Lateral extracavitary technique in surgical treatment of traumatic and tuberculous disorders of thoracic and thoracolumbar spine

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Summary of background
Controversy continues on the best decompression-reconstructive technique for treating tuberculous (TB) and traumatic spine disorders. Recently, the advantages of combined surgery could be successfully gained using one-stage salvage technique with enough accessibility to all three spinal columns.
Study design
and objectives This was a retrospective study of 50 patients with traumatic (28) and TB (22) disorders of thoracic and thoracolumbar spine treated by lateral extracavitary procedure.
Patients and methods
The two groups (traumatic and TB) were recruited between 2009 and 2012. Patients were examined perioperatively and followed up clinically for pain by visual analog scale; sensory and motor deficit by American Spine Injury Association grading; functionality by Oswestry disability index; and radiologically by kyphosis correction, loss of correction, and fusion time, as well as with laboratory investigations for TB patients. Operative time, hospital stay, blood loss, and complications were documented.
Results
Mean follow-up period was 36±5.5 months. Local symptoms were significantly relieved postoperatively. Deformity correction and neurological recovery significantly improved ($P<0.05$). Solid interbody fusion was evident in 47 cases. Overall, three patients had superficial wound infection and three had intercostal neuralgia.
Conclusion
Lateral extracavitary technique is a feasible and effective tool for maintained deformity correction, bony fusion, thecal decompression, and functional improvement.

Keywords:
lateral extracavitary, thoracic and thoracolumbar spine, traumatic disorders, tuberculous disorders

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Introduction

Infectious and traumatic disorders±kyphotic deformity commonly affect thoracic and thoracolumbar junction (TLJ) spine region. Among the spine injuries, 90% involve the thoracic and lumbar region; approximately 50% of all vertebral body fractures and 40% of all spinal cord injuries occur from T11 to L2. Moreover, tuberculous (TB) spondylitis continues to have a high incidence in developing countries [1,2]. However, controversy remains regarding the best surgical approach and instrumentation modality. The classic ventral approach appears logical but has higher morbidity [3,4]. Thus, posterior and posterolateral approaches are gaining more acceptance, as they address the three columns from single incision with less morbidity [5]. We discuss our experience with lateral extracavitary (LEC) technique and clinical, laboratory, functional, and radiological outcomes in 50 patients with TB and traumatic disorders.

Patients and methods

During a 4-year interval between January 2009 and December 2012, 50 patients enrolled in our hospital underwent LEC surgery. The study was approved by the ethical committee of Al-Minia University. Retrospective assessments were done after approval of the local medical ethical committee and written informed consent obtained from all patients. There were 27 (54%) males and 23 (46%) females. The

inclusion criteria were patients who had a histopathologically confirmed diagnosis of complicated TB spondylitis±paravertebral abscess and burst fracture±dislocation in thoracic and TLJ spine segment with significant progressive vertebral body destruction, pain not responding to conservative methods, neurological deficit, and deformity (kyphosis >40°). A confirmed diagnosis was made by histological examination of the tissue removed at surgery to identify the nature of the lesion in infectious cases. The patients were divided into two groups according to the nature of disorders: group I (traumatic), which had 28 patients, and group II (TB lesion), which had 22 patients.

The thoracic spine was involved in 27 (54%) patients (13 cases in group I and 14 in group II) and TLJ spine (T11–L2) in 23 (46%) patients (15 cases in group I and eight in groups II).

The American Spine Injury Association (ASIA) motor index was used for neurological evaluation [42 (84%) patients had neurological deficits (A, B, C, and D)]. The kyphosis angle was calculated on lateral spinal radiograph and multidetector computed tomography (MDCT) by modified Konstam's method [6]. MRI was performed to detect epidural abscess in TB lesions, neural structure state (gliosis, transection, and infiltration of the cord), and integrity of posterior ligamentous complex. Pain was evaluated by visual analog scale (VAS) and functionality by using Oswestry disability index (ODI), which is valid in Arabic language.

Bone fusion was confirmed by appearance of continuing trabecular pattern of dense cortical bone across the disc space between the vertebral bodies and by sentinel sign, when a metal cage was used [7]. If there is difficulty in assessing the trabecular pattern, MDCT scan was performed.

TB patients were given antitubercular therapy for 1 year [8,9]. All patients were followed up until 36 months.

Operative procedure

The patients laid prone under hypotensive general anesthesia with pillows under chest and pelvis and underwent one-stage spinal-cord decompression, anterior corpectomy from posterior either single extensile or T-shaped incision, and distraction-compression using pedicular screws to correct kyphosis±coronal malalignment with grafting±cage. The anesthesiologist decreased tidal volume during our procedure, and sometimes used single lung ventilation to decrease lung inflation/deflation to facilitate paravertebral necrotic evacuation, anterior column corpectomy, intracorporal bone grafting, and shortening reconstruction. In thoracic and thoracolumbar regions, 6–8 cm of two or more diseased or healthy rib and the transverse processes of affected vertebrae were excised. The diaphragm may be a problem, which was solved by subperiosteal dissection of the arcuate ligament of the diaphragm or linear incision (2.5 cm from the vertebral attachment) to facilitate the repair. In the lumbar spine (L1–L2), the origin of psoas muscle was subperiosteally dissected to allow removal of the prevertebral and paravertebral abscess, necrotic caseous, or traumatic bony material and destroyed vertebrae from the anterolateral surface of the body by entrance of the extracavitary space without laminectomy, preserving posterior tension surface. The space created on the lateral surface of the body should be widened using a burr or piecemeal excision of the vertebral body to facilitate mesh cage insertion and avoidance of difficulty in its entry.

The anterior column defect was measured and reconstructed with titanium mesh cage filled with impacted morselized rib or iliac bone graft, or by resected healthy rib plus tricortical iliac crest graft applied press fit. Rod stabilization was completed after adequate anterior compression and correction. Intraoperative spinal cord monitoring with Stagnara's wake-up test was used for patients with no or minimal neurological deficit.

Postoperative regimen

Postoperative plain radiograph (two views) and MDCT were done for all patients to assess alignment, deformity correction, and implant or graft placement. All the patients were given parenteral antibiotics (third-generation cephalosporin) till drain removal (3–5 day after operation). Antitubercular regimen in group II was started with the standard 4-drug therapy of isoniazid, rifampicin, ethambutol, and pyrazinamide with the standard doses for 3 months. This was followed by 3-drug therapy (rifampicin/INH/ethambutol) for at least 9 months. One or 2 weeks after surgery, the patients permitted to sit on the bed or walk supported by orthosis; this orthosis support was maintained for 3 months. Passive and active movements of the trunk and lower limb muscles were individualized for every case and supervised by a physiotherapist.

Follow up

The patients were followed up at 1-month intervals in the first 3 months, 3-month intervals in the next 9 months, 6-month intervals in the second year, and then once a year till the end of the follow-up. At each follow-up, the patients were evaluated clinically, radiologically, and functionally, as well as with laboratory investigations in TB lesions.

Statistical analysis

The collected data were coded, tabulated, and statistically analyzed using SPSS (version 24) (IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp). Descriptive statistics were done for numerical data by mean, SD, and minimum and maximum of the range, whereas categorical data were done by number and percentage. The χ^2 test was used for noncontinuous variables, and Student *t* test was used to analyze the statistical significance in each group and between two groups. *P* value less than 0.05 was considered significant, *P* value less than 0.01 was considered highly significant, and *P* value more than 0.05 insignificant.

Results

The mean follow-up period was 35±5.5 (20–48) months. The mean age was 39.5±4.5 (30–65) years. Thoracic levels were the most common affected level in 27 (54%) patients, and TLJ level in 23 (46%) patients. TB lesion (group II) was found in 22 (44%) cases [seven (31.8%) in T5–6, four (18.2%) in T8, two (9.1%) in T9, two (9.1%) in T3–4, and seven (31.8%) at TLJ] and traumatic disorders (group I) in 28 cases [seven (25%) in T4–5, five (17.9%) in T6–7, four (14.3%) in T8–9, four (14.3%) in T10, and eight (28.6%) in TLJ]. A total of 42 (84%) cases had neurological deficits (A, B, C, and D) owing to affection at different level/levels [24 (57.1%) in group I and 18 (42.9%) in group II].

From the six complete paraplegics, one case (group I) improved to grade C, and two cases (group II) improved to grade B and C, and three cases remained completely paraplegic (two in group I and one in group II) owing to complete transection in group I and longstanding compression with dense gliosis and fibrosis after late presentation in group II. Among all the cases, only one patient in group II had transient deterioration from ASIA D–C, who improved to ASIA E by medical treatment after one and a half month (Table 1). There was a significant difference between preoperative and final ASIA motor index in each group and significant difference between groups I and II in the final follow-up state ($P<0.05$). The percentage of neurological state improvement was better in group II (86.4%) than group I (60.7%) (Fig. 1). At the final follow-up, the ambulatory status of paraplegics in all cases showed a statistically significant increase from 40 to 72% ($P<0.05$).

Anterior column was reconstructed with a mesh cage filled with morselized bone graft in 36 (72%) cases [20 cases in group I and 16 in group II], with bone graft resected from either healthy rib/laminae, and both facets and transverse process or tricortical iliac bone graft in 14 (28%) cases [eight cases in group I and six in group II].

Erythrocyte sedimentation rate significantly decreased from 170±30 (140–200) preoperatively to a normal level of 15±5 (10–25) postoperatively, and also, C-reactive protein with its titer significantly improved to normal levels within 3–6 months ($P<0.001$) in group II.

Spinal canal compromise showed statistically significant improvement from 75.35±7.31% preoperatively to 16±4.5% postoperatively ($P=0.001$) in both groups.

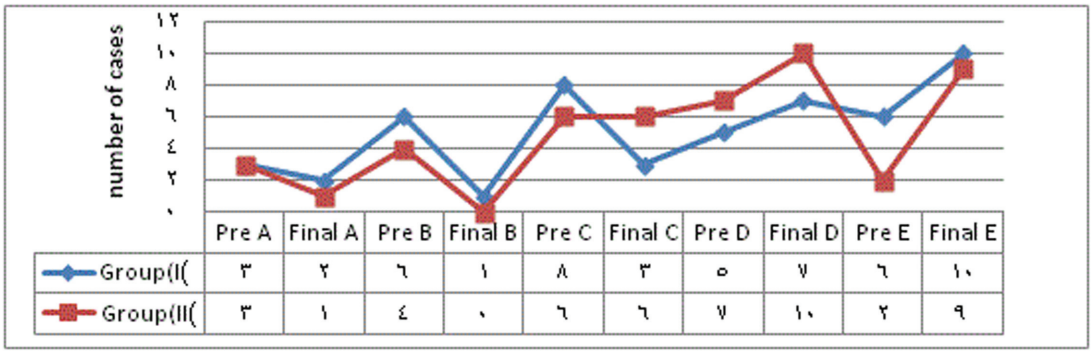
In each group, there was a significant difference between preoperative and immediate postoperative and between preoperative and final kyphotic angle ($P<0.001$), with insignificant difference between the two groups in the final kyphotic angle (Table 2).

Table 1 Preoperative, immediate postoperative, and final follow-up state of American Spine Injury Association motor index

	Immediate postoperative ASIA index					Final ASIA index (48 months)				
Preoperative ASIA index	A	B	C	D	E	A	B	C	D	E
A (6 cases)	3	2	1	–	–	3	1	2	–	–
B (10 cases)	–	1	5	4	–	–	–	6	4	–
C (14 cases)	–	–	2	7	5	–		1	7	5
D (12 cases)	–	–	1	5	6	–	–	–	6	6
E (8 cases)	–	–	–	–	8	–	–	–	–	8
Total	3	3	9	16	19	3	1	9	17	19

ASIA, American Spine Injury Association.

Figure 1



ASIA motor index in all groups. ASIA, American Spine Injury Association.

Table 2 Perioperative outcomes, kyphotic angle correction, visual analog scale, and Oswestry disability index score

	Group I (mean±SD)	Group II (mean±SD)	*P* value
EBL (Ml)	950±300	1100±250	<0.001
Hospital stay (day)	3.95±1.2	6.28±2.3	0.000
Operative time (min)	165±20	190±40	<0.001
Preoperative angle	50±3.17°	49±5.2°	0.756
Immediate postoperative	20±2.34°	19±3.2°	0.657
Final angle	22±6.4°	22±2.35°	0.435
% of correction	60	60	0324
Loss of correction	2±4.1°	3±1.12°	0.867
Preoperative VAS	7.28±1.2	7.34±0.88	0.543
Final VAS	4±0.57	1.21±0.5	<0.05
P (pre versus final) VAS	<0.02	<0.001	–
Preoperative ODI	69.5±10.5	70±9.5	0.634
Final ODI	20±1.2	11±0.25	<0.05
P (pre versus final) ODI	0.05	0.000	–
Fusion time (months)	12±2.5	9.5±1.5	0.798

EBL, estimated blood loss; ODI, Oswestry disability index; VAS, visual analog scale.

Mean intraoperative estimated blood loss (EBL) was 950±200 ml (700–1650 ml). Mean operative time was 200±40 min (160–280 min). Mean hospital stay was 4 ±1.5 days (2–10 days). Mean EBL was more in group II than group I, whereas hospital stay and operative time were less in group I than group II. There was a significance difference between the two groups regarding EBL, operative time, and hospital stay ($P<0.001$) (Table 2).

Fusion was evaluated by sentinel sign [7] and dynamic radiographs. MDCT scan was done when radiographs were insufficient and was needed for seven (14%) patients for confirmation of fusion. A total of 47 (94%) patients showed fusion at the final follow-up, and three (6%) cases in group I failed to fuse.

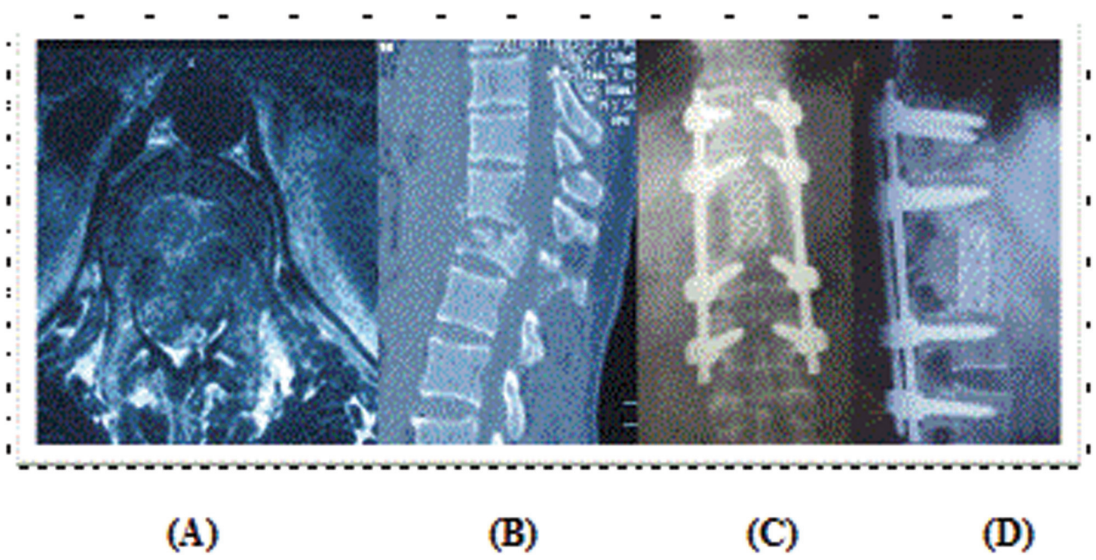
VAS and ODI score significantly improved between preoperative and final follow-up state in each group, with significant difference between the two groups in the final follow-up state ($P<0.05$) (Table 2).

Regarding complications, one case had neurological worsening, which recovered after one and a half month, in group II; three case had superficial wound infection, which resolved within 1 month after local debridement (one case in each group); three case had intercostal neuralgia (one case persistent) after rhizotomy; and one case in group I had intraoperative excessive bleeding due to uncontrolled epidural veins injury before bipolar electrocoagulation. Two cases showed pleural injury that needed repair by proline 4/0 with intercostal tube and three cases had cage subsidence, which showed radiological loss of correction (Figs 2 and 3).

Discussion

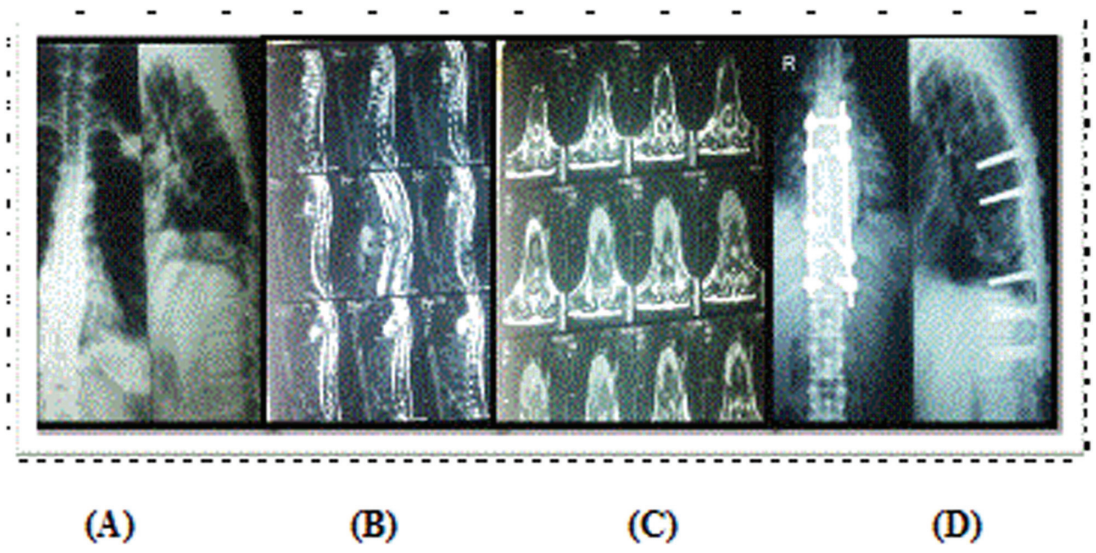
Direct cord compression by displaced bone/discal fragments, necrotic or neoplastic tissues, and/or kyphotic deformities require different surgical procedure from either anterior or posterior approach [10]. Mirnard [11] had a limited vertebral bodies approach by costotransversectomy. However,

Figure 2



(a, b) MRI and MDCT findings of a 55-year-old male patient (ASIA grade B) with hyperintense spinal cord signal opposite T12 fracture. (c, d) 6-month follow-up radiograph after LEC procedure using pedicular screws fixation with a mesh cage replacing T12. ASIA, American Spine Injury Association; LEC, lateral extracavitary; MDCT, multidetector computed tomography.

Figure 3



(a, b, c) Plain radiograph and MRI finding of a 30-year-old female patient (ASIA grade C) with TB destructive lesion and paravertebral abscess at T8–9. (d) 12-month follow-up radiograph after LEC procedure using pedicular screw fixation with rib bone grafting. ASIA, American Spine Injury Association; LEC, lateral extracavitary; TB, tuberculous.

Capener [12] changed it by resecting a longer segment of the rib to create a wider working space on the anterolateral vertebral body surface. In our study, the cases were operated by LEC technique, which involves unilateral or bilateral costotransversectomy with 6–8 cm extraperiosteal resection of one or more ribs at the affected level/levels to enter extracavitary space without disruption of posterior tension surface (laminectomy).

LEC procedure allows simultaneous adequate thoroughness spinal canal decompression with a percentage of about 78.8%. Preservation of the posterior tension surface (posterior ligamentous complex and lamina) permits relative kyphosis correction of about 60% in our study, which improves global sagittal spinal malalignment and reconstruction of anterior compression column without additional morbidity of ventral exposure. The percentage of ambulatory state improvement in all patients was about 70%, which reflected directly on the variable percentage of VAS and ODI scores' improvement according to different affection. LEC

Table 3 Results of Aebli *et al.* [14], Laheri *et al.* [16], and Jain *et al.* [15], traumatic and tuberculous groups

	Aebli *et al.* [14]	Jain *et al.* [15] (traumatic)	Laheri *et al.* [16]	Jain *et al.* [15] (TB)
No of cases	32	23	28	25
Operative time (min)	167 (159–220)	269 (215–315)	Not evaluated	220 (210–270)
Blood loss (ml)	820	918 (550–1100)	850 (400–2000)	1100 (750–2200)
Hospital stay (days)	Not evaluated	Not evaluated	Not evaluated	16 (10–35)
Follow-up (months)	20	24 (12–60)	68 (48–84)	24 (12–60)
% of correction	95%	60.1%	62.5%	58.2%
% of ambulance	Not evaluated	Not evaluated	Not evaluated	36%
Loss of correction	0.0 (–0.5–0.5)°	2.2°	3.2°	1.5°
% ASIA improvement	20 A,4B,5D/10B,15C,5D	81.8%	91.3%	81.8%

ASIA, American Spine Injury Association; TB, tuberculous.

creates wider posterolateral exposure which decreases intraoperative cord manipulation and possible postoperative neurological worsening but neurological deterioration expected and one (2%) case showed more neurological worsening owing to postoperative collecting hematoma which needs evacuation. Fusion was evident in 94% of the cases, and three cases failed to fuse owing to inadequate bone grafting.

Less cord manipulation and traumatization by indirect decompression with lower incidence of iatrogenic neurological deterioration are the main advantages of LEC approach but palpable defect was prominent owing to two or three excised rib. Violation of thoracic cavity in LEC may cause possible pleural and lungs injury and consequently another morbidity associated with paraplegia [13].

The results of group I of our study were convergent with the results of Aebli *et al.* [14] and Jain *et al.* [15] (anterolateral decompression of traumatic group) regarding EBL, operative time (longer in Jain *et al.* [15]), postoperative kyphotic angle, however, there was longer follow-up period in our study. There was a higher percentage of correction angle and less loss of correction in the study by Aebli and colleagues than our study and the one by Jain and colleagues (Table 3). Our outcomes showed relative improvement of percentage of ambulatory, VAS, and ODI state of about 60.7, 45.2, and 71.9%, respectively.

The results of group II of our study relatively agree with Laheri *et al.* [16] (poster lateral decompression) and Jain *et al.* [15] (anterolateral decompression of TB group) regarding operative time, hospital stay, EBL, and bony fusion, but the Laneri percentage of ambulance and neurological improvement outcome were less in the present study. Follow-up period was longer in the study by Laheri. The study by Laheri showed relatively higher percentage of correction and the study by Jain *et al* showed lower loss of correction than the other two studies (Table 3). Our outcomes showed favorable improvement of percentage of ambulatory, VAS, and ODI state of about 86.4, 83.5, and 84.3%, respectively.

On comparing between the two groups of our study, we found that neurological, ambulatory, and functional outcomes (VAS and ODI) significantly improved in group II than group I, owing to late presentation with deteriorated ASIA index, gliosis or fibrosis, and transection of the cord in group I. Operative time, EBL, and hospital stay significantly increased in group II than the other group, owing to high vascularity of TB lesions and needing more surgical time to evacuate preveretebral and paravertebral collection to perform thorough debridement causing lengthening of operative time in group II. However, loss of correction was insignificantly higher in group II than group I. Fusion was greater in group II (100%) than group I (89.3%), and fusion time was faster in group II owing to tendency of healing in TB lesions.

Conclusion

One-stage three-column correction stabilization surgery could be successfully obtained by LEC technique. This procedure attained good results for maintained deformity correction, bony fusion, spinal cord decompression, and neurological improvement. However, satisfactory outcomes were obtained more in TB than traumatic disorders owing to neural insult and transection.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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