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COMPARISON OF THE SURGICAL TECHNIQUES FOR AN ANTERIOR TRANSTHORACIC APPROACH TO THE DORSAL SPINE

DORSAL OMURGAYA ANTERİOR TRANSTORASİK YAKLAŞIM İÇİN UYGULANAN CERRAHİ TEKNİKLERİN KARŞILAŞTIRILMASI

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SUMMARY

Thoracic and spine surgeons have become increasingly involved with anterior transthoracic approaches to the thoracic and upper lumbar spine. The major complications reported are potential pulmonary morbidity of a thoracotomy, post-thoracotomy pain, and cardiovascular injury. Some authors have reported technical difficulties, failure to perform the planned surgical strategies, and unfamiliarity with the approaches.

Objectives: The aim of our study is to define the exact approach for each dorsal and upper lumbar vertebra, figuring out the exact steps and trying to reduce the possibility of vascular injury and pulmonary morbidity with elimination of the post-operative pain, and to improve the surgical exposure to facilitate the spine surgical procedures.

Methods: Between May 2009 and January 2012, 38 patients received surgery with a thoracic, cervicothoracic, or thoracolumbar approach for dorsal spinal procedures. The choice of approach was dictated by the level and length of spinal involvement, and the surgical approaches could be described in terms of the lesion at four anatomical levels of the spinal column: (1) from C7 to T2; (2) from T2 to T6; (3) from T6 to T12; and (4) from T12 to L3 (C: cervical vertebrae, T: thoracic vertebrae).

Results: All patients survived surgery with no postoperative mortality, and no major pulmonary complications or cardiac complications were detected (0%). Three patients (0.7%) had wound infection.

Conclusions: The choice of laterality and type of surgical approach depends on the level and length of vertebral column involvement. Certain surgical principles and techniques will help general thoracic and spine surgeons to improve the quality of surgical exposure and to minimize intraoperative as well as postoperative complications.

Key Words: Dorsal spine, vertebral levels, rib removal, intercostal vessel injury.

Level of Evidence: Retrospective clinical study, Level III

ÖZET

Toraks ve omurga cerrahları, son yıllarda torasik ve üst lomber omurganın hastalıklarında giderek artan bir oranda anterior torasik girişimler yapmaya başlamışlardır. Torakotominin potansiyel akciğer ve kardiyovasküler yaralanma gibi majör komplikasyonların yanı sıra post-torakotomi ağrısı gibi minör komplikasyonları da rapor edilmiştir. Bazı cerrahlar bu girişimlere aşinalığının az olması ve preoperatif uygun planlama yaparak uygun girişimi seçmemesi bu tür potansiyel komplikasyonların en önemli sebebidir.

Amaç: Bu çalışmanın amacı, dorsal ve üst lomber bölge için yapılacak girişimlerde pulmoner ve kardiyovasküler yaralanma risklerinin en aza indirilmesi için yapılacak girişimlerin adım adım gözden geçirilmesi ve bu farklı yöntemlerin mukayese edilmesidir.

Materyal ve Metot: Mayıs 2009 ile Ocak 2012 arasında 38 hasta dorsal spinal işlemler için torasik, servikotorasik ve torakolomber anterior girişimler uygulanmıştır. Yaklaşımların seçiminde patolojinin yer aldığı omurga seviyesi ve patolojinin uzunluğu (kaç mobil segmenti etkilediği) en önemli kriter olarak seçilmiştir. Buna göre: 1) C7-T2; 2) T2-6; 3) T6-12 ve T12-L3 arası uygulamalar olarak 4 anatomik bölge belirlenmiştir.

Sonuçlar: Hastaların hiç birisinde mortalite ve majör komplikasyon görülmemiştir. Sadece 3 hastada yüzeyel enfeksiyon görülmüştür.

Sonuç: Girişimin tipi ve sağdan veya soldan oluşunu belirleyen şey, patolojinin yer aldığı omurga düzeyi ve patolojinin kaç mobil segmenti tuttuğudur. Bu çalışmanın verileri ışığı altında, uygun teknik, uygun girişimle anterior transtorasik girişimlere ait komplikasyonlar en aza indirilebileceği fikri elde edilmiştir.

Anahtar Kelimeler: Dorsal omurga, vertebral düzey, kaburga çıkartılması, interkostal damar yaralanmaları.

Kanıt Düzeyi: Retrospektif klinik çalışma, Düzey III

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INTRODUCTION

In the last 30 years, anterior transthoracic approaches to the spinal column have become the preferred techniques to manage most problems involving the lower cervical, thoracic, and upper lumbar portions of the spine in children and adults[2] The first reported series of thoracotomies for transthoracic access to the spine were performed by Hodgson and Stock in 1956 for the treatment of spinal tuberculosis (Pott disease)[5]. The potential pulmonary morbidity of a thoracotomy, post-thoracotomy pain, and cardiovascular injuries were the major complications reported. Other complications were also reported in the literature. Some authors have reported technical difficulties, failure to perform the planned surgical strategies, and unfamiliarity with the approach[1,5,9].

The aim of our study is to define the exact approach for each dorsal and upper lumbar vertebra, figuring out the exact steps of each approach, trying to reduce the possibility of vascular injury and pulmonary morbidity with elimination of the postoperative pain, and improving the surgical exposure, to facilitate the spine surgical procedures.

The thoracic spine can be approached through the right or left chest, and communication with the spine surgeon is mandatory so that the approach and extent of exposure can be tailored appropriately[1]. In the absence of lateralizing pathology, either a right- or left-sided thoracotomy can be used to expose the thoracic spine. The side of approach must provide maximum exposure to the pathology to be treated. Local factors, such as previous thoracotomy, pleurodesis, or infection, should also be considered. In general, a right-sided approach provides more direct access to the upper dorsal spine, as the mediastinal structures lie to the left of the vertebral bodies, while a left-sided approach provides more access to the lower dorsal and upper lumbar spine, to avoid liver retraction or injury[9]. Based on our experience in 38 patients, in the absence of lateralizing pathology and local factors, the safest surgical approaches can be described in terms of the lesion at four anatomical levels of the spinal column: 1) from C7 to T2 with a longitudinal cervicothoracic approach; 2) from T2 to T6 with right posterolateral thoracotomy; 3) from T6 to T12 with left posterolateral thoracotomy; and 4) from T12 to L3 with left posterolateral thoracotomy and detachment of the diaphragmatic origin.

PATIENTS AND METHODS

Between May 2009 and January 2012, 38 patients aged 12 to 55 years with a mean age of 29 years underwent surgery with a thoracic, cervicothoracic, or thoracolumbar approach for spinal procedures. There were nine women and 27 men. Different pathologies of the vertebral column required anterior transthoracic exposure of the dorsal spine and adjacent cervical or lumbar vertebrae, either for proper reduction and fixation of the anteriorly displaced thoracic vertebrae, drainage of infected vertebrae, correction of dorsal spinal scoliosis, or resection of spine tumors. The initial selection and the indications for surgery were performed by the spine surgeons. Diagnostic evaluation consisted of standard spinal roentgenograms, magnetic resonance imaging, contrast computed tomographic myelography, and selected arteriography, when indicated, for visualization of the artery of Adamkiewicz. All patients were followed by thoracic and spine surgical teams until discharge. Complications, including pulmonary dysfunction, retained secretions, atelectasis, pleural collection and pneumothorax, vascular injury, postoperative hemorrhage (transfusion or return or re-operation), diaphragmatic hernia, ileus, bowel obstruction, venous thromboembolism, and surgical site infection, were reported on a daily basis.

We report the different approaches for proper exposure of each thoracic vertebra to achieve good exposure without intrathoracic visceral injury (Table-1). The choice of approach is dictated by the level and length of spinal involvement. Surgical approaches can be described in terms of the lesion at four anatomical levels of the spinal column: 1) from C7 to T2 with a cervicothoracic approach in two patients, with a neck incision paralleling the sternocleidomastoid muscle combined with an upper ministernotomy to T4; 2) from T2 to T6 with right posterolateral thoracotomy in nine patients, the right side was preferred because of the location of the heart, aortic arch and great vessels; 3) from T6 to T12 with left posterolateral thoracotomy in 18 patients, the left side was preferred to avoid liver retraction; and 4) from T12 to L3 with left posterolateral thoracotomy and detachment of the diaphragmatic origin in nine patients.

1. Exposure of the C7 to T2 vertebrae was performed through a longitudinal cervicothoracic incision made along the anterior border of the sternocleidomastoid muscle with an upper ministernotomy down to the sternal angle, followed by blunt dissection of the subcutaneous tissue with division of the platesma muscle. The carotid sheath and innominate artery were encircled and retracted laterally, the innominate vein was encircled and retracted inferiorly, and the pharynx, thyroid and esophagus were retracted medially with gentle pressure (Figure-1a,b).

2. Exposure of the T2 to T6 vertebrae was performed through a right posterolateral thoracotomy, entering the chest through the bed of the rib of involvement corresponding to the appropriate level of spinal pathology after sub-periosteal resection of that rib to give space for retraction. For example, a disc at the T4 level would be approached through a right posterolateral thoracotomy through the bed of the fourth rib. The right side is preferred, to avoid thelocation of the heart, aortic arch and great vessels. The skin incision must be directed parallel to the direction of the involved rib (Figure-1.c).

Subcutaneous tissue dissection with division of the latismus dorsi muscle, thoracodorsal fascia and serrates anterior digits were performed to expose the anterior aspect of the rib. Towel compression of the lung with medial retraction was mandatory, followed by meticulous longitudinal division of the mediastinal pleura covering the spine longitudinally with ligature suspension and traction. Ligation and division of the posterior intercostal vessels crossing over the body of the vertebra was needed in some cases, but this step may be omitted if the pathology is limited to the intervertebral discs, as in cases of scoliosis correction (Figure-1.d).

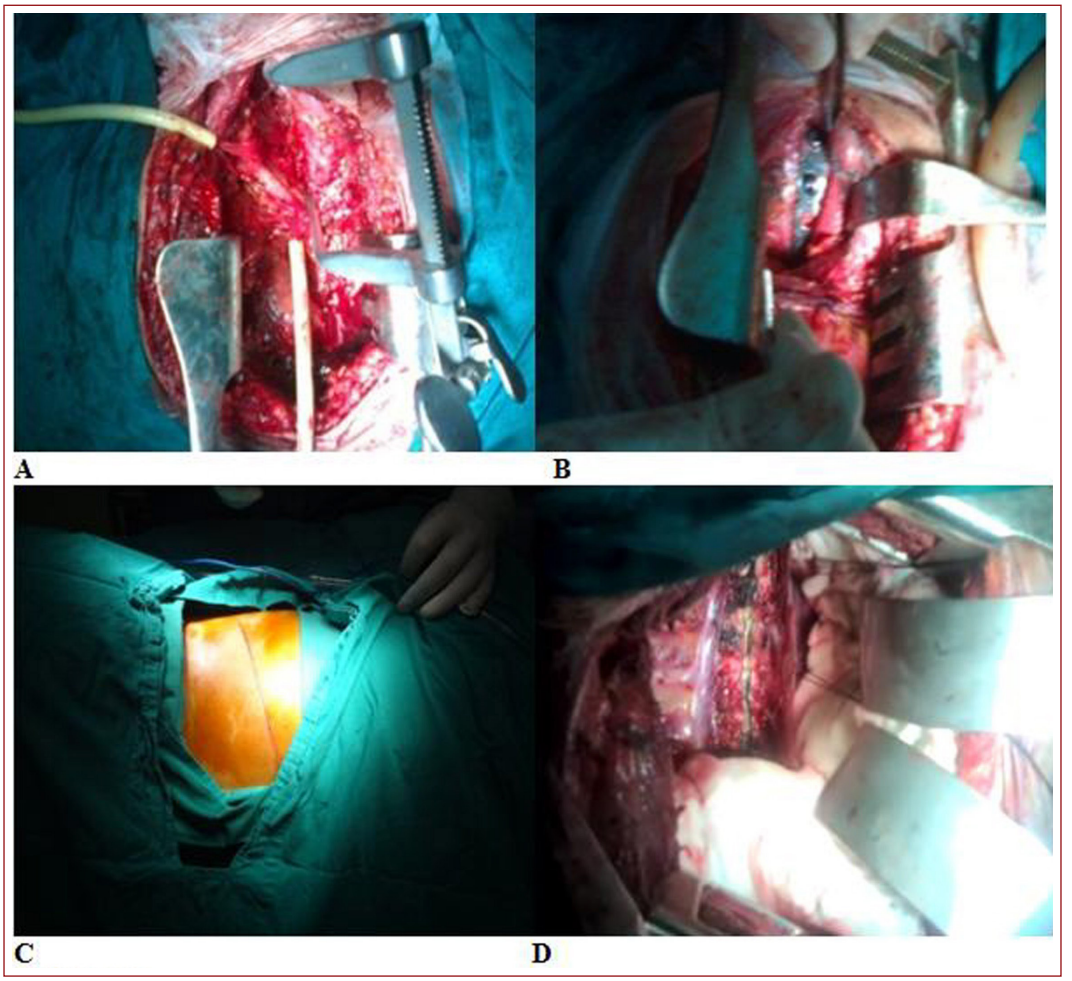

Figure-1. a) and b) The carotid sheath and innominate artery were encircled and retracted laterally, the innominate vein was encircled and retracted inferiorly, and the pharynx, thyroid and esophagus were retracted medially with gentle pressure. **c)** The skin incision must be directed parallel to the direction of the involved rib. **d)** The segmental arteries may be divided, providing excellent exposure.

3. Exposure of the T7 to T12 vertebrae was performed by left posterolateral thoracotomy, entering the chest through the bed of the involved rib corresponding to the level of the spinal pathology after sub-periosteal resection of that rib, except for T10, T11 and T12, for which entrance of the chest was done through the bed of the ninth rib. For example, a lesion at the T8 level would be approached through a right posterolateral thoracotomy through the bed of the eighth rib, while a lesion at the T11 level would be approached through a right posterolateral thoracotomy through the bed of the ninth rib.

The left side is preferred, to avoid the location of the liver. Again, the skin incision must be directed parallel to the direction of the involved rib. Subcutaneous tissue dissection with division of the latismus dorsi muscle, thoracodorsal fascia and external oblique muscle digits were performed to expose the anterior aspect of the rib. Exposure of the spine was obtained by towel compression of the lung with medial retraction, as well as ligature retraction and elevation of the diaphragmatic copula downwards**.** Meticulous longitudinal division of the mediastinal pleura covering the spine with ligature suspension and traction were mandatory (Figure-2.a,b). Ligation and division of the posterior intercostal vessels crossing over the body of the vertebra should only be done if necessary, due to the potential resultant morbidity (this step may be omitted if the pathology is present in the intervertebral disc, as for cases of scoliosis correction). There is no need for traction of the esophagus or descending thoracic aorta, as they will be away from the operative field due to the effect of the patient's lateral decubitus position.

Subcostal vessel ligation and division with longitudinal division of the fibers of the psoas major was carried out to expose the spine, with the peritoneum and retroperitoneal structures mobilized medially and retracted, and with particular attention directed to the location of the ureter. Once exposure was obtained, additional segmental arteries could be divided to provide excellent exposure (Figure-2.d).

After completion of the procedure, the lumbar and costal origin of the diaphragm was reattached to the lower ribs by pericostal non-absorbable sutures, and the chest was closed in the usual manner after insertion of a chest drain.

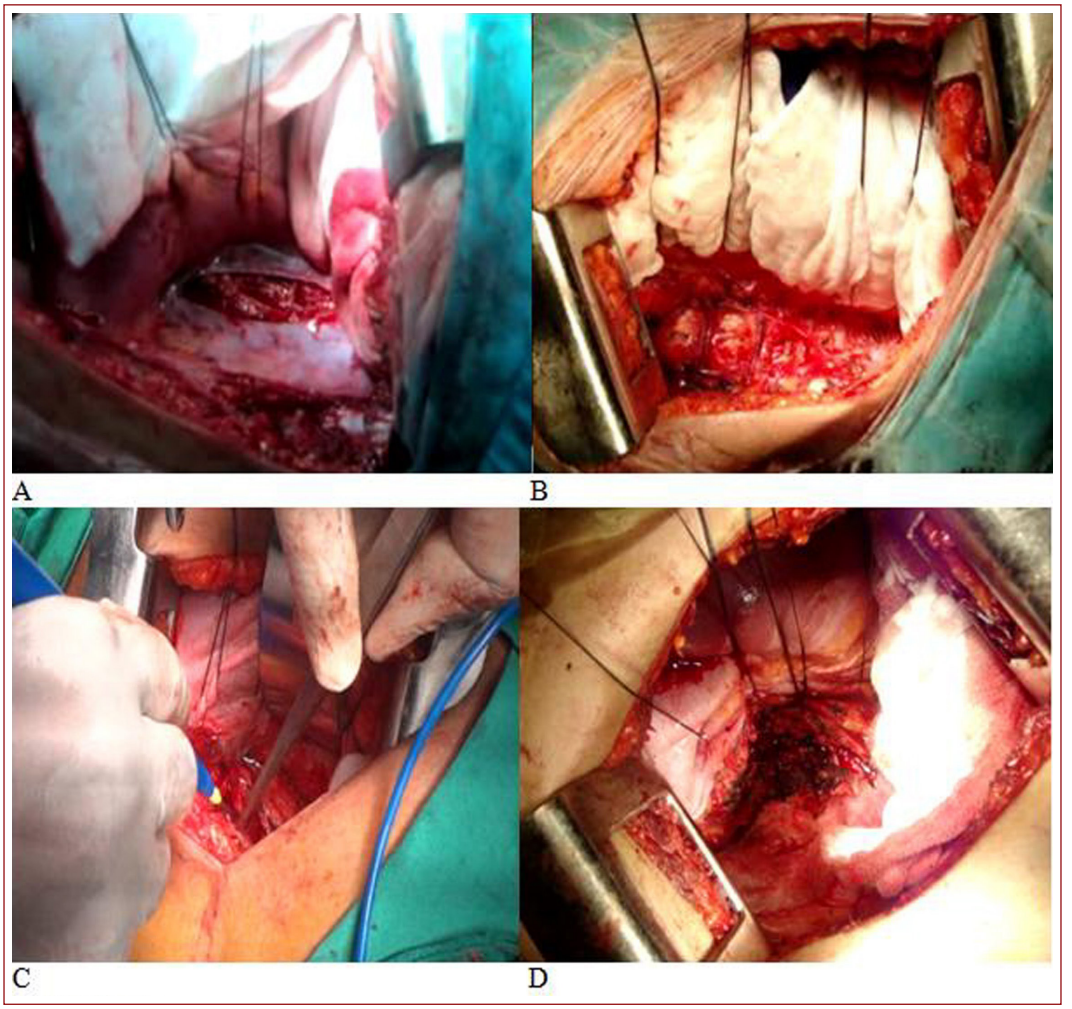

Figure-2.a) and **b)** Meticulous longitudinal division of the mediastinal pleura covering the spine with ligature suspension and traction were mandatory. **c)** Left lower posterolateral thoracotomy incision through the bed of the ninth rib as described for the previous approach, with detachment of the lumbar and costal origin of the diaphragm by blunt pushing after incision of the parietal pleura reflection over T12 to avoid entering the peritoneum. **d)** Once exposure is obtained, additional segmental arteries may be divided, providing excellent exposure.

4. Exposure of the T12 to L2 vertebrae was performed through a left lower posterolateral thoracotomy incision through the bed of the ninth rib as described for the previous approach, with detachment of the lumbar and costal origin of the diaphragm by blunt pushing after incision of the parietal pleura reflection over T12, to avoid entering the peritoneum (Figure-2.c).

RESULTS

All patients survived surgery with no postoperative mortality. The majority of patients were extubated on the table after completion of the procedure, and the others were extubated on the second day postoperatively due to a prolonged procedure. By following the strict steps for each approach with post-procedural lung inflation by the anesthetist, we had no pulmonary complications or cardiac complications (0%). Eleven patients (28%) had preoperative paraplegia or paraparesis from anterior cord compression, two of which were due to a Pott abscess, while the others were post-traumatic. The two patients with a Pott abscess and seven patients with post-traumatic paraplegia (23%) reported a marked postoperative improvement. Three patients (0.7%) had a wound infection that resolved after a period of frequent dressing and secondary sutures. There were no cases with postoperative bleeding, pleural effusion, empyema or atelectasis. All the chest drains were removed within the first three days postoperatively with complete lung inflation.

The treatment of the vertebrae and intervertebral discs is generally performed by the spine surgeon and depends on the disease process (Table-1).

Table-1. Type of surgical approaches and primary pathology

Anatomical levels of the spinal column	Approach	Number of patients	Pathology	Number of patients	Percentage
C7 to T2	Cervicothoracic approach	2	Congenital kyphoscoliosis	6	15%
T2 to T6	Right posterolateral thoracotomy	9	Traumatic fracture	16	42%
T6 to T12	Left posterolateral thoracotomy	18	Pott abscess	4	10%
T12 to L3	Left posterolateral thoracotomy with detachment of the diaphragmatic origin	9	Osteomyelitis	5	13%
			Tumors	7	18%

A total of 38 operations were performed, including vertebral body corpectomy in 16 patients with traumatic fracture of the vertebral body and compression of the spinal cord, followed by reconstruction with a metal cage filled with bone graft from the excised rib or from the iliac crest (Figure-3.a). Discectomy alone was performed in 6 patients with congenital kyphoscoliosis followed by posterior correction and fixation after one week (Figure-3.b). Drainage of Pott abscesses with fixation by plates and screws in healthy vertebrae was performed for 4 patients (Figure-3.c). Drainage of osteomyelitis with insertion of methyl methacrylate struts was performed for 5 patients, while excision of benign tumors involving the dorsal spine was performed for 7 patients (Figure-3.d).

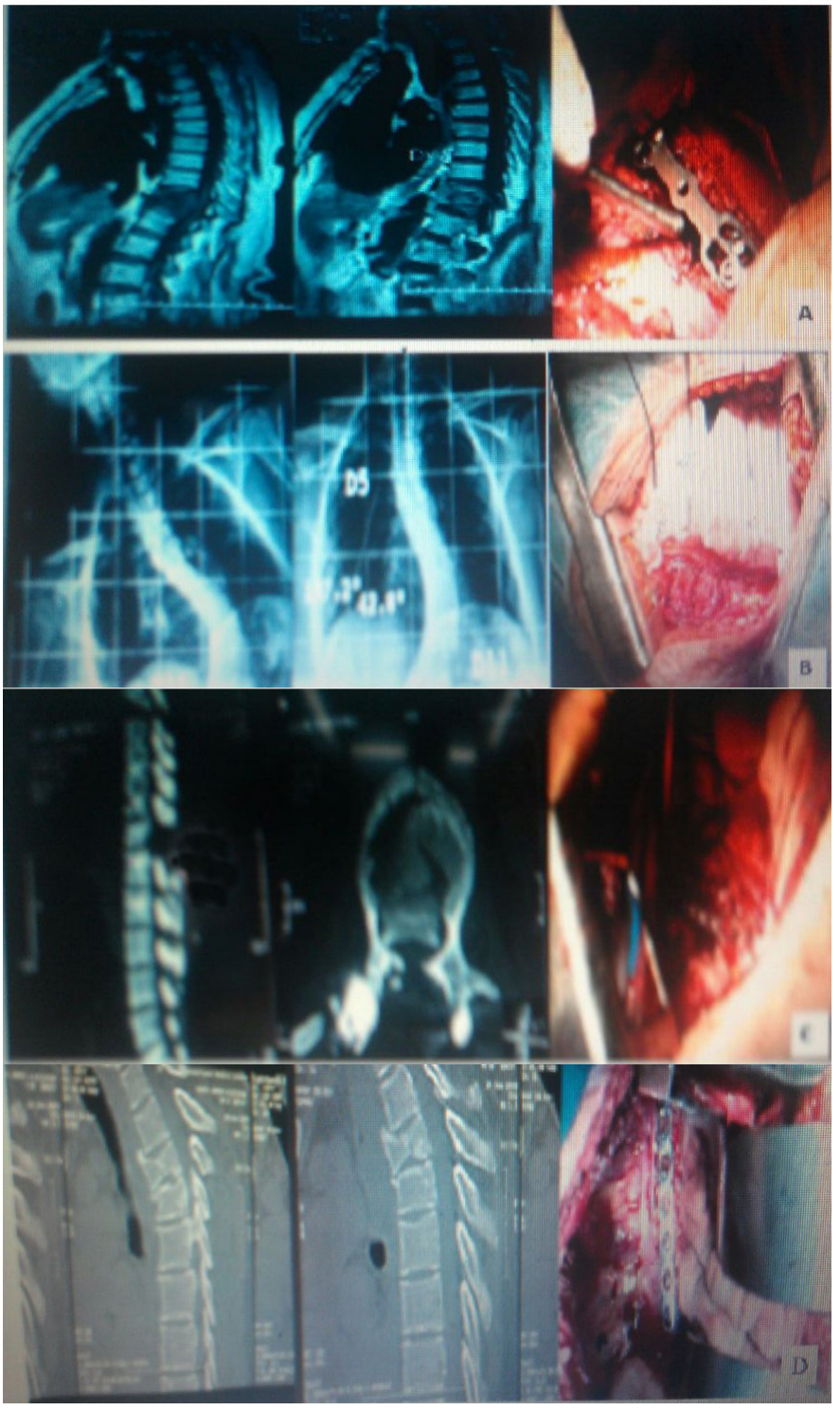

Figure-3. a) Corpectomy in 16 patients with traumatic fracture of the vertebral body and compression of the spinal cord followed by reconstruction with a metal cage filled with bone graft**. b)** Discectomy alone was performed for 6 patients with congenital kyphoscoliosis, followed by posterior correction and fixation after one week**. c)** Drainage of Pott abscesses with fixation using plates and screws in healthy vertebrae was performed for 4 patients**. d)** Drainage of osteomyelitis with insertion of methyl methacrylate struts was performed for 5 patients, while excision of benign tumors involving the dorsal spine was performed for 7 patients**.**

DISCUSSION:

Postoperative morbidity rates have varied from 7.8% to as high as 29.5% in previous studies (Table-2). Pulmonary complications were the major complications, and consisted of pulmonary dysfunction, retained secretions, atelectasis, pulmonary edema, adult respiratory distress syndrome, pleural effusion, and pneumothorax from air leaks, possibly due to lung parenchymal injury[7]. Cardiac complications comprise the second largest number, and consist of dysrhythmias, myocardial infarction, and congestive failure. Urinary tract infection, cerebrovascular accident, gastrointestinal complications, wound infection, and dehiscence are recorded in a varying number of patients[8]. In our study, a longitudinal pleural opening parallel to the axis of the vertebral column decreased the incidence of postoperative pleural effusion resulting from pleural cell irritation from multiple punctures. Subperiosteal rib resection adequately improved exposure (roomy field) without a need for excessive opening of the rib retractor, resulting in less postoperative pain. In addition, the excised rib was used for filling the metal cage required in most cases. Proper inflation of the lungs before chest closure and good hydration of the patients were mandatory in all cases, to prevent atelectasis and retained viscid secretions. The intercostal arteries should only be divided if necessary due to the potential resultant morbidity. If the thoracic pathology involves a substantial number of spinal segments below T6, a spinal angiogram should be performed to visualize the artery of Adamkiewicz. The causes of cardiac, cerebral, urinary and gastrointestinal complications have been inadequately explained in the literature.

With a longitudinal cervicothoracic approach, Walsh and colleagues (1997) suggested that a left-sided neck incision should be used unless contraindicated by the laterality of the disease process, as there is less likelihood of injury to the contralateral recurrent laryngeal nerve by retraction of the trachea and esophagus to obtain appropriate exposure[11]. We performed a left-sided approach for one patient, while the other was approached through the right side because of protrusion of the fractured T1 to the right side (Figure-1. b,c).

Although we did not experience any postoperative mortality in our study, the mortality rate after anterior exposure of the spine varies from zero to as high as 8.2% in the literature (Table-2). These rates depend primarily on the disease process, patient selection, and the age group undergoing surgery. Cancer patients appear to have the highest incidence of postoperative mortality, although Naunheim et al. (1994), by multivariate analysis of their data, showed that the only significant independent predictor of postoperative fatality was the presence of osteomyelitis, and this was associated with a mortality rate of 25% [10]. Faciszewski et al. (1995) reported only four deaths out of a total of 1,223 patients (0.33%). Complete paraplegia was reported in two patients (0.16%). Both patients had undergone anterior corpectomy with strut grafting, and a strut graft dislodged posteriorly before the posterior procedure could be performed, with no reported original pathology[4].

The treatment of the vertebrae and intervertebral discs is generally performed by the neurosurgeon or orthopedic surgeon and depends on the disease process. In Pott disease or other infectious processes, a paraspinal abscess is evacuated, precise curettage of the diseased vertebra is executed, and a titanium cage filled with bone fragments from the excised rib is seated in place[3]. In patients with a complex kypho-scoliotic deformity, extensive exposure is necessary to manage both the upper and lower ends of the spinal curvature and for removal of all intervertebral discs in between, as noted by Janik et al. (1997)[6]. Anterior removal of fragmented vertebrae after trauma is best achieved using a titanium cage filled with fragmented bone from the autologous rib and removed vertebrae, as suggested by McElvein et al. (1988) using a vascularized rib segment[8], but others have suggested a simple plate and screw.

Table-2. Mortality and morbidity rates after anterior transthoracic spinal operations in previous studies.

Investigator	Date of study	Mortality Rate (%)	Morbidity Rate (%)
Richardson et al.	1976	4.5	NR
Faciszewski et al.	1985	0.33	0.16%
McElvein et al.	1989	0	17.7
McAfee and Zdeblick	1988	0	17.0
Anderson et al.	1993	2.7	22.0
Naunheim et al.	1994	3.2	NR
Janik et al.	1997	0	9.8
Walsh et al.	1997	8.2	29.5
NR, not recorded			

Other methods may be used for reconstruction but most of these are not vascularized, or a methyl methacrylate strut may be fashioned and used instead of a bone graft, as suggested by Walsh et al. (1997). In patients with malignant involvement, Walsh et al. (1997) removed the vertebral body and performed a discectomy above and below the involved vertebra. The tumor was removed down to the posterior longitudinal ligament, which was incised and retracted to expose and decompress the dural sac. The nerve roots must be visualized as well as the bony end plates of the vertebrae above and below the resected discs. These structures must be free of gross tumor[11].

CONCLUSIONS:

The choice of laterality and type of surgical approach depends on the level and length of vertebral column involvement. Certain surgical principles and techniques will help general thoracic and spine surgeons to improve the quality of surgical exposure and minimize the intraoperative and postoperative complications. Outlining and understanding the primary spinal pathology, with adequate preoperative assessment of the respiratory function and cardiovascular system, will help to minimize morbidity and mortality.

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