Mini-open thoracoscopic-assisted spinal thoracotomy for traumatic injuries: A technical note

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INTRODUCTION

Management of acute traumatic fractures of thoracic and thoracolumbar spine has varied widely with time and individual surgeon preferences. Previous operations have included posterior only surgery versus anterior only surgery versus combined anterior/posterior surgical stabilization. [10] However, open anterior approaches and posterior only approaches for corpectomies are morbid procedures with typically high complication rates.

Mini-open thoracoscopic-assisted thoracotomy (MOTA) spine surgery has been introduced to mitigate the complications of anterior only, posterior only, or 360 procedures. It also has advantages of being minimally invasive while providing a direct vision of the pathological site in three dimensions rather than two-dimensional images of thoracoscopy. There is, however, a paucity of literature...
regarding the safety and efficacy of MOTA thoracotomy for treating unstable thoracic burst fracture (TBF). Here, we evaluated the results of utilizing the MOTA technique in anterior decompression and fusion of 22 traumatic TBFS.

**MATERIALS AND METHODS**

This retrospective study was conducted at a tertiary care spine center after approval from the Institutional Review Board. A total of 22 patients with unstable TBF underwent the MOTA thoracotomy technique. Patients with incomplete neurological involvement and with previous pulmonary pathologies were excluded from the study [Table 1]. Multiple clinical and radiographic variables were studied [Table 2]. Patients were followed yearly for instrument-related complications for 5 years. Only patients with AIS A deficits were included in the study.

**Surgical technique**

General anesthesia utilized a double-lumen tube for intubation to maintain single lung ventilation when required. All patients included in the study first underwent posterior stabilization in the prone position followed by the right lateral decubitus (i.e., left chest upwards) position [Figure 1].

**Mini-thoracotomy portal**

On a radiolucent table, the mini-thoracotomy surface was marked on the skin by noting the level of the fractured vertebrae/disc and/or adjacent vertebrae. For a single-level fracture/corpectomy, the incision line extended from the middle of the posterior wall of the proximal vertebrae to middle of the anterior wall of distal vertebrae [Figure 1]. For a two-level fracture/corpectomy, the incision line extended from the posterior inferior edge of proximal vertebrae above the fracture to anterosuperior edge of distal vertebrae below the fracture. The incision extended to the rib, with the intercostals subperiosteally dissected from the upper border of the rib. Next, the parietal pleura was incised, followed by placement of the rib spreader. At this point, anesthetist would deflate the lung on the operated side. Other portals (viewing portal and retraction portal) were established under visually assisted thoracoscopy guidance. A thoracoscope was then inserted through mini-thoracotomy into the chest. The viewing portal was placed about two intercostal spaces proximal to involved level and at the anterior edge of the body, while the retraction portal was placed one intercostal space proximal to the involved level and 9 cm anteriorly [Figure 2].

The thoracoscope was then removed from mini-thoracotomy incision and inserted through viewing portal sleeve, to the desired vertebral level. Regular spine instruments (short handle) were utilized to perform the single- or two-level corpectomy of the involved fracture vertebra, along with cord decompression [Figure 3]. Appropriate sized graft was harvested from the ipsilateral iliac crest and inserted anteriorly ensuring a snug fit [Figures 4 and 5]. Parietal pleura was resutured, the lung retractor was removed, and anesthetists reinflated the lung. An intercostal drainage (ICD) tube was left in place.

**Table 1:** Inclusion and exclusion criteria for thoracoscopic approach for thoracic burst fractures.

| Inclusion criteria | Exclusion criteria |
|--------------------|-------------------|
| Patients with thoracic burst fractures | Patients with incomplete neurology |
| Patients with ASIA-A neurology | Patients with previous pleural/lung pathology |
| Follow-up of minimum 5 years | Patients who cannot tolerate single lung ventilation |
| No previous dorsal spine pathology | Patients with severe respiratory dysfunction |

**Table 2:** Clinical and radiological parameters assessed.

| Clinical parameters assessed | Radiological parameters assessed |
|------------------------------|---------------------------------|
| Neurology                    | Preoperative kyphotic angle     |
| Level of fracture            | Postoperative kyphotic angle    |
| Type of fracture             | % of kyphosis correction        |
| Associated injuries          | Loss of kyphotic correction     |
| Intraoperative time          | Radiologic fusion               |
| Estimated blood loss         | Status of implants on follow-up |
| Chest tube drainage          |                                 |
| Length of hospital stay      |                                 |
| Complications                |                                 |

[Figure 1: Right lateral decubitus of patient after posterior surgery with left-sided chest upwards and surface marking for single-level corpectomy, S: Superior, I: Inferior, A: Anterior, P: Posterior.]

[Figure 2: Special instruments required for mini-open thoracosscopic-assisted thoracotomy. Self-retaining retractor and thoracoscope.]
Postoperative care

Patients were mobilized on the 1\textsuperscript{st} postoperative day (e.g., sitting with or without support). The ICD drain was removed when 24 h collection in both drains together was <50 ml. Sitting radiographs were taken on the 3\textsuperscript{rd} postoperative day and at every follow-up examination [Figure 6]. Fusion was independently evaluated on X-rays by two spine surgeons, each with more than 5 years of experience in the field.

RESULTS

Twenty-two patients were included in study. They averaged 35.5 years of age and were followed up for 8 years 3 months on an average [Table 3]. The patients were predominantly males with T9 and T12 vertebrae fractures (M:F = 6:1). There were 20 single- and 2 double-level corpectomies performed. The average operating time for the MOTA procedure for a single-level corpectomy was 91.5 ± 14.5 min and 150 ± 18.6 min for two levels. The average blood loss was 311 and 550 ml, respectively, in the two groups. ICD was removed typically on the 3\textsuperscript{rd} postoperative day, and the average LOS was 5 days.

About 95.45\% of cases showed fusion at the latest follow-up. One patient showed radiological evidence of pseudoarthrosis. The average preoperative kyphotic angle was corrected from 34.2 ± 3.5° to 20.5 ± 1.0° postoperatively with an average correction of 41.1\%. Radiographs at final follow-up showed an average loss of kyphotic correction of 2.4\% and there was no evidence of implant loosening or migration.

The most common complication was intercostal neuralgia seen in 12 patients; 10 required membrane stabilizing agents (pregabalin) and two patients required intercostal nerve block. There was one case with traumatic cerebrospinal fluid leakage; this was successfully managed with a muscle graft and postoperative lumbar drainage. The patient with pseudoarthrosis was clinically asymptomatic. On close follow-up, there was no evidence of implant failure or increase in kyphosis. Hence, no active intervention was done.

DISCUSSION

The mini-open thoracoscopic surgery (MOTA) was introduced for anterior thoracic and thoracolumbar spinal cord decompression with anterior column reconstruction. It provides direct three-dimensional visualizations of focal neurovascular structures, while also providing easy access to manage complications.\cite{2} Its major advantage is direct access to perform a vertebrectomy, decompression, and bone graft or cage insertion.

This technique has been used successfully in various indications such as Pott’s spine, metastatic spine tumors, and thoracic disc prolapse. Lu et al\cite{5} used MOTA in their 50 patients with thoracic Pott’s disease. Vijay et al\cite{7} used a similar technique in 12 patients with metastatic thoracolumbar spine pathology. Madi\cite{6} in their prospective study of 20 patients of thoracolumbar fractures, underwent...
Table 3: Demographics of study group and intraoperative data and latest follow-up.

| Case No. | Age  | Sex   | Type of fracture                  | TLICS | Posterior stabilization | Corpectomy levels | Duration of mini-open thoracoscopic-assisted thoracotomy (min) | Blood loss (ml) | Follow-up  |
|----------|------|-------|----------------------------------|-------|------------------------|-------------------|---------------------------------------------------------------|----------------|------------|
| 1        | 25   | Male  | T12 burst                        | 6     | T11-L1                 | One               | 120                                                          | 500.00         | 9 years    |
| 2        | 25   | Male  | T12 burst fracture               | 8     | T11-L1                 | One               | 120                                                          | 700.00         | 9 years    |
| 3        | 29   | Male  | T6 compression                   | 6     | T5-T7                  | One               | 120                                                          | 150.00         | 9 years    |
| 4        | 40   | Male  | T8 burst                         | 6     | T7-T9                  | One               | 90                                                           | 230.00         | 9 years    |
| 5        | 35   | Female| T12 burst                        | 6     | T11-L1                 | One               | 120                                                          | 360.00         | 9 years    |
| 6        | 37   | Male  | T8 burst                         | 6     | T7-T9                  | One               | 120                                                          | 220.00         | 9 years    |
| 7        | 42   | Male  | T8 burst                         | 6     | T7-T9                  | One               | 120                                                          | 150.00         | 9 years    |
| 8        | 29   | Male  | T8 compression                   | 5     | T7-T9                  | One               | 120                                                          | 340.00         | 8 years 9 months |
| 9        | 29   | Male  | T10 burst                        | 6     | T9-T11                 | One               | 90                                                           | 220.00         | 8 years 9 months |
| 10       | 44   | Male  | T12 burst fracture with translation | 9     | T11-L1                 | One               | 60                                                           | 300.00         | 8 years 9 months |
| 11       | 41   | Female| T8 compression                   | 5     | T7-T9                  | One               | 90                                                           | 250.00         | 8 years 9 months |
| 12       | 50   | Female| T9 burst                         | 6     | T8-T10                 | One               | 60                                                           | 270.00         | 8 years 6 months |
| 13       | 47   | Male  | T12 bony chance                  | 9     | T11-L1                 | One               | 60                                                           | 330.00         | 8 years 3 months |
| 14       | 33   | Male  | T8 burst                         | 6     | T7-T9                  | One               | 60                                                           | 230.00         | 8 years 9 months |
| 15       | 38   | Male  | T12 burst                        | 6     | T11-L1                 | One               | 60                                                           | 500.00         | 8 years    |
| 16       | 24   | Male  | T12 burst                        | 6     | T11-L1                 | One               | 90                                                           | 300.00         | 8 years    |
| 17       | 32   | Female| T10 burst                        | 6     | T9-T11                 | One               | 90                                                           | 250.00         | 8 years    |
| 18       | 51   | Male  | T9,T10 flexion compression       | 6     | T8-T11                 | Two               | 180                                                          | 450.00         | 8 years    |
| 19       | 30   | Male  | T12 burst                        | 6     | T11-L1                 | One               | 90                                                           | 370.00         | 8 years    |
| 20       | 33   | Female| T8 burst                         | 6     | T7-T9                  | One               | 90                                                           | 250.00         | 7 years    |
| 21       | 26   | Male  | T7, T8 burst fracture with translation | 7     | T6-T9                  | Two               | 120                                                          | 650.00         | 7 years 7 months |
| 22       | 41   | Male  | T7 burst                         | 6     | T7-T9                  | One               | 60                                                           | 300.00         | 8 years    |

Figure 6: (a) Preoperative anteroposterior and lateral radiograph showing burst fracture of T12 vertebra. (b) Sagittal and axial magnetic resonance imaging showing fracture of T12 vertebra with surrounding edema. (c) Postoperative anteroposterior and lateral radiographs showing T11-L1 posterior pedicle screw instrumentation with anterior iliac crest strut graft in position.

anterior surgery by a similar approach. Kocis[3] in their retrospective study of 127 patients with thoracolumbar fractures also used a similar procedure as did Lee et al.[4] [Table 4].

The present study shows the results of MOTA technique to perform corpectomy for unstable TBF. The average operating time was 120–180 min, significantly less than the open thoracotomy approach (average: 210–617 min). The average estimated blood loss (EBL) was 300–500 mL which is comparable with previously published MOTA approach literature; this is also significantly less than the average 1362 ml[9] EBL for open thoracotomy. Patients in this study were discharged an average of 5 days postoperatively, while other minimal invasive approaches cited a mean duration
Table 4: Review of literature.

| Authors         | Year | No. of subjects | Pathology                                             | Conclusion                                                                 |
|-----------------|------|-----------------|-------------------------------------------------------|----------------------------------------------------------------------------|
| Khoo et al.     | 2002 | 371             | Thoracic and thoracolumbar fractures                  | VATS is safe, less morbid, and cosmetically better                          |
| Lu et al.       | 2012 | 50              | Pott's spine                                          | Technically challenging and has steep learning curve                       |
| Vijay et al.    | 2016 | 12              | Metastatic spinal disease of thoracolumbar spine       | MOTA is safe and effective                                                 |
| Ronald et al.   | 2007 | 21/9            | Thoracic disc prolapse                                 | Less morbid compared to open approach                                       |
| Madi            | 2005 | 20              | Thoracolumbar fractures                                |                                                                             |
| Kocis et al.    | 2009 | 127             | Thoracolumbar fractures                                | Procedure is simpler with no outcome differences                            |
| Lee et al.      | 2016 | 111-VATS        | Multiple pathologies of thoracic and thoracolumbar spine | Has minimal approach related complications (three cases of atelectasis), significant correction of focal kyphosis of 13.7 degrees, maintenance of the correction at 1 year follow-up, and 100% fusion of the anterior column |
| William et al.  | 2010 | 52              | Thoracic and lumbar fractures                          | VATS group has longer operating times, more approach related complications, and high conversion rates to open surgery when compared to MOTA |

of 5.3 days.\[8\] Alternatively, the LOS for open procedures ranged from 10 to 35 days.\[8\] We had 1 major (4.5%) complication (dural tear) and 12 patients (54.5) with minor complications of intercostal neuralgia. Complications for open thoracolumbar corpectomy ranged from 9 to 56.\[1]\n
About 95.45% of cases in the current series showed fusion at their latest follow-up, with overall good stabilization of kyphosis. One patient with pseudoarthrosis was managed conservatively as he was clinically asymptomatic with no evidence of progression of kyphosis or implant failure.

Major limitations of this study include the very small sample size, retrospective nature of analysis, data from a single center, and lack of control group. Our study is just a preliminary report on the safety and efficacy of MOTA approach for the management of TBF. A multi-centric analysis with a larger sample size is needed to further validate our findings. However, we believe that the MOTA approach may serve as a useful middle ground between open and endoscopic procedures mitigating the disadvantages of each.

CONCLUSION

The MOTA approach to unstable thoracic single-/double-level fractures is yet to be confirmed, as this study is only a preliminary report as to its safety/efficacy.

Declaration of patient consent

Institutional Review Board permission obtained for the study.

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Conflicts of interest

There are no conflicts of interest.

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