



# Right infraaxillary thoracotomy approach for upper thoracic vertebral decompression and fusion at T2–T6 levels: a technical note

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## Abstract

**Purpose** Disorders of the upper thoracic spine can lead to serious disability and morbidity. However, operating on the upper thoracic vertebrae T2–T5 remains challenging because of the anatomical features of the thoracic spine. We describe a novel anterolateral upper thoracic approach, which is safe and reproducible and allows direct access to the upper thoracic spine from T2 to T6 inclusive, obviating the risk of damaging complex anatomical structures inherent in the anterior trans-sternal approach.

**Methods** Three patients with upper thoracic spinal-related spinal cord compression disease, presented with progressive thoracic myelopathy and upper back pain. Magnetic resonance imaging showed direct spinal cord compression due to upper thoracic vertebral destruction. In addition preoperative computed tomography also revealed vertebral erosion and collapse. The surgical management of the three patients involved decompression and reconstruction via the right infraaxillary thoracotomy approach, and fixation with a titanium mesh cage and an anterior plate in each.

**Results** Clinical outcome measures including pre- and postoperative radiographic parameters were assessed. There were no complications associated with this technique. The back pain and neural function gradually improved, and plate placement was achieved in all patients. None of the patients experienced clinical symptoms or screw loosening or breakage in this study.

**Conclusions** The technique described is a safe and novel right infraaxillary thoracotomy approach to provide direct access from vertebral bodies T2–T6 and to provide adequate room for upper thoracic vertebral decompression and fusion surgery. However, a suitable fixation implant should be designed.

**Graphical abstract** These slides can be retrieved under Electronic Supplementary Material.

**Key points**

1. anterolateral approach
2. upper thoracic vertebral decompression
3. fusion surgery

**Figure 1:** Operative positioning patients are positioned with the right-hand side elevated about 60°–90°. The dark line represents where the incision will be made (A) Semi-lateral position, (B) anterolateral incision, (C) vertebrectomy of T3, and (D) tantalum plate and cage inserted into T2/T4.

**Figure 2:** Preoperative MR image (A, B) and CT image (C), postoperative image (D, E, F).

**Figure 3:** Pictorial diagram describing this anatomic technique. The incision (A) and anatomy would come across (B) of right infraaxillary thoracotomy approach.

**Figure 4:** Another patient with thoracic tuberculous infection was treated via right infraaxillary thoracotomy approach. Preoperative CT image (A, B) and postoperative image (C and D).



**Keywords** Anterolateral approach · Upper thoracic vertebral decompression · Fusion surgery

**Electronic supplementary material** The online version of this article (<https://doi.org/10.1007/s00586-018-5686-x>) contains supplementary material, which is available to authorized users.

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## Introduction

Conventionally, the anterior trans-sternal approach (C4–T4) is useful for the treatment of a variety of upper thoracic (T1–T4) anterior column-related spinal pathologies, including infection, oncologic and traumatic lesions, which can lead to serious disability and morbidity [1–4]. However, with the increasing application of surgery, this technique is still challenging to perform on upper thoracic vertebrae down to T5 because of anatomical features including the aortic arch and great vessel block. To our knowledge, the posterior approach through costotransversectomy provides an indirect approach for accessing the rib head, neural foramen, pedicle, and anterolateral spinal canal. However, it is still difficult to decompress severe direct anterior spinal cord compression [5, 6]. And other direct upper thoracic vertebral approaches can be mainly divided into the high transthoracic approach (C6–T4), and the modified anterior approach (C3–T4) [7, 8]; however, using these approaches, it is not easy to decompress the spinal cord at the upper thoracic (T1–T4) level of the anterior column and difficult to create an adequate operative space because of the scapula block [3, 9, 10].

Consequently, the objectives of this study were firstly to report right infraaxillary thoracotomy, which usually use in minimally invasive cardiac surgery approach, which is also safe and reproducible and provides excellent direct access to the upper thoracic vertebral bodies (T2–T6); secondly, to highlight the technical challenges of this approach and approach-related complications; and third, to evaluate clinical outcomes using this surgical technique in three cases. We believe that the advantage of this anterolateral upper thoracic approach is not only the avoidance of unnecessary interference with the complex anatomical features associated with the anterior trans-sternal approach (C4–T4), but also the ability to avoid the scapula block of the high transthoracic approach (C6–T4).

## Materials and methods

Between September 2016 and February 2017, three patients (all male) with upper thoracic (T1–T4) anterior column-related spinal cord compression disorders (one metastatic, one eosinophilic granuloma and one spinal tuberculosis) presented with thoracic myelopathy and upper back pain. The patients' ages ranged from 9, 33 and 54 years (mean 32 years). All patients were treated by decompression and reconstruction via the upper right infraaxillary thoracotomy approach and then fixed with a titanium mesh cage and an anterior plate or thoracic anterior fixation system (which depend on vertebra body size in our hospital).

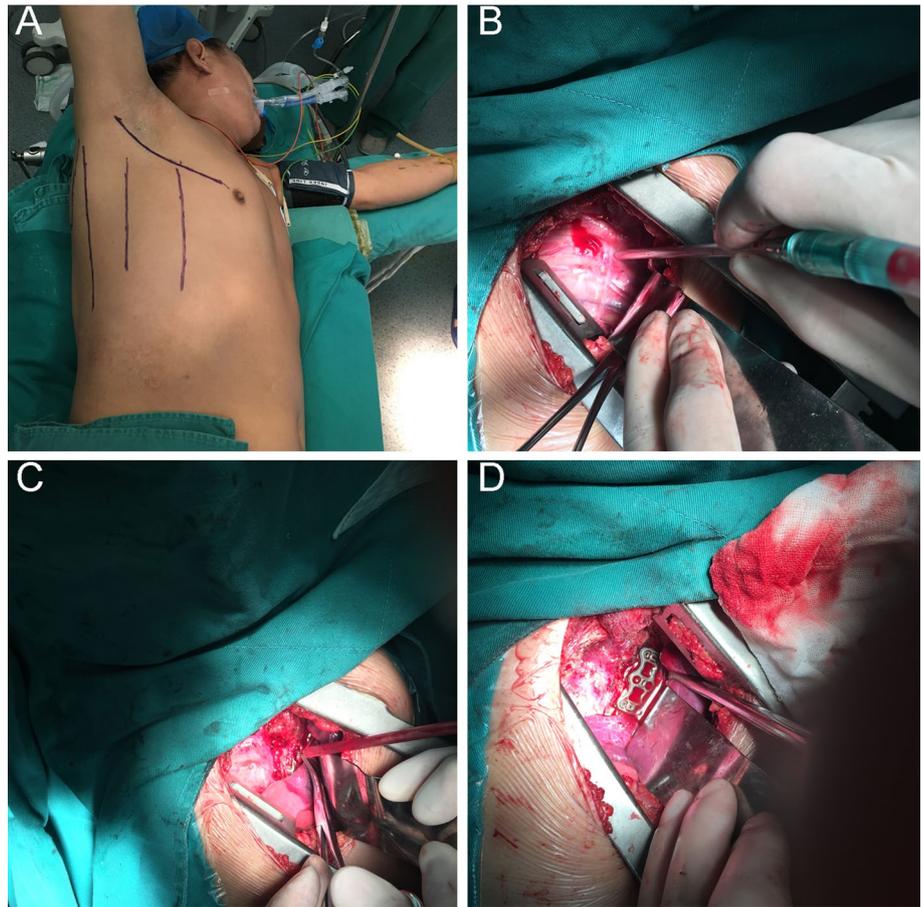
## Surgical technique

Using general anesthesia with differential lung ventilation, the patients were placed in a 70° left lateral position with a pillow beneath the left chest. The right upper arm was abducted anteriorly and the elbow flexed to 90°. The forearm of the patients was set in front of the face and held by a padded positioner bar (Fig. 1a). The right limb was placed in straps and taped to avoid scapula block and increase the space between the scapula and the pectoralis major, enhancing access and facilitating instrumentation. A right-sided approach was preferred as it was a safer distance from the thoracic duct and heart. All pressure areas were protected. An oblique 12 cm (posterior superior to anterior inferior) anterolateral incision was made from armpit to nipple an 8-cm skin incision along the edge of the pectoralis major muscle was made at the right anterior axillary line (Fig. 1a), centered over the levels of interest, the length determined by the size of thorax. A thoracotomy incision was made through the third or fourth intercostal space. The front saw serratus anterior was split between the latissimus dorsi and the pectoralis major, and an incision was made over the rib corresponding to the involved vertebra. The rib was removed or retracted to expose the lung. The upper thoracic vertebrae were carefully exposed, and segmental vessels and hemiazygos veins [11] over the vertebral body were ligated, to allow adequate exposure for debridement and grafting (Fig. 1b). The disk spaces above and below the target vertebra were identified, and rongeurs and curets were used to remove the vertebral body and disk to obtain spinal cord decompression (Fig. 1c). An appropriately sized titanium mesh cage with suitable autologous bone grafts was then implanted, and complete interbody fusion was achieved with an anterior cervical titanium plate system (Fig. 1d). Finally, a deep drainage tube was put in place and the incision closed in layers in the standard fashion (Fig. 2a, b).

## Results

Anterolateral approaches for upper thoracic vertebral decompression and fusion were performed successfully in all three patients (Fig. 3). The operation time was 70–120 min (mean 87 min), and none of the patients experienced blood loss exceeding 200 mL. All of the patients (Fig. 4a–d) were followed up for an average of 8 months (range 7–11 months), and no surgery-related complications had occurred in any of the patients by the last follow-up, such as dysphagia, chylothorax, screw loosening or breakage. Satisfactory pain relief, partial neural function recovery and good screw placement were achieved in all patients by the final follow-up.

**Fig. 1** Operative positioning patients are positioned with the right-hand side elevated about 60°–90°. The dark line represents where the incision will be made **a** Semi-lateral position, **b** anterolateral incision, **c** vertebrectomy of T3, and **d** tantalum plate and cage inserted into T2/T4



## Discussion

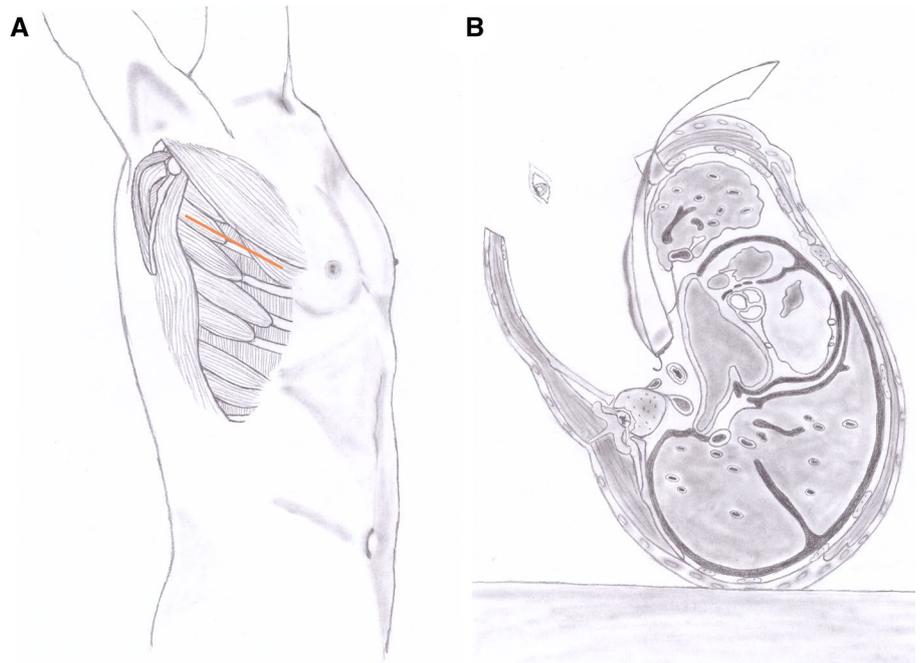
The value of the anterior approach to the spine in providing greater access and better outcomes of lesions affecting the vertebral body has been amply demonstrated. A variety of approaches have been used for upper thoracic vertebrae. In the anterior trans-sternal approach (C4–T4) widely used to treat challenging upper thoracic spine disorders, adequate exposure is always hindered by many vital structures, including the great vascular and thoracic duct [12–14]. However, the extensive dissection and exposure associated with the approach increases patients' risk of injury to adjacent blood vessels and thoracic duct, if the spine surgeon is not be familiar with it [9, 15–17].

Upper thoracic vertebral body-related disease may cause complications such as spinal cord compression-related neurological deficit, spine instability or kyphotic deformity, and conservative treatment has a poor effect in patients, so surgical treatment is always necessary [18–21]. Indications for surgery include severe back pain and/or neurological deficit in response to conservative treatment, neurological deficits associated with bone destruction, cold abscess, metastatic tumor and progressive deformity [22–25]. The aim of

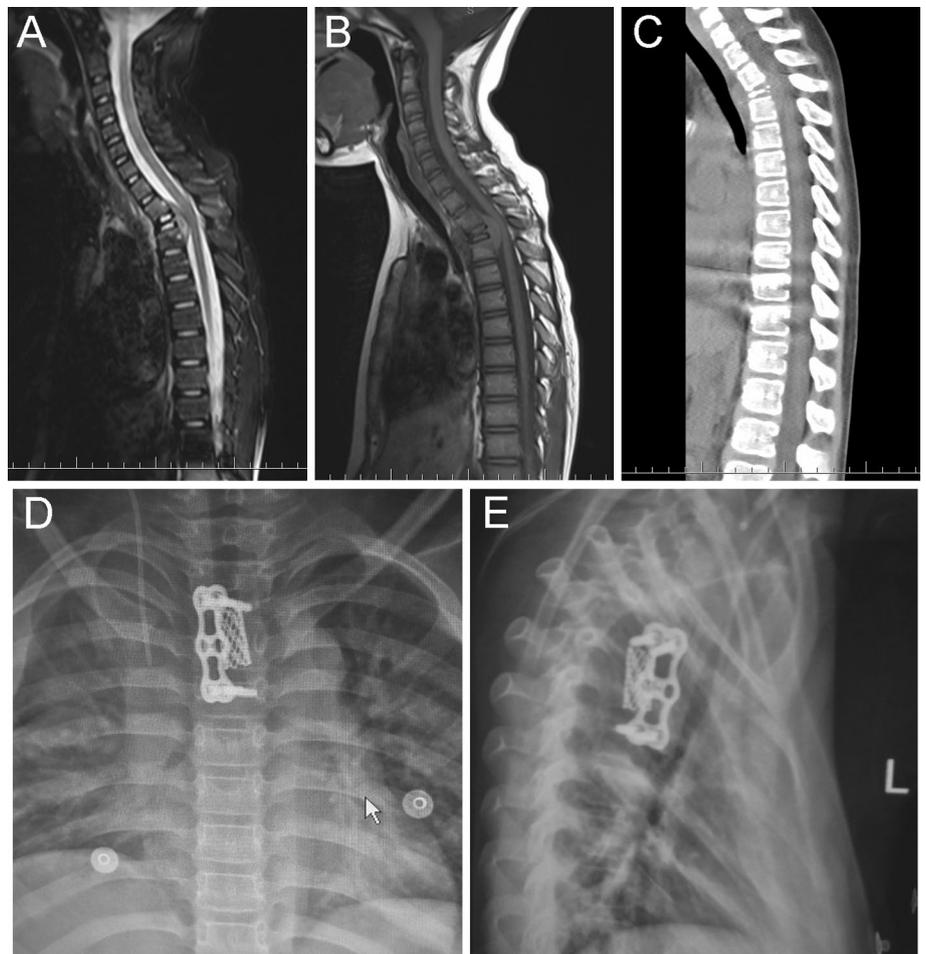
surgical treatment is radical debridement, decompression of the spinal cord and restoration of spinal stability.

In this study, three patients with upper thoracic vertebral body bone destruction underwent decompression and fusion through a right infraaxillary thoracotomy approach, and all of them achieved a good outcome. This indicates that the anterolateral upper thoracic approach provides safe and effective access for surgical treatment of upper thoracic vertebral body disease. This approach makes it easy to expose lesions at T2–T6 levels and to perform vertebrectomy and complete neurological decompression. At the same time, this approach can treat the lung adhesions caused by tuberculosis infection as well and avoid infection diffusing to healthy spinal posterior column. Moreover, this approach avoids the mediastinum, minimizing the risk of injury to the esophagus, pleura, recurrent laryngeal nerve, vagus nerve, and major vessels. We recommend the right-sided anterolateral upper thoracic approach, because this approach avoids injury to many vital structures, including the heart, hilum, and most importantly the thoracic duct during exposure. In the present study, no other complications occurred. However, some points should be emphasized and observed during surgery: We recommend removal of the 4th rib, exposure of the lung, and, as in the

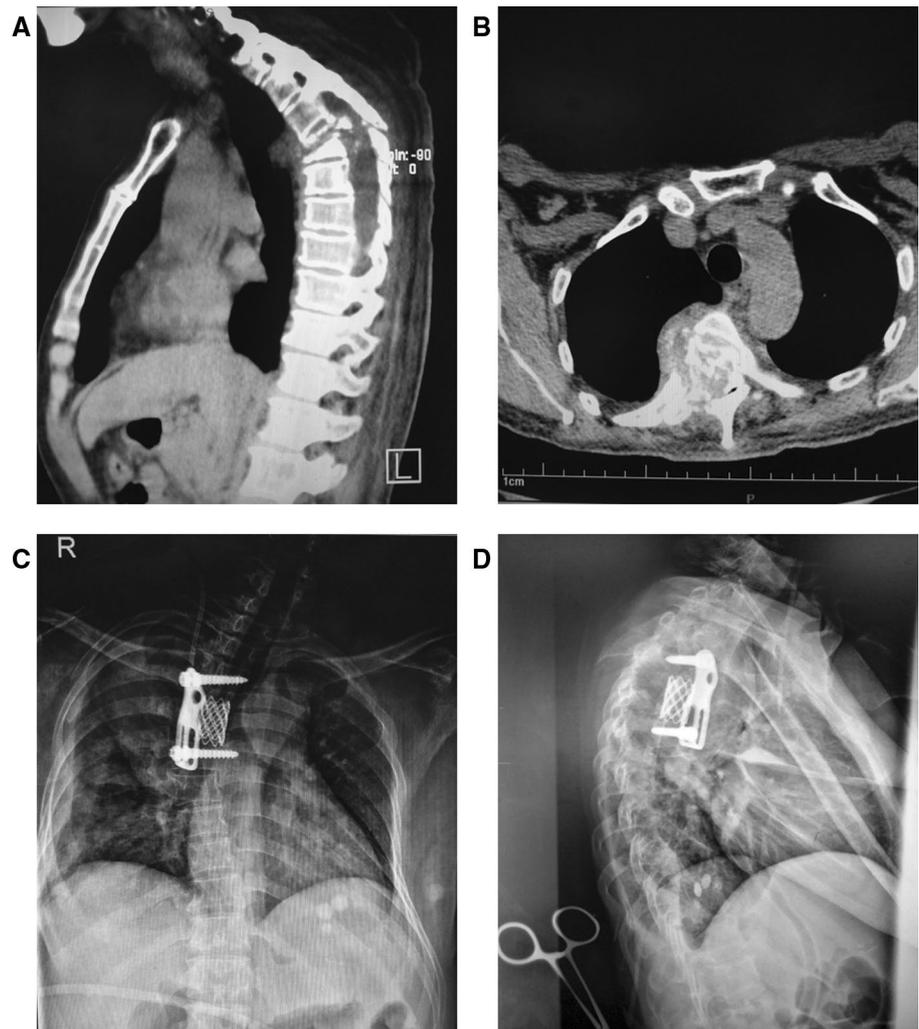
**Fig. 2** Pictorial diagram describing this anatomic technique. The incision (a) and anatomy would come across (b) of right infraaxillary thoracotomy approach



**Fig. 3** Preoperative MR image (a, b) and CT image (c), postoperative image (d–f)



**Fig. 4** Another patient with thoracic tuberculosis infection was treated via right infraaxillary thoracotomy approach. Preoperative CT image (a, b) and postoperative image (c, d)



transthoracic approach, exposure of the spine and division of the vertebral segmental vessels. Care should be taken during subperiosteal separation of the vertebral body to avoid injury to the left-sided thoracic duct.

Thoracoscope may provide a relatively ideal minimally invasive approach; however, thoracoscope learning may require a certain steep learning curve, and it is very difficult to handle pleural adhesions, adhesions as well as complete spinal cord decompression due to lesion adherent to the dura. Thoracoscopic technique was described by *Dickman* who also suggests that it is difficult to handle the upper thoracic vertebral lesions [26].

There are a number of limitations to this study, which must be considered before implementing any changes to existing practices. This was a single-surgeon, single-center, consecutive series. There was no control group or comparative group to assess the overall performance of our right infraaxillary thoracotomy approach compared to the existing anterior trans-sternal approach. Furthermore, so far, there is no suitable fixation implant for this approach.

However, this is the first retrospective clinical study of its kind to assess the safety and efficacy of this approach. Up to the final follow-up visit, none of the patients suffered from any neurological postoperative deterioration and there were no incidences of screw loosening or plate breakage. Consequently, we feel our approach would be reproducible in other spinal practices. We also feel that this surgical technique has a role to play in allowing more direct access to pathology affecting the upper thoracic vertebrae, providing immediate stability with instrumentation and, as a consequence, preserving neurological integrity and pain relief, maintaining alignment without deformity, and providing early mobilization.

In conclusion, our novel right infraaxillary thoracotomy approach to directly access pathology affecting upper thoracic vertebrae can safely expose the upper thoracic vertebrae and allows good visualization and adequate operating space for T2–T6; however, a suitable fixation implant should be designed.

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**Author's contribution** JL, SL, KH, XL, YS, KX and YT designed the study. JL, SL, KH, XL, YS, KX and YT were involved in acquisition of data. JL, SL, KH, XL, YS, KX and YT interpreted the data. JL, SL, KH, XL, YS, KX and YT were involved in manuscript preparation.

## Compliance with ethical statement

**Conflict of interest** All the authors declare that they have no conflict of interest.

**Ethics approval** Ethical approval was given by the Medical Ethics Committee of Youjiang Medical University for Nationalities.

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