

## A Single Stage Dorsal Corpectomy, Reconstruction and Stabilization: Can we Depend on the Costotransversectomy Approach?

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**BACKGROUND:** Pathologies involving the thoracic spine region may require a 360-degree fusion that is routinely achieved through two separate approaches, anterior and posterior. However, it is time consuming and associated with non-negligible postoperative morbidities. Costotransversectomy approach can effectively achieve circumferential spinal decompression, posterior stabilization, and ventral reconstruction in a single approach with high safety profile.

**OBJECTIVE:** To evaluate the efficacy and safety of costotransversectomy approach as a single approach in patients with different thoracic spine pathologies, identifying risk factors for perioperative morbidity.

**PATIENTS AND METHODS:** This is a prospective study of 48 patients with dorsal spine pathologies who were managed by costotransversectomy between January 2018 and December 2020. Patients' demographics, preoperative assessment, operative data, early postoperative complications, and two-year clinical and radiological follow-up were tabulated and analysed. Risk factors for perioperative morbidity were evaluated. Only variables with p-value <0.05 in univariate analysis were included in multivariate analysis.

**RESULTS:** The study included 48 patients who underwent costotransversectomy for dorsal spinal pathologies. Mean age at presentation was 44 years. Tuberculosis (TB) was the most common indication of surgery. Blood loss ranged between 300 and 800 mL, whereas operative time ranged between 120 and 240 minutes. There was a significant improvement in the functional status of patients. Fusion was achieved in 45 patients (93.75%) during the follow-up period. Morbidity occurred in 9 patients (18.75%). Old age, diabetes mellitus, and TB were significant risk factors for postoperative morbidity in the univariate analysis, and only diabetes mellitus was significant in the multivariate analysis.

**CONCLUSION:** Costotransversectomy is a safe and effective approach for the management of patients with thoracic spine disorders in a single setting, achieving favourable clinical and radiological outcome. Diabetes proved to be a significant risk factor associated with increased postoperative morbidity in a multivariate analysis.

**KEYWORDS:** Costotransversectomy, Outcomes, Single approach, Thoracic spine.

### INTRODUCTION

Traditionally, circumferential 360-degree fusion of the thoracic spine is performed via two approaches. The posterior approach is used for posterior decompression and pedicular fixation, whereas the anterior transthoracic approach is used for effective vertebrectomy and reconstruction of the weight bearing anterior column. Not all patients will be candidates for these approaches, especially if they had previous thoracic surgery or poor pulmonary status, which makes the anterior approach riskier, in addition to the high complication rate associated with anterior thoracotomy. The two staged approaches will increase the operative time and the incidence of perioperative morbidity and mortality. Thus, these patients would greatly benefit from a single approach that could simultaneously access both the anterior and posterior

regions of the thoracic spine.<sup>1</sup>

The anterior only approaches are ideal for effective direct corpectomy having direct access to the ventral spinal pathology. The anterior approach is coupled with ventral reconstruction and possible short segment fixation with a better visualization angle and less manipulation of the spinal cord and ventral dura. It also allows earlier identification of the segmental arteries arising from the aorta compared to the posterolateral approaches. However, it is usually associated with non-negligible surgical morbidities like possible vascular or neurological injuries, surgical site infection, pulmonary complications, genitourinary injury or even abdominal or diaphragmatic hernias.<sup>2,3</sup>

The posterolateral approaches to the thoracic spine have gained large popularity among neurosurgeons in the last decades. These approaches allow single-session circumferential spinal decompression, rigid posterior stabilization, and anterior reconstruction without entering the pleural or abdominal cavity, thus eliminating the need for chest tube, with less complications and better recovery

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compared to the anterior approach. The efficacy of such approaches has been described in multiple ventral spinal pathologies of the dorsal spine, including trauma, TB, neoplasms, disc herniation, and posterior longitudinal ligament ossification. These approaches include the transpedicular, the costotransversectomy, and the lateral extra-cavitary approaches. The surgical field becomes wider as one chooses the approach from the former to the later, respectively, allowing better visualization, hence better ventral decompression, but with more tissue devitalization.<sup>3-8</sup>

The transpedicular approach through a dorsal midline incision can achieve effective posterior decompression, posterolateral vertebrectomy, coupled with posterior transpedicular fixation even for multiple levels in a single session. This technique is familiar to many spine surgeons, and surely avoids the high morbidity complicating whether the anterior approach or the combined anterior and posterior approaches, hence it is considered an ideal approach for severely ill patients. This technique entails scarification of the dorsal root to allow ventral reconstruction by expandable cylinders. Despite being achievable with less operative time, less blood loss, and better postoperative rehabilitation due to limited tissue manipulation, the transpedicular approach affords narrower oblique access than costotransversectomy. Therefore, it may entail technical difficulty in applying the expandable cylinders or controlling the bleeding during vertebrectomy due to the oblique trajectory.<sup>3,4</sup>

The costotransversectomy approach, via a posterior midline incision, with exposure and resection of the proximal 4-6 cm of the related rib can deal with multiple levels pathology and allow proper transpedicular fixation, still with acceptable complications rate.<sup>5,7-9</sup> The costotransversectomy with an oblique trajectory with difficult visualization angle to ventral spinal pathologies may be technically demanding, with potential inadequate decompression for ventral midline pathologies. Also sometimes, it may be associated with difficult ventral reconstruction. Furthermore, there is a potential risk of pleural or vascular injuries, in addition to late identification of the segmental vessels increasing the risk of blood loss.<sup>8,10</sup>

This study aimed at evaluating the perioperative and the two-year outcomes of the costotransversectomy approach in patients with different thoracic spine pathologies, assessing safety and efficacy and identifying the risk factors increasing the perioperative morbidity.

## PATIENTS AND METHODS

This is a prospective study of the data of 48 consecutive patients who underwent costotransversectomy between January 2018 and December 2020. All patients who underwent the costotransversectomy procedure for a single thoracic segment disease were included, whatever the indication (Infection, trauma, malignancy, etc.). Patients lost at follow-up were excluded from this study.

The study was approved by the Ethics Committee of the Faculty of Medicine, Alexandria University (the institutional review board (IRB) regarding human subjects). All patients had signed informed consent before surgery and for active participation in this study.

Patients' evaluation included detailed history-taking, clinical assessment including neurological examination, and routine preoperative laboratory investigations. Radiological assessment included plain X-ray, computed tomography (CT), and magnetic resonance imaging (MRI). The patients were also assessed according to the American Spinal Injury Association (ASIA) score, and they were asked to express their pain on an eleven-point scale, numerical rating scale (NRS), which ranges from 0 to 10 (For no pain and the most severe pain, respectively).

## Surgical Technique

The surgical procedure was done under general anaesthesia and the patient was in a prone position over a radiolucent table, allowing intraoperative fluoroscopy. A broad-spectrum intravenous antibiotic was administered 30 minutes before the time of skin incision. All procedures were conducted under electrophysiological monitoring. A midline skin incision was made over the affected vertebra, regularly extending 2 levels above and below the affected level, and dissection was continued until the identification of the tip of the transverse process. Transpedicular fixation 2 levels above and below the affected level was done. This was followed by connecting a temporary rod to these pedicular screws contralateral to the side of desired costotransversectomy. After exposure of the ribs, the proximal 4 cm of the rib attached to the diseased vertebra along with the related transverse process were removed. The related intercostal bundle was double ligated then divided to add more exposure. High-speed drills and downward angled curettes were used for the vertebrectomy procedure under microscopic guidance. Removal of the bony tissue was done till reaching the contralateral pedicle to achieve complete anterior decompression. A vertical titanium mesh cage or an expandable cage was used to fill the vertebral body defect, and then the posterior screws were connected using rods and cross-links. Finally, the skin was closed over a suction drain. The operative time, estimated blood loss, need for intraoperative blood transfusion, and intraoperative adverse events were recorded.

After the operation, the patients were transferred to the recovery unit and then to the ward. Additionally, radiological assessment was performed by X-ray or CT, if required. All patients were discharged on oral broad-spectrum antibiotics, oral analgesics, and nerve tonics. Follow-up visits were scheduled at 1, 3, 6, 12, and 24 months after the operation. Any delayed complications were recorded. In addition, both ASIA and NRS scores were recorded at the last follow-up visit.

The collected data included patients' demographic characteristics, indications for surgery, preoperative

ASIA and NRS scores, operative time, blood loss, blood transfusion, adverse intraoperative events and their management, postoperative hospitalization period, postoperative complications, changes in ASIA and NRS, in addition to fusion rates. The primary outcome was the perioperative outcomes of the costotransversectomy approach, while secondary outcomes included risk factors assessment for perioperative morbidity after the costotransversectomy approach.

### Statistical Analysis

Regarding the statistical analysis of the collected data, we expressed numerical data as medians (with ranges), whereas categorical data were presented as numbers and percentages. The data were processed by the statistical package for the social sciences (SPSS) software (version 26 for MacOS). The NRS and ASIA scores were compared over two time points using the Wilcoxon signed rank and marginal homogeneity tests, respectively. Additionally, regression analysis was done to clarify risk factors for perioperative morbidity. Any p-value less than 0.05 was considered statistically significant.

### RESULTS

This study included 48 patients, 29 males and 19 females, who underwent costotransversectomy for dorsal pathologies between January 2018 and December 2020, with a minimum follow up of 24 months. The age of the patients ranged between 21 and 65 years (Median, 44 years). Regarding the associated medical comorbidities, diabetes mellitus (DM) and hypertension were present in 7 patients (14.58%) and 5 patients (10.42%), respectively. Tuberculosis was the most common indication for the surgery in 22 patients (45.83%), followed by trauma in 14 patients (29.17%). Other indications included solitary spine metastasis in 8 patients (16.67%) and aneurysmal bone cysts in 4 patients (8.33%). The preoperative ASIA score classification of patients was as follows; B (45.83%), C (33.33%), and D (20.83%). Preoperative pain ranged between 6 and 10 on the NRS. (Table 1) summarizes the previous data.

The duration of the surgical procedure ranged between 120 and 240 minutes (Median, 190 minutes), while the intraoperative blood loss had a median value of 500 mL (range, 300 – 800 mL). Intraoperative blood transfusion was required in nine patients (18.75%). Intraoperative complications included dural tear in 3 patients (6.25%) and pleural tear in 5 patients (10.42%). The former was managed by watertight dural repairs, while the latter

was managed by airtight pleural sutures, however, a thoracostomy tube was needed in three cases. No major vascular injuries were encountered in our study. (Table 2) demonstrates the intraoperative events in this study.

The duration of hospitalization ranged between two and five days (Median, 3 days). Early postoperative complications included superficial surgical site infection in 2 patients (4.17%), deep vein thrombosis (DVT) in 4 patients (8.33%), and pulmonary complications in 4 patients (8.33%). Nine patients (18.75%) developed postoperative morbidity. Fusion was achieved in 45 patients (93.75%) during the follow-up period.

Two-years ASIA score showed a significant improvement compared to the baseline values ( $p < 0.001$ ), as there was a significant increase in patients with class E and a decline in class B patients. Additionally, there was a significant decline in pain intensity on the NRS, where the median NRS declined from 8 before the operation to 2 at 2 years postoperative. (Table 3) summarizes the changes in ASIA and NRS in the study participants at two-year follow-up.

Among the studied risk factors, old age, diabetes mellitus, and TB were significant risk factors for postoperative morbidity in the univariate analysis, while only diabetes mellitus maintained its significance in the multivariate analysis, as demonstrated in (Table 4).

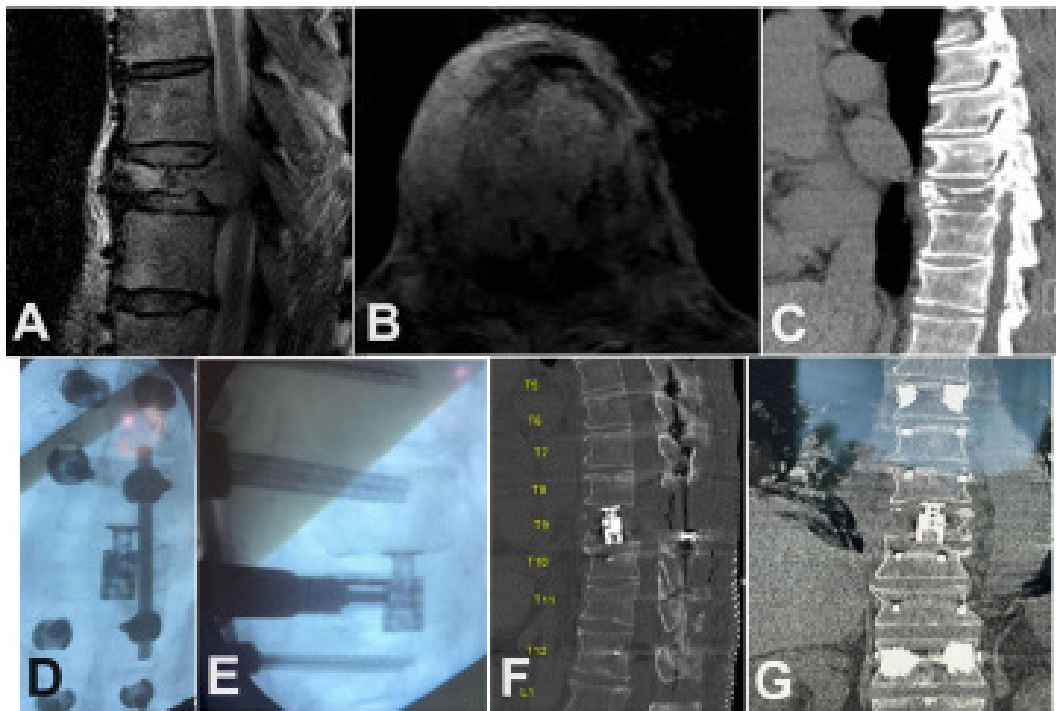
### Illustrated Cases:

#### Case 1:

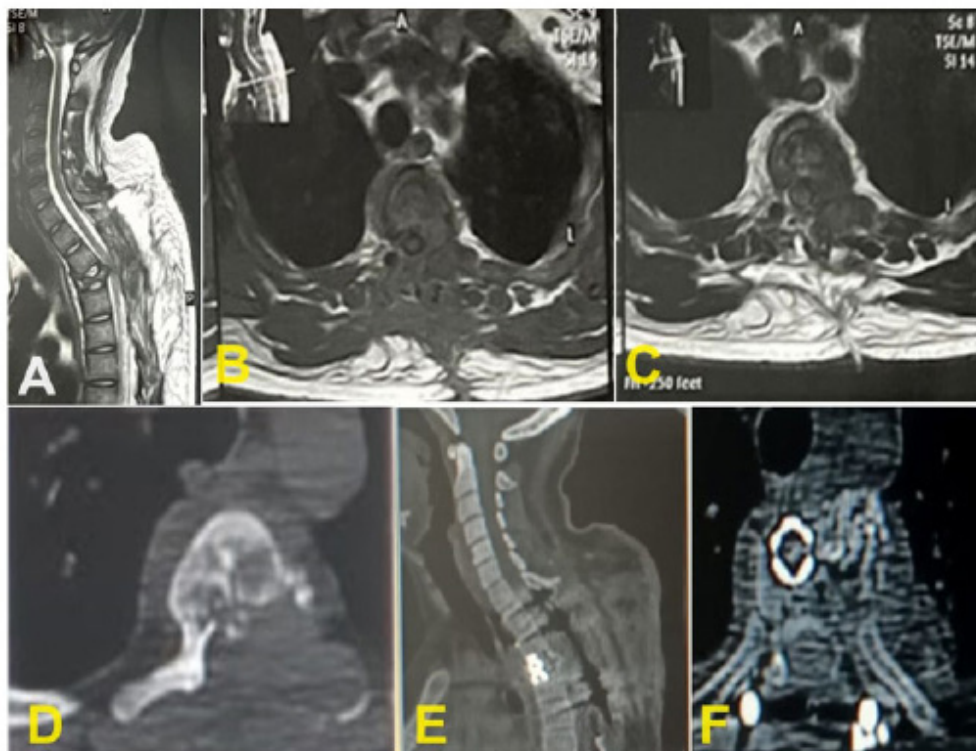
A 38 years old male patient presented with paraparesis due to D9 traumatic fracture (Fig. 1). The motor power in the lower limbs was grade 3 on the Medical Research Council (MRC) scale. The patient underwent costotransversectomy after which he improved postoperatively to become ambulant after 2 weeks.

#### Case 2:

A 55 years old male patient presented with paraparesis grade 2 on the MRC scale due to D3 neoplastic lesion eroding the vertebral body and the left pedicle and encroaching on the spinal canal (Fig. 2). Despite proper decompression and fixation through costotransversectomy approach, the patient maintained the same degree of weakness due to delayed intervention, as he was unfit for surgery for a long period.



**Fig 1:** (A) T2 weighted sagittal MRI demonstrates D9 traumatic fracture with significant loss of vertebral height and retropulsed fragment. (B) T2 weighted axial MRI shows the fracture and the retropulsed fragment encroaching on the spinal canal. (C) Sagittal CT bone window of the dorsal spine documenting the near total collapse of D9 vertebra. (D) Intraoperative anteroposterior C-arm view of the dorsal spine after transpedicular fixation, with application of contralateral temporary rod and reconstruction by an expandable cage. (E) Lateral view C-arm showing insertion of a ventral expandable cage. (F) Postoperative sagittal CT image showing proper vertebral decompression and positioning of the expandable cage. (G) Postoperative coronal CT image shows transpedicular fixation and proper expandable cage insertion.



**Fig 2:** (A) T2 weighted sagittal MRI cervicodorsal spine demonstrating a neoplastic lesion in D3 eroding the vertebral body and encroaching on the spinal cord. (B & C) Axial T2 weighted MRI showing involvement of the left pedicle and encroachment on the spinal canal. (D) Axial CT image demonstrates the erosion of the vertebral body and the left pedicle by the neoplastic lesion. (E) Postoperative sagittal CT view of the cervicodorsal spine showing reconstruction by an expandable cage. (F) Postoperative CT axial view showing proper decompression and reconstruction.



**Table 1: Basic demographic and clinical data of the study participants**

Variables	Numbers (%)
Age, median (range)	44 (21 – 65) years
<b>Gender</b>	
-Male	29 (60.42%)
-Female	19 (39.58%)
<b>Comorbidities</b>	
-Diabetes mellitus	7 (14.58%)
-Hypertension	5 (10.42%)
<b>Indication for surgery</b>	
-Tuberculosis	22 (45.83%)
-Trauma	14 (29.17%)
-Solitary metastasis	8 (16.67%)
-Aneurysmal bone cyst	4 (8.33%)
<b>Preoperative ASIA score</b>	
-B	22 (45.83%)
-C	16 (33.33%)
-D	10 (20.83%)
Preoperative NRS, median (range)	8 (6 – 10)

ASIA: American Spinal Injury Association, NRS: Numerical rating scale.

**Table 2: Operative data in the study participants**

Variables	Numbers
Operative time, median (range)	190 (120 – 240) minutes
Blood loss, median (range)	500 (300 – 800) mL
Blood transfusion	9 (18.75%)
<b>Intraoperative complications</b>	
-Dural tear	3 (6.25%)
-Pleural tear	5 (10.42%)
-Vascular injury	0 (0%)

**Table 3: Changes in ASIA and NRS in the study participants at two-year follow-up**

	Preoperative	Two-year follow-up	P-value
<b>ASIA score</b>			
-B	22 (45.83%)	11 (22.9%)	
-C	16 (33.33%)	12 (25%)	< 0.001*
-D	10 (20.83%)	18 (37.5%)	
-E	0 (0%)	7 (14.6%)	
NRS, median (range)	8 (6 – 10)	2 (1 – 4)	< 0.001*

ASIA: American Spinal Injury Association, NRS: Numerical rating scale.

**Table 4: Risk factor for postoperative morbidity**

Regression	Univariate	Multivariate		95% confidence interval for odds ratio	
	p value	p value	Odds ratio	Lower	Upper
	Age	0.014*	0.106	0.546	0.238
Male gender	0.671				
Diabetes mellitus	<0.001*	<0.001*	2.364	1.11	3.78
Hypertension	0.840				
Tuberculosis	0.042*	0.214	1.23	0.71	1.46
Trauma	0.225				
Solitary metastasis	0.888				
Aneurysmal bone cyst	0.078				
ASIA score B	0.314				
ASIA score C	0.661				
ASIA score D	0.310				
NRS	0.515				
Operative time	0.384				
Blood loss	0.276				
Blood transfusion	0.990				

ASIA: American Spinal Injury Association, NRS: Numerical rating scale

## DISCUSSION

With gaining of neurosurgical expertise and advanced surgical hardware, surgical approaches to the anterior thoracic spine have evolved over the past decades to decrease the morbidity rates, enhance the postoperative fusion, and enhance the clinical outcomes.<sup>8</sup> The posterolateral approaches have numerous advantages over the anterior approaches when considering the management of thoracic spine disease, as they provide proper and effective management of different pathologies in a single surgical session. On the other hand, the anterior approach not only provides poor fixation points, but it also could increase the risk of catastrophic pulmonary complications, leading to increased hospitalization periods and associated healthcare costs.<sup>3,11</sup>

This study presents the application of the costotransversectomy approach in patients with different thoracic spine pathologies in an Egyptian tertiary care center. This approach was first reported by Menard in 1894 for TB abscess drainage in cases with Potts paraplegia.<sup>12</sup> In this study, the costotransversectomy approach was adopted for additional vertebral pathologies including trauma, metastasis, and solitary bone cysts. Lubelski et al. reported that their indications for the costotransversectomy approach were neoplasms, trauma, disc herniation, scoliosis and osteomyelitis.<sup>13</sup> El Naga et al. reported that their indications included malignancy (34.5%), infection (27.6%), deformity (19.8%), and trauma (18.1%).<sup>14</sup> Differences among studies could be explained by the different epidemiological characteristics

of thoracic spine disease in each geographical region.

In this study, the operative time ranged between 120 and 240 minutes (Median, 190 minutes). Wiggins et al. reported a much longer operative time, which ranged between 260 and 730 minutes for the same approach (Mean, 420 minutes), while Shi et al. reported a range of operative time between 170- 250 minutes.<sup>5,15</sup> Differences in this parameter among studies could be explained by differences in pathology complexity, patients' conditions, incidence of intraoperative complications and surgical expertise.

The intraoperative blood loss ranged between 300 and 800 mL (Median, 500 mL) in our study. Similar findings were reported by Shi et al., as the mean intraoperative blood loss was 460 ± 47 mL.<sup>5</sup> Zairi et al reported smaller amounts of intraoperative blood loss, which ranged between 50 and 500 mL (mean 230 mL).<sup>16</sup> On the other hand, Lubelski and his colleagues reported higher parameters with a mean value of 1556 mL.<sup>13</sup> Another study reported a much higher amount of intraoperative blood loss, which ranged between 300 and 10000 mL (mean 2276 mL).<sup>15</sup>

In the current study, two types of intraoperative complications were encountered; pleural tears (10.42%) and dural tears (6.25%). All tears were directly repaired, with 3 patients with pleural tears requiring chest tube insertion. A previous study reported pleural tear in eight patients (6.8%); five of them were directly repaired while the remaining three required intercostal tube insertion.

Dural tears were encountered in 8.5% of their cases, and all of them were directly repaired.<sup>17</sup> Lubelski et al. reported an incidence of 3% for the same two complications in association with costotransversectomy.<sup>13</sup>

Considering the duration of hospitalization, it ranged between 2 and 5 days (Median, 3 days) in this study. Zairi et al. reported a mean hospitalization period similar to the current study, as it ranged between two and six days (Mean, 3.6 days).<sup>16</sup> Other authors reported longer hospitalization periods. Wiggins et al. reported that the mean postoperative hospital stay in patients undergoing the same approach was 9.2 days (Range, 3 – 27 days).<sup>15</sup> Besides, Lubelski and his colleagues reported that their patients had a mean postoperative stay of 9.8 days.<sup>13</sup> Differences in treatment protocols between different medical facilities and postoperative complications could explain the previous heterogeneity.

Regarding the functional outcome, it was noted that there was a significant improvement in the ASIA score at two-year follow-up compared to the preoperative recordings ( $p < 0.001$ ). This was manifested by the decline in class B patients and the appearance of class E patients. The beneficial impact of single-stage approaches for anterior thoracic vertebral lesions has been highlighted in previous studies. Wang et al. noted improvement or stabilization of the neurological condition with significant pain improvement in 96% of their cases with vertebral metastasis, operated upon by single-staged posterolateral transpedicular approach.<sup>18</sup> Chandra et al. reported significant pain improvement in all their cases with costotransversectomy approach, with improvement in ASIA scores in 76% of them.<sup>1</sup> El Naga and his colleagues reported a 94% improved or sustained postoperative motor scores compared to the preoperative values following thoracic costotransversectomy.<sup>14</sup>

Postoperative morbidity rate was 18.75% (9/48). Lubelski et al. reported a 15% complication rate for the same approach.<sup>6</sup> Another study reported a much higher complication rate of 38%.<sup>15</sup> Two patients developed superficial surgical wound infections after the operation (4.17%). Shi et al. reported a lower incidence of the same complication (1.5%) which is slightly lower than the current study findings.<sup>5</sup> Other studies reported higher rates of wound complications that could occur in up to 24% of patients after costotransversectomy.<sup>19-21</sup> Four patients (8.33%) developed DVT. A previous review reported an average rate of 3.7% for the same complication, while Wiggins et al. reported an incidence of 6.9%.<sup>6,15</sup> On the other hand, Sciubba et al. reported a much higher incidence for DVT (28.57%).<sup>22</sup>

When it comes to the risk factors for postoperative morbidity after the costotransversectomy approach, old age, diabetes mellitus, and TB were significant risk factors in the univariate analysis. Regarding the multivariate analysis, only diabetes mellitus was significant. Findings regarding the deleterious effect of diabetes mellitus were addressed by Luo et al., who confirmed

the association between diabetes and worse outcomes after spine surgeries.<sup>23</sup> Lee and his colleagues confirmed the association between postoperative morbidity and old age.<sup>24</sup> Moreover, TB-associated malnutrition could explain the poor outcomes in TB cases. More trials should be done to elucidate the specific risk factors for morbidity after costotransversectomy.

### Limitations of the study

The current study has some limitations, as the included sample was relatively small and collected from a single neurosurgical institute. More studies should be performed to cover the previous drawbacks. Also, these studies should compare the costotransversectomy approach with other approaches to determine which is best for achieving better outcomes.

### CONCLUSION

Costotransversectomy approach is a safe and effective approach for the management of patients with thoracic spine disorders. This approach leads to a significant decline in operative time, blood loss, and the incidence of perioperative morbidity and mortality. It is associated with a marked improvement in patients' functional status and pain, with accepted perioperative morbidity rate and high fusion rates. Old age, diabetes mellitus, and TB were significant risk factors for postoperative morbidity in the univariate analysis, and only diabetes mellitus maintained its significance in the multivariate analysis.

### List of abbreviations:

ASIA: American Spinal Injury Association.  
 CT: Computerized tomography.  
 DM: Diabetes mellitus.  
 DVT: Deep vein thrombosis.  
 MRC: Medical Research Council.  
 MRI: Magnetic resonance imaging.  
 NRS: Numerical rating scale.  
 SPSS: Statistical package for the social sciences.  
 TB: Tuberculosis.

### Disclosure

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