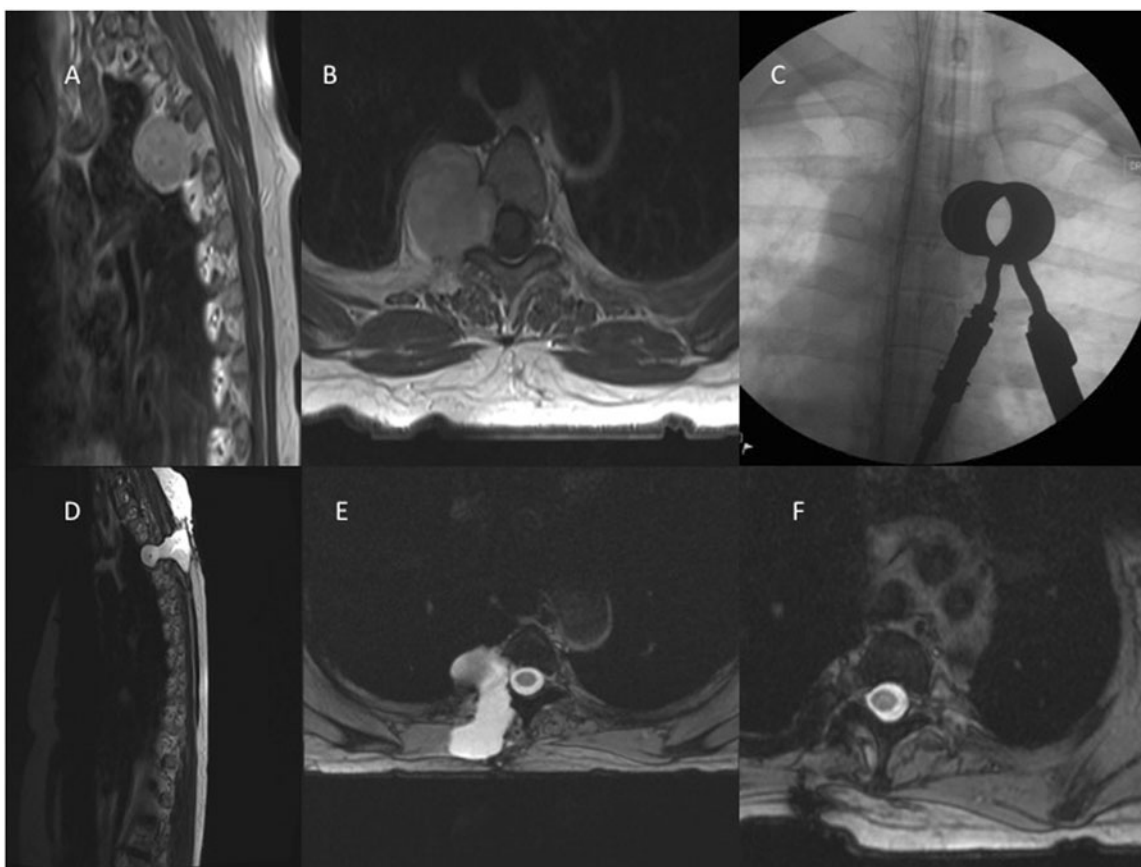
Table 1. Eden's classification.

Type I	Intra- and extradural type
Type II	Intra- and extradural and paravertebral type
Type III	Extradural and paravertebral type
Type IV	Foraminal and paravertebral type

Table 2. Main demographical data and operative parameters.

Patient	Age	Sex	Level	Type	Size (cm)	Op Time (min)	EBL (ml)	GTR	Complication	LOS (days)	Histology
1	45	F	T6	III	4 × 3 × 5	160	200	Yes	No	6	Schwannoma
2	63	M	T11	III	6 × 3.6 × 5.5	540	500	No	No	4	Schwannoma
3	68	F	T3	III	3 × 3.5 × 4	155	100	Yes	No	2	Schwannoma
4	41	F	T4	III	3.5 × 3.7 × 4	165	300	Yes	No	4	Hemangiopericytoma
5	68	M	T8	III	4 × 4 × 3.5	75	50	Yes	No	2	Schwannoma

op time: operative time; EBL: estimated blood loss; LOS: length of hospital stay.



**Figure 1.** Preoperative sagittal (A) and axial (B) T1-weighted MRI revealing an homogeneously enhanced mass centered on the right T3–T4 foramen (grade III dumbbell tumor). The patient underwent minimally invasive resection through a tubular retractor (C) laced over the left T3–T4 foramen. Immediate postoperative T2-weighted MRI on Sagittal (D) axial (E) plane demonstrating the surgical corridor axial (F). T2-weighted MRI on axial plane performed at 1 year confirming gross-total resection.

complication was reported. The mean length of hospital stay was 3.6 days (range 2–6 days) and all patients were discharged at home. Histological analysis confirmed the diagnosis of grade 1 schwannoma in four patients and revealed a hemangiopericytoma in one patient. Simple monitoring was decided for all patients, even to the patient who underwent a subtotal resection, as the remaining tumor was far from the spinal canal and the analysis revealed no evidence of anaplasia.

### Follow up

The mean follow up period was 46 months (range 32–54 months). During follow-up, no patient reported significant pain requiring treatment. At 6 months, the Mac Nab was excellent in all patients. For patients who underwent complete resection, no tumor recurrence was noted (two patients completed 2 years of follow up and two patients completed only 1 year of follow up). For patient who experienced subtotal resection, no tumor growth was reported after 4 years.

### Discussion

‘Dumbbell tumor’ is used as a conceptual term meaning a tumor that involves several anatomical regions such the intradural space, the epidural space and paravertebral space.<sup>18,20</sup> Ozawa et al.<sup>20</sup> reported a large retrospective series of 118 dumbbell tumors, among a total of 674 spinal cord tumors followed in their institution between 1988 and 2002. Although, these tumors can occur at all levels, the cervical spine was the most frequently involved

(44%), followed by the thoracic spine (27%). They demonstrated that more than 50% of the dumbbell tumors were type III, harboring a large volume at diagnosis, as in our series. Indeed, in this tumor type, clinical symptoms occur late, as the extraforaminal component is predominant and the tumor growth is slow.<sup>21</sup> They also demonstrated that almost all tumors were benign in the adult population (schwannoma 80%, neurofibroma 12% or meningioma 5%), while 64% of patients younger than 10 years had malignant tumors (neuroblastoma, sarcoma). Thus, CT-guided biopsy should be considered in younger patients or in particular cases, when clinical or radiological findings are not suggestive of a benign tumor. In addition to the MRI that reveals a homogeneously enhanced and well-limited tumor, the CT-scan can be helpful by revealing a foraminal enlargement with sclerotic margins rather than osteolysis. In such situations, the management can reasonably be defined without histological analysis.<sup>1,2,20,21</sup> As for many rare diseases, there is no consensus for the ideal management of dumbbell tumors. However, simple monitoring is a valuable option for small and asymptomatic tumors, especially for elderly patients. Radiosurgery has been recently reported as an efficient treatment modality for growing or symptomatic tumors.<sup>22,23</sup> However, radiation to benign tumors of the spine as a primary treatment modality has not been advocated, and descriptions of its role are scarce in the literature. Due to the lack of evidence, this treatment should be recommended for patients who are not candidate for surgery. For most patients, surgical resection remains the standard treatment, associated with excellent outcome and low recurrence rate when gross total resection is achieved.<sup>14,20</sup> The complex localization of these tumors,

extending both into the vertebral canal and into the chest cavity (type III and IV), makes surgical treatment challenging. Various surgical strategies have been reported, aiming to achieve gross total resection, while minimizing surgical trauma to surrounding structures (spinal cord, pleural, diaphragm) and preserving spinal stability. Most proposed operative approaches<sup>24</sup> were based on the Eden's classification: for type I, the posterior approach; for types II, the posterior ( $\pm$  thoracic) approach; for type III, the combined posterior and thoracic approach; and for type IV, the thoracic ( $\pm$  posterior) approach. Indeed, thoracotomy has been long considered as a necessary step for complete resection of type III and IV dumbbell tumors.<sup>24,25</sup> More recently, thoracoscopy has been proposed as a valuable alternative to standard thoracotomy.<sup>26–28</sup> Although, the thoracoscopic approach is significantly less painful during the recovery period than thoracotomy and much less likely to be associated with post thoracotomy pain syndrome, this strategy requires a second stage procedure with chest tube placement, which is likely to increase the overall morbidity.

Regarding the posterior approach, conventional laminectomy is not sufficient by providing a limited access to the tumor mass. The extended posterolateral approach has been proposed as an alternative treatment modality to widely expose the tumor, preventing the need for additional thoracoscopy.<sup>29</sup> During this procedure, complete facetectomy and extended costotransversectomy in addition to the standard laminectomy. The wide exposure allowed gross total resection in most reported cases. However, it requires a wide muscle desinsertion, leading to increased blood loss and postoperative pain. Pleural violation with chest tube insertion has been reported to be a frequent complication with such approach. Moreover, fusion was needed in all cases with regard to the amount of resected bone.<sup>29,30</sup>

In recent years, posterior minimally invasive procedures have gained popularity in the management of spine tumors, by achieving the same results as open procedures while dramatically decreasing the overall morbidity.<sup>31</sup> The reported experiences were limited to tumors confined to the vertebral canal,<sup>11</sup> the foramen or the vertebral body.<sup>31</sup> In a cadaver study, Mussachio et al.<sup>32</sup> demonstrated the feasibility of minimally invasive costotransversectomy through a non-expandable retractor. The authors demonstrated that this procedure was a safe and effective alternative to the current open procedure to access the vertebral canal and to perform a corpectomy, for the management of metastatic spine disease. In our study, this approach was effective by providing a wide access to the two portions of the dumbbell tumor with minimal bone resection. We were able to achieve complete tumor resection by using small tip CUSA and starting in the center of the tumor and extended to the edges, even though the retractor was non expandable we were able to orient it in different directions to have access to the different parts of the tumor. This approach provides adequate access to the intraspinal and intrathoracic extra pleural compartment with decreased disruption to the spinal and Para spinal structures compared to traditional open techniques, thus preserving spinal stability (Figure 2). In one patient, the resection was incomplete as the tumor was adherent to the diaphragm. After a prolonged dissection, we decided to coagulate the residual tumor to limit the operative risks. It is likely that the open approach has led to the same result. The patient underwent a simple monitoring that showed no recurrence until now. Ando et al.<sup>2</sup> reported a series of eight patients who underwent a single-stage posterolateral approach for the resection of type III and IV dumbbell tumors. They performed an extended laminectomy, facetectomy, and costotransversectomy. Fusion was performed in all cases at the end of the

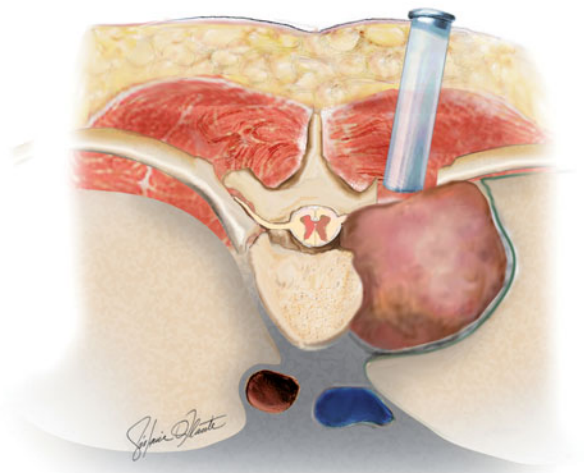


Figure 2. Artist's illustration depicting the access to the tumor through the tubular retractor after performing the costotransversectomy.

procedure. The reported operative time ranged from 185 to 420 mins (mean 313 mins) and the estimated blood loss ranged from 71 to 1830 mL (mean 658 mL). They reported two pulmonary complications occurring in two patients (atelectasia and pleural penetration). Our results compare favorably and indicate that minimally invasive costotransversectomy is a valuable treatment option for the management of voluminous thoracic dumbbell tumors. In our series, all patients harbored extradural tumors and no dural opening was required. However, previous reports demonstrated that intradural extension (type I and II) could be efficiently managed. After resection of the intradural component, CSF leak may be prevented by dural closure by simple manual knot tying sutures, topical administration of fibrin glue over the dural repair and tight closure of the fascia.

To the best of our knowledge, this is the first study demonstrating the feasibility and safety of minimally invasive costotransversectomy for the complete resection of thoracic dumbbell tumors. However, this is limited series with short follow-up. Extended experience is needed to better define to role of this minimally invasive procedure within the therapeutic armamentarium.

## Conclusion

Thoracic dumbbell tumors can be safely and completely resected using a single-stage minimally invasive procedure. Costotransversectomy can be performed through a non-expandable retractor allowing sufficient access to all parts of the tumor.

## Disclosure statement

The authors have no conflict of interest to disclose.

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