Aesculap Spine
miaspas mini TTA

Microsurgical Anterior
Trans-Thoracic Approach

Surgical Technique
Microsurgical Anterior Trans-Thoracic Approach
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Microsurgical Anterior Trans-Thoracic Approach
Foreword

In the last 10 years, research in the field of spinal surgery was dominated by the development of less invasive techniques to approach the thoracic and lumbar spine from anterior. So called "mini-open" as well as closed endoscopic techniques are now becoming more and more standard approaches for the treatment of a variety of spinal diseases.

The modification of conventional open-techniques into microsurgical anterior approaches to the lumbar spine (MiniALIF) has gained wide acceptance among spinal surgeons. There was an obvious need to extend this "mini-open"-philosophy to approach the thoraco-lumbar junction as well as the thoracic spine.

This manual describes microsurgical modifications of transthoracic as well as trans-thoracic/retroperitoneal approaches to the spinal segments Th5 to L2.

We tried to keep these approaches as simple as possible in order to make them reproducible.

The main advantages of these minimally invasive transthoracic approaches are reduced perioperative morbidity, reduced ICU-Stay and hospitalisation, reduced blood loss as well as less complications such as post-thoracotomy-pain.

H. Michael Mayer, M.D.
Medical Director
Spine Center Munich
1. The Microsurgical Transthoracic Approach to T5-T10*

1.1 Terminology
A microsurgical modification of the conventional thoracotomy to approach the anterior thoracic spine from T 5-T 10 will be described. It is called ‘Mini-TTA ’ (TTA = Trans Thoracic Approach)

1.2 Surgical Principle
The anterior thoracic spine is approached from the right side through a limited thoracotomy with a 4-6 cm skin – incision depending on the number of levels to be treated. The thoracic cavity can be opened either by resection of a small part of the rib (‘window-technique’), by a rib-flap (‘open-door-technique’), by a single osteotomy of one rib (‘sliding-technique’) or by a simple intercostal approach. A specially designed soft-tissue-spreader is used to retract the ribs, the ipsilateral lung and, if necessary, the diaphragm (see also next chapter). With the use of a surgical microscope or an endoscope for thoracoscopy, a mono- or bisegmental anterior exposure of the thoracic spine can be achieved.

1.3 History
The technique was evolved from the microsurgical approaches described for the exposure of the lumbar spine and lumbosacral junction (MAYER 1997, 1998). A soft tissue spreader which can be used for transperitoneal exposure of L 5 / S 1 as well, has been modified adding different blades for retraction of the thoracic contents as well as of the ribs. The first patient has been operated on March 6, 1996 by the author.

1.4 Advantages
- Small skin incision
- Small, less traumatic thoracotomy
- Less trauma to the rib cage with window-, open-door-, sliding- or intercostal-technique
- No cosmetic alterations
- Short Intensive Care Unit (ICU) -stay
- Better illumination and magnification of surgical field
- Safe dissection of tissues anterior and in the spinal canal
- No lab training necessary

1.5 Disadvantages
- Exposure limited to 1 - 2 segments with surgical microscope
- Individual learning curve
- Long Instruments
- Limited manipulation of the motion segment (e.g. reduction)
- Limited options for anterior instrumentation

1.6 Indications
This approach has been used in patients with the following indications:
- Thoracic disc herniations
- Fractures
- Spondylodiscitis / Spondylitis
- Palliative treatment of monolocular malignant tumors
- Enucleation or marginal excision of benign tumors or tumor-like lesions
- Anterior biopsies of lesions with unknown dignity

1.7 Contraindications
There are no absolute contraindications for this approach. However, decision should be made on an individual basis in the following patients:
- patients with previous thoracotomy or thoracoscopic surgery
- patients with pleural empyema
- patients in whom one-lung ventilation is not possible
- patients with severe or acute respiratory insufficiency
- patients with vascular diseases or malformations of or in the thoracic cavity.

1.8 Patient’s informed consent
Information about approach – specific risks and hazards should contain the following points:
- Postoperative pain due to resection of the rib and alteration of intercostal nerve (Post-thoracotomy-syndrome)
- Injury of intrathoracic blood- vessels with hematotherax and repeated surgery
- Injury to the oesophagus and the mediastinum with infection (mediastinitis)
- Injury to the thoracic duct with chylothorax
- Injury to the lung, postoperative pneumotherax
- Postoperative Atelectasis
- Injury to the diaphragm and lesion of retroperitoneal structures (bowel, spleen etc.) with diaphragm hernia, peritonitis, retroperitoneal bleeding
- Injury to the pericardium and heart with postoperative scarring
- Injury to splanchnic nerves
- Pleuritis

1.9 Surgical Technique

1.9.1 Preoperative planning
All data necessary for a meticulous preoperative planning can be obtained by a.-p. and lateral x-ray of the thorax and thoracic spine as well as by magnetic resonance imaging (MRI). It is mandatory to have a clear impression of the pathology to be treated as well as of the topography of the anatomic region where the pathology is located. The radiologist should be asked to mark the level of T 12 or L 1 on a MRI-scout view of the whole spine in the sagittal plane (Fig. 1). This facilitates intraoperative localization especially of soft-tissue pathology like thoracic disc herniations. In patients with variations of the lumbosacral junction (sacralization of L 5 or lumbalisation of S 1) it is recommended to mark L 5 on the MRI-scout view (i.e. the vertebra suprajacent to the last intervertebral space!).
Size and localization of the thoracic blood vessels such as the aorta or the azygos / hemiazygos-system should be analysed preoperatively. Involvement of these blood-vessels in the pathology (e.g. tumors, spondylitis with prevertebral soft tissue involvement) must also be assessed. Selective intubation and unilateral ventilation is helpful during surgery through a mini-thoracotomy. This should be clarified with the anaesthesiologist preoperatively. If unilateral ventilation is not possible or contraindicated (especially in older patients or in patients with pulmonary problems) this must not be a contraindication to the microsurgical approach. The retractor-system described below is able to retract a ventilated lung as well.

1.9.2 Positioning
The patient is placed on the operating table in a left lateral position (Fig. 2a). The approach is from the right side. The cranial and caudal parts of the operating table are tilted in order to achieve a right convex bending of the thoracic spine. However, care must be taken, that the level of pathology (e.g. intervertebral space, vertebral body) shows an orthograde projection onto the skin level in a lateral fluoroscopic view. The lower (left) arm is stretched out, a small soft towel roll is placed under the axilla in order to prevent lesions to the brachial plexus. The upper (right) arm is placed in 90° elevation, the elbow is slightly bended and the forearm is placed on an arm-rest. The ulnar sulcus must be free, and both arms should be placed without pressure or tension.
The position of the body of the patient is held by two soft pads from behind: one supports the buttock, the other the neck. A third one is placed from anterior to fix the pelvis below the anterior superior iliac spine (Fig. 2b). Due to this fixation, the patient can be tilted using the operating-table if necessary during the operation. The head of the patient is supported by a gel-cushion and placed in a neutral position. The operating table must be radiolucent from the lumbosacral junction to the level of the pathology to be treated. This is mandatory, because fluoroscopic control of the level to be approached is paramount to avoid wrong level exploration as well as to place the skin incision in the right place.

If higher thoracic levels must be approached, the upper (right) arm must be placed in maximum elevation. (Cave: Do not oversretch the brachial plexus!).

1.9.3 Localisation

The skin incision is determined by localizing the level to be approached in projection to the skin level. If the pathology cannot be visualized directly by fluoroscopy (e.g. disc herniations), the level must be determined by counting the vertebral bodies from L 5 up to the target level. (Make sure, that L5 in the lateral fluoroscopic view is really L5). Lumbosacral anomalies may be a pitfall (see above). The level to be approached is marked on the skin with lateral fluoroscopic projection. If a disc space is approached (e.g. disc herniations, spondylodiscitis), then the orientation of the disc space as well as the anterior and posterior borders are marked. If a vertebral body is the surgical target (e.g. tumors or fractures) then the silhouette of the vertebral body should be drawn onto the skin under fluoroscopic control. This facilitates the placing of the skin incision according to the size of the exposure which is needed. The skin incision is marked parallel to the orientation of the rib or the intercostal space underneath and should be centered over the pathologic level.

1.9.4 Surgical Steps

Exposure of the rib or intercostal space (Fig. 3)

Exposure of the ‘target-rib’ or intercostal space to enter the thoracic cavity is easy at the mid-and lower thoracic levels. Through a 4–6 cm skin incision, the lateral part of the serratus muscle is exposed and split parallel to the orientation of its fibers. Thus the underlying rib or intercostal space are exposed. At levels above T 7 the latissimus dorsi muscle has to be retracted or incised anteriorly to expose the rib. The ‘target-rib’ is always determined by the localisation of the skin incision and not by the conventional method (rib two levels above the pathology).
**Mini-Thoracotomy**

Intercostal approach (Fig. 4a)

In young patients with elastic rib cage with a monosegmental pathology (e.g. thoracic disc herniation), thoracotomy can be performed by an intercostal approach. The intercostal muscles are split close to the superior rim of the caudal rib and the thoracic cavity is entered after splitting of the visceral pleura. The intercostal space can be opened with the rib-spreader in order to give sufficient exposure.

‘Window-technique’ (Fig. 4b)

Subperiostal dissection is performed and the intercostal muscles are dissected first from the superior rim of the caudal rib and then from its caudal rim. Due to the oblique insertion of the external intercostal muscles, dissection is facilitated if the muscles are detached from posterior to anterior at the inferior rim and from anterior to posterior at the superior rim. Thus, trauma to the intercostal blood vessels and nerve is minimized. The rib is exposed over a length between 4-6 cm. With a curved dissector, the rib is isolated from its periostal bed. Osteotomies are performed at the anterior and posterior borders of the exposed part and the rib is taken out (and preserved for grafting if necessary). Thus a ‘window’ of 5-6 cm length and 3-4 cm width is created, the size depending on the width of the excised rib.

‘Open-Door-technique’ (Fig. 4c)

The thoracic cavity can also be entered through a rib flap. In this alternative exposure, the intercostal muscles are only detached from the superior rim of the rib. The osteotomies are performed the same way as described above, however the osteotomized part of the rib is opened (like a door) in order to enter the thoracic cavity. At the osteotomy sites, small drill holes are set to facilitate transosseous sutures at the end of the operation. This technique can be used if no bone grafting is necessary and if an intercostal exposure is not recommendable due to anatomic reasons (e.g.: stiff rib cage, osteoporotic bone).

‘Sliding-Technique’ (Fig. 4d)

This is another alternative which gives a sufficient monosegmental exposure without rib defect. Only one osteotomy is performed and while spreading the intercostal space, one rib ‘slides’ over the other to give a wider exposure as compared to an intercostal approach. This technique can be used in the lower thoracic spine and at the thoracolumbar junction (see next chapter).
Exposure of the target area

After rib osteotomy the visceral pleura is incised and the thoracic cavity is opened. The rib retractor is inserted. The rib blades are available in different sizes (Fig. 5). The blades can be rotated in the retractor and thus be adjusted to the individual anatomic situation (Fig. 6) in patients being ventilated unilaterally, the collapsed lung can be retracted with an inflatable balloon mounted on a blunt lung blade which is fixed on the rib-retractor. (Fig. 7)

Exposure of the thoracic spine

The procedure is then continued with the help of a surgical microscope (‘microsurgery’) or an endoscope (‘open’ thoracoscopic surgery). Thus, the anterolateral circumference of the thoracic spine can be exposed. The rib head(s) of the level(s) to be approached are identified. The correct level is identified by intraoperative fluoroscopic control. The pleura parietalis is opened in a T-shaped manner longitudinally anterior to the rib head and in a 90° angle on the rib head. Special pleura scissors have been developed for this purpose (Fig. 8). Blunt dissection of the anterolateral circumference is performed with peanut swabs. If necessary, the segmental vessels can be closed with ligaclips, cut and dissected from the surgical field.
1.9.5 Surgical Strategies
Thoracic Disc Herniations (Fig. 9)
- Identification of disc level
- Opening of pleura (as described above)
- Removal of rib head and radiate ligaments with rongeurs and high-speed drill (Fig. 10)
- Opening of the disc space posterior third underneath the rib head
- Removal of 3-5 mm of adjacent vertebral bodies
- Identification and drilling of superior border of pedicle until dura can be identified
- Tracing the dura and removal of posterior third of intervertebral disc including the herniated part and the posterior longitudinal ligament

Cave:
- Achieve hemostasis without compression of the spinal cord (e.g. careful bipolar coagulation of epidural veins; surgicell; gelfoam, cottonoid patties etc.)
- Resect the posterior longitudinal ligament until the decompressed dura is identified clearly
- Avoid injury to foraminal structures (segmental nerve and blood vessels)
- Restrict removal of parts of the vertebral bodies or pedicle to a minimum

Partial and Complete Corpectomy
(e.g. fractures; tumors; spondylitis)
- Identification of the target vertebral body and the adjacent discs
- Ligation and dissection of the segmental vessels on the target vertebral body
- Removal of the adjacent intervertebral discs (see above) and ‘isolation’ of the target vertebra
- Identification of the pedicle and removal to identify the dura
- In spondylitis cases identify the intercostal nerve after removal of corresponding rib head
- Trace the nerve down into the spinal canal to identify the thecal sac
- ‘Shell out’ the target vertebra with high speed drill (fractures) or by piecemeal removal with rongeurs (tumors; spondylitis)
- Decompression of the spinal cord by displacing the posterior part of the ‘vertebral body shell’ into the ‘shelled out’ part with hockey-stick-dissectors (Fig. 11).
- In spondylitis cases identify the layer between infectious tissue and dura
- Completion of decompression across to the base of the opposite pedicle
- If necessary prepare graft bed for fusion or vertebral body replacement

Cave:
- Extremely careful dissection is necessary because of obscured normal anatomy by posttraumatic (organised) hematoma (fractures), pleura adhesions and prevertebral abscesses (spondylitis)
1.9.6 Postoperative Care

A chest-tube is placed in all patients. If the amount of drainage fluid is less than 100 cc within the last 24 hours, the chest tube is closed for 6 hours. When a control X-ray of the lung shows a normal picture, it can be removed. This is usually between 24 and 72 hours postoperatively depending on the type of surgery. Following the operation, the patient can be extubated in the operating room. It is rarely necessary to perform postoperative artificial ventilation except for patients with significant obstructive lung disease or after a prolonged operating time. The patients remain in the ICU until the chest tube is removed. Postoperative pain is controlled by non-steroidal antiinflammatory medication as well as by a patient-controlled analgesia (PCA) usually with morphine-type analgesics. The patients are mobilized on the first postoperative day irrespective of the type of surgery. Respiratory therapy begins immediately after the patient is awake and ready to cooperate.

1.10 Complications and Hazards

Besides the well-known complications of conventional thoracotomy, the following potential intraoperative complications may be faced:
- Inadequate exposure due to wrong positioning and/or localization
- Direct or indirect injury to lung, thoracic duct, azygos / hemiazygos-vein, segmental vessels, aorta or heart, intercostal vessels, intercostal nerves, sympathetic chain / splanchnic nerves
- Spinal cord injury or ischemia
- Dural tears

Control of vascular injuries is most demanding through a limited transthoracic approach. The surgeon should always be prepared to enlarge the surgical field to a conventional thoracotomy if such complications cannot be managed adequately.

1.11 Results

Results are preliminary. A total of 25 patients have been treated with this approach. The indications are listed in Table 1 (Tab. 1). The average age of the patients was 43.9 years (range: 41–77 years). Perioperative data are shown in Table 2.

ICU stay was 2 days on the average. All patients were mobilized the day after the operation. There were 4 complications in this early series (Tab. 3). One patient suffered from severe pain at the thoracotomy site which resolved only after 4 months. Two other patients complained about temporary intercostal neuralgia. In both patients, the thoracotomy was performed using the ‘window’ – technique (rib stays attached to the lower intercostal muscle and is reinserted at the end of the operation). Obviously the intercostal nerve was irritated by the ‘mobile’ rib in the early postoperative period. The neuralgia resolved spontaneously in both patients after 2–3 months. There was one chylothorax in a young patient with an old T 12-fracture. Lesion to the thoracic duct was not realized intraoperatively. The complication was successfully treated by thorax drainage for 12 days and fat free diet. A surgical reintervention was not necessary. In all patients, postoperative MRI was performed to document the effect of the operation.

### Indications for miniTTA
- Thoracic disc herniations
- Fractures
- Spondylitis/Spondylodiscitis
- Tumors

### miniTTA Perioperative data

<table>
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<tr>
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<th>n=25</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICU</td>
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<tr>
<td>Thorax drainage</td>
<td>2 days</td>
</tr>
<tr>
<td>Hospitalization</td>
<td>7-8 days</td>
</tr>
<tr>
<td>Blood loss</td>
<td>100-400 cc</td>
</tr>
</tbody>
</table>

### miniTTA Complications

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Thoracotomy pain</td>
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<tr>
<td>Intercostal neuralgia</td>
<td>2</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>0</td>
</tr>
<tr>
<td>Chylothorax</td>
<td>1</td>
</tr>
</tbody>
</table>

### Tab. 1: Indications

### Tab. 2: Intra + post op data

### Tab. 3: Complications
1.12 Critical Evaluation

This approach represents a modification of the conventional thoracotomy described for the treatment of pathologies of the anterior thoracic spine. As far as our preliminary experience shows, mini-thoracotomy lead to a reduction of intra- and postoperative morbidity in the type of diseases treated so far. Trauma to the rib cage and muscles covering the anterolateral part of the thorax is diminished. Postoperative ICU-stay is short as well as the time of hospitalisation. The same is true for intraoperative blood loss, incisional pain and cosmetics. These data are comparable to data obtained with a closed thoracoscopic technique. As compared to closed thoracoscopic techniques, the learning curve is short for surgeons trained in open thoracotomies. The only difference is the size of the approach and the use of optical aids for illumination and magnification (surgical microscope or endoscope).

The approach however seems to be ideal only for patients with mono- or bisegmental pathology. Excision of herniated discs, palliative excision of malignant tumors, decompression of the spinal canal in tumors, spondylitis and fracture-cases can be achieved without major difficulties. The same is true for biopsies or drainage of prevertebral abscesses.

However, technical skills must be trained by surgeons not familiar with the use of a surgical microscope or endoscope. Exposure is possible, but more difficult in patients in which one-lung ventilation is not possible.

The lack of anterior instrumentation systems which are compatible with a minimal invasive anterior approach (microsurgical open or endoscopic) has triggered the development of a new Modular Anterior Construct System (MACS TL). This implant system combines the advantages of plates and rod – fixation systems with the options to use a twin-screw or a single hollow – screw fixation in the vertebral body (Fig. 12a, b). Moreover its polyaxial concept as well as various instruments for manipulations such as distraction or compression allow for better adaptation to different anatomical situations (Fig. 13 a,b).
2. The Microsurgical Transthoracic Approach to the Thoracolumbar Junction

**Terminology**

A microsurgical modification of the transthoracic-retroperitoneal approach to pathologies of the thoracolumbar junction (T11 – L2) is described.

**2.1 Surgical Principle**

The surgical principles follow the principles described in the previous chapter. The anterolateral aspect of the thoracolumbar junction is approached through a 4-6 cm skin incision from the left side. A mini thoracotomy is used to approach the spine at the base of the diaphragmatic insertion on the left side. The approach is then extended into the retroperitoneal cavity through dissection of the diaphragm on the vertebral bodies of T12 / L1 without detaching the diaphragmatic insertion in a circumferential way. The soft-tissue-spreader described in the previous chapter is used to retract the ribs as well as the ipsilateral lung. It is completed by a diaphragm-blade which holds the retroperitoneal contents downwards and retracts the incised diaphragm. Since a high retraction force has to be applied due to the intraabdominal contents, the diaphragm-blade can be fixed on the vertebral body L1 or L2 with a U-shaped integrated K-wire (Fig. 14). As described in the previous chapter a surgical microscope or an endoscope is used to illuminate and magnify the target area. This approach is mainly used for anterior decompression of the spinal canal and anterior interbody bone grafting in fractures.

**2.2 History**

The technique was developed from the microsurgical approach described above.

**2.3 Advantages**

- Small skin incision
- Small, less traumatic thoracotomy
- Less trauma to the rib cage with window-, open-door-, sliding- or intercostal-technique
- Window-, open-door-, sliding- or intercostal-technique
- No cosmetic alterations
- Short ICU-stay
- Better illumination and magnification of surgical field
- Safe dissection of tissues anterior and in the spinal canal
- No lab training necessary
- 3-D-Vision with Cyberspace-Helmet-Technique

**2.4 Disadvantages**

- Exposure limited to 1-2 segments with surgical microscope
- Individual learning curve
- Long Instruments (if used with microscope)
- Limited manipulation of the motion segment (e.g. reduction)
- Limited options for anterior instrumentation

**2.5 Indications**

The approach has been used in patients with the following indications:

- Disc herniations at the thoracolumbar junction (T10/11/12)
- Fractures (T10 – L1)

It can as well be used for the treatment of

- Spondylodiscitis / Spondylitis
- Palliative treatment of monolocular malignant tumors
- Enucleation or marginal excision of benign tumors of tumor-like lesions
- Anterior biopsies of lesions with unknown dignity
2.6 Contraindications (see previous chapter)

There are no absolute contraindications for this approach. However, decision should be made on an individual basis in the following patients:

- patients with previous thoracotomy or thoracoscopic surgery
- patients with pleural empyema
- patients in whom one-lung ventilation is not possible
- patients with severe or acute respiratory insufficiency
- patients with vascular diseases or malformations of the thoracic cavity
- patients with previous operations of or around the diaphragm
- patients with previous retroperitoneal approaches from the left side (e.g. kidney, spleen)

2.7 Surgical Technique

Preoperative planning

Preoperative planning and preparation includes a.-p. and lateral x-rays of the thorax and the thoracolumbar junction. Magnetic resonance imaging (MRI) is mandatory. Identification of T 12 or L 1 respectively follows the same criteria as described in the previous chapter. Selective intubation and unilateral ventilation is helpful but not necessary for the approach to the thoraco-lumbar junction.

2.7.1 Positioning (Fig. 15)

The patient is placed on the operating table in a right lateral position. The approach is from the left side. The operating table is tilted in the coronal plane in order to achieve a left convex bending of the thoraco-lumbar junction. Care must be taken, that the level of pathology (e.g. intervertebral space, vertebral body) shows an orthograde projection onto the skin level in a lateral fluoroscopic view. Both legs are bent in the knee-joints about 80°, supported with soft cushions and fixed with a tape. The lower (right) arm is stretched out, a small soft towel roll is placed under the axilla in order to prevent lesions to the brachial plexus, the upper (left) arm is placed in 90° elevation, the elbow is slightly bent and the forearm is placed on an arm-rest. The ulnar sulcus must be free, and both arms should be placed without pressure or tension.

The position of the body of the patient is held by two soft pads from behind: one supports the buttock, the other the neck. The table is then tilted about 20° backwards. The head of the patient is supported by a gel-cushion and placed in a neutral position.

The operating table should be radiolucent from the lumbosacral junction to the level of the pathology to be treated to avoid wrong – level-exploration.

Fig. 15: Right lateral position
2.7.2 Localisation

The skin incision is determined by fluoroscopy. The C-arm is placed in the a.-p.-position over the target level and the projection of the vertebral body or disc space onto the skin is marked. If a vertebral body is the surgical target (e.g. tumors or fractures) then the superior / inferior as well as the anterior/posterior borders are drawn onto the skin under fluoroscopic control (Fig. 16). The skin incision is marked parallel to the orientation of the rib or the intercostal space underneath the drawing of the target area and should be centered onto the pathologic level.

2.7.3 Surgical Steps

Exposure of the rib or intercostal space.

The approach is primarily transthoracic. Exposure of the ‘target-rib’ or intercostal space to enter the thoracic cavity is easy at the thoraco-lumbar junction. A 4-6 cm skin incision is placed over the target area and the inferior lower parts of the anterior serratus muscle as well as the superior apert of the oblique external abdominal muscle are exposed and split parallel to their fiber orientation. Thus the underlying rib or intercostal space are exposed.

Mini-Thoracotomy

Intercostal approach.

If no bone graft is needed, an intercostal approach is preferred at the thoraco-lumbar junction. Usually the rib cage is more elastic at this level even in older patients. The intercostal muscles are split close to the superior rim of the caudal rib and the thoracic cavity is entered after splitting of the visceral pleura. The intercostal space can be opened with the rib-spreader in order to give sufficient exposure. The other types of thoracotomy techniques are described in the previous chapter.

Exposure of the target area

Thoracotomy at the thoraco-lumbar junction leads to exposure of the diaphragm. Since the insertions of the diaphragm at the lower ribs underlies anatomic variations, it can be necessary to dissect the insertion of the diaphragm from the infrajacent rib. However, in the majority of the cases the thoracotomy is located superior to the lower anterior insertion of the diaphragm. When the rib retractor is opened, the surgeon should take care of the insertion of the diaphragm in the costodiaphragmatic recess anterior to the thoracotomy. If forceful retraction is performed, the diaphragm might tear in the recess. The diaphragm can now be retracted with modified Langenbeck hooks (Fig. 17). The base of the diaphragm is exposed as well as the anterolateral circumference of the lower thoracic segments (Fig. 18).
Exposure of T 10 – L 2

The procedure is continued with the help of a surgical microscope (‘microsurgery’) or an endoscope (videoassisted, ‘open’ thoracoscopic surgery). First the parietal pleura superior to the base of the diaphragm is opened longitudinally anterior to the head of the 11th and 12th rib (Fig. 19). Blunt dissection of the anterolateral circumference is performed in the way described above.

Dissection of the diaphragm starts at the base. To avoid lesions to retroperitoneal structures, the diaphragm should be carefully elevated by superiostal preparation of the lateral parts of the crus sinister from the vertebral body. It can then be carefully elevated and split from the level of the vertebral body about 3-4 cm in a vertical direction. The author recommends to first ‘line’ the split by bipolar coagulation to avoid bleeding. As soon as retroperitoneal fat tissue is visualized, the dissection is continued with peanut-swabs. Thus, the anterolateral circumference of T 12, L 1 and usually superior half of L 2 can be exposed. The segmental vessels are exposed, ‘isolated’ bluntly with a dissector, clipped and dissected. Care has to be taken not to injure the thoracic duct. In most of the cases where the approach is extended to L 1/L2 the superior insertions of the psoas muscle on the left side have to be dissected from the vertebral body. As soon as the lower vertebral body of the target area is exposed, the diaphragm blade is inserted with the help of the blade holder (Fig. 20). The diaphragm blade is fixed onto the vertebral body by a U-shaped K-wire which is integrated in the blade. The blade is then connected to the counter-spread which is fixed on the rib holder (Fig. 21). Thus, the target area is sufficiently exposed.
2.7.4 Surgical Strategies
For anterior decompression in fracture cases, the anterolateral circumference of the fractured vertebral body is exposed first (Fig. 22). The posterolateral third of the fracture area is resected with the help of chisels and high-speed burrs (Fig. 23). The posterior fragment which usually occupies the spinal canal is decreased in size by the highspeed burr until only a thin bony layer occupies the spinal canal. This layer is then carefully luxated into the ‘hollow’ posterior part of the vertebral body with the help of the hockey-stick dissector (Fig. 24). It thus can be removed carefully with the rongeur. The preparation of the graft bed is then completed and a tricortical bone graft from the iliac crest can be inserted press-fit (Fig. 25a, b). Figure 26 shows an example of an L1-fracture after posterior reduction and instrumentation followed by anterior fusion.

2.7.5 Postoperative Care (see previous chapters)
2.8 Complications and Hazards (see previous chapters)

2.9 Results
The results are included in Table 4. The approach was performed in 7 patients to the levels T 11/12 (fracture n=3, disc herniation n=1), to T12 / L1 (fracture n=2) and to L 1/2 (Degenerative Instability n=1).

2.10 Critical Evaluation
The anterior approach to the thoracolumbar junction has been known to be the most traumatizing approach to the spine. It has included circumferential dissection of the diaphragm, excision of a rib and often wide incision or detachment of the psoas muscle. Since the majority of pathologic changes in this anatomical region are fractures which occur predominantly in a young patient population. The need for diminishing iatrogenic trauma in these young patients has been evident. The approach which has been described in this chapter represents one possible solution to the problem of inadequate surgical trauma.

References


### Sets and Instruments

#### 3.1 Retractor System

**BV148 miaspas mini TTA transthoracal retractor set:**

set consisting of:

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BV151P</td>
<td>Orga-tray</td>
</tr>
<tr>
<td>1</td>
<td>BV153R</td>
<td>Retractor</td>
</tr>
<tr>
<td>1</td>
<td>BV154R</td>
<td>Counter retractor</td>
</tr>
<tr>
<td>1</td>
<td>BV155R</td>
<td>Lung retractor</td>
</tr>
<tr>
<td>2</td>
<td>BV162T</td>
<td>Rib retractor blade, small</td>
</tr>
<tr>
<td>2</td>
<td>BV163T</td>
<td>Rib retractor blade, large</td>
</tr>
<tr>
<td>1</td>
<td>BV169T</td>
<td>Diaphragm retractor blade, small</td>
</tr>
<tr>
<td>1</td>
<td>BV170T</td>
<td>Diaphragm retractor blade, medium</td>
</tr>
<tr>
<td>1</td>
<td>BV171T</td>
<td>Diaphragm retractor blade, large</td>
</tr>
<tr>
<td>1</td>
<td>BV164T</td>
<td>Lung retractor blade, small</td>
</tr>
<tr>
<td>1</td>
<td>BV165T</td>
<td>Lung retractor blade, medium</td>
</tr>
<tr>
<td>1</td>
<td>BV166T</td>
<td>Lung retractor blade, large</td>
</tr>
<tr>
<td>1</td>
<td>BV413R</td>
<td>Handle for retractor blades</td>
</tr>
<tr>
<td>1</td>
<td>BV399R</td>
<td>Forceps for retractor blades</td>
</tr>
<tr>
<td>1</td>
<td>JF511</td>
<td>Wrapping drape, 140x 100 cm</td>
</tr>
<tr>
<td>1</td>
<td>JG785B</td>
<td>Identification label, red</td>
</tr>
</tbody>
</table>
**Retractor blades:**

Rib retractor blade
BV162T, small
BV163T, large

Lung retractor blade
BV164T, small
BV165T, medium
BV166T, large

Diaphragm retractor blade
BV169T, small
BV170T, medium
BV171T, large
3.2 Instruments

FG050 miaspas mini TTA instrument set
set consisting of:

1 Piece FG051R Mini TTA perforated basket with storage
1 Piece FL449R Mini TTA osteotome, curved
1 Piece FL448R Mini TTA osteotome, straight
1 Piece BB092R Mini TTA scalpel handle, 170 mm
1 Piece FD440R Mini TTA micro scissors, bayonet shaped, straight
1 Piece FD441R Mini TTA micro scissors, bayonet shaped, angulated
1 Piece FF579R Rongeur, 5x 14 mm
1 Piece FF587R Rongeur, 4x 14 mm
1 Piece FG853R Mini TTA punch, width 3 mm
1 Piece FG855R Mini TTA punch, width 5 mm
1 Piece FF422R Mini TTA hockey dissector, bayonet shaped, right
1 Piece FF423R Mini TTA hockey dissector, bayonet shaped, left
1 Piece FF424R Mini TTA graft holder, bayonet shaped, 170 mm
1 Piece BD614R Mini TTA forceps, surgical
1 Piece BD114R Mini TTA forceps, anatomical
1 Piece JF511 Wrapping drape, 140x 100 cm
1 Piece JG785B Identification label, red
Scalpel Handle
bayonet shaped

BB092R, working length 170 mm

Micro scissors
bayonet shaped

FD440R, straight
working length 180 mm

FD441R, angulated
working length 180 mm

FL448R, straight

FL449R, angulated

Osteotome
bayonet shaped

FL448R, straight

FL449R, angulated

FD440R, straight
working length 180 mm
Rongeur

**FF579R**, 5 x 14 mm

**FF587R**, 4 x 14 mm

Punch

**FG853R**
- width 3 mm
- jaws open 10 mm
- angulation 130°

**FG855R**
- width 5 mm
- jaws open 12 mm
- angulation 130°

Hockey Dissector

bayonet shaped

**FF422R**, right
- working length 160 mm

**FF423R**, left
- working length 160 mm
Graft Holder
bayonet shaped

FF424R,
working length 170 mm

Forceps
bayonet shaped

BD614R
toothed

BD114R
dissecting
working length 170 mm
3.3 Disposables (please order separately)

**Lung Retraction**

BV182P
Pump / tube system for mini TTA retraction balloon *

**Retraction balloon**

BV184P, size "S" *
BV185P, size "M" *
BV186P, size "L" *

**Fixation pin for diaphragm blade**

BV173S, size "S" **
BV174S, size "M" **
BV175S, size "L" **

** 5 pieces per box, individually sterile packed (gamma)
* 3 pieces per box, individually sterile packed (ETO)
3.4 Related instruments

Self-retaining retractor

Angular intra hand piece

GB521R
GB522R

Burrs

GD814R
Diamond Burr
Ø 3.1 mm

GD816R
Diamond Burr
Ø 6.0 mm

GD810R
Rosen Burr
Ø 3.1 mm

GD812R
Rosen Burr
Ø 6.0 mm

GD703R
Barrel Burr
Ø 5.0 mm

Small oscillating saw hand piece

GB128R
without saw blades,
with key GB 20

Double saw blade

GC660R
adjustable 16 – 26 mm
AESCULAP®

All it takes to operate.