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Basic Science

A quantitative analysis of posterolateral approaches to the ventral thoracic spinal canal

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Abstract

BACKGROUND CONTEXT: Various posterolateral approaches exist to access ventral thoracic spinal canal pathologies. Selecting the optimal surgical approach requires sound understanding of the exposure and working angle afforded by each approach.

PURPOSE: The purpose of this study was to quantify exposure of the ventral spinal canal with various posterolateral thoracic spinal approaches and to determine how regional anatomical differences affect measurements.

STUDY DESIGN: This is a quantitative anatomical cadaveric study.

METHODS: Four fresh cadaveric C7–L1 specimens were used with a saline infusion model to mimic in vivo thecal sac dimensions. Using stereotactic navigation, we measured exposure (expressed as percentage of total width) and maximum approach angle of the ventral spinal canal without thecal sac retraction after each surgical condition: laminectomy (L), 50% medial facetectomy (MF), transpedicular (TP), costotransversectomy (CTV), and lateral extracavitary (LE). The thoracic spine was divided into four regions (T1–T2, T3–T6, T7–T10, and T9–T12). A two-sided paired *t* test was used.

RESULTS: At T1–T2, visualized exposures were 25.8%, 31.5%, 42.3%, 45.1%, and 46.8%, respectively, after each surgical condition. Costotransversectomy and LE did not provide significant increase in exposure compared with the preceding condition. At T3–T6, exposures were 19.1%, 29.6%, 38.7%, 44.4%, and 44.5%, respectively. Only LE did not provide significant increase in exposure compared with the preceding condition. At T7–T10, visualized exposures were 17.9%, 30.6%, 39.9%, 44.9%, and 53.3%, respectively. All successive surgical conditions provided a significant increase in exposure. At T11–T12, visualized exposures were 14.2%, 25.8%, 43.1%, 47.7%, and 52.7%, respectively. Only LE did not provide a significant increase in exposure compared with the preceding condition. Each successive surgical condition provided a significantly increased lateral approach angle compared with the preceding condition, except LE at T1–T2. Maximum approach angle was more favorable at T1–T2 for L, MF, TP, and CTV compared with other thoracic regions.

CONCLUSIONS: Medial facetectomy and TP approaches provide significantly increased exposure of the ventral spinal canal at all thoracic regions. Costotransversectomy provided significantly increased exposure compared with TP at T3–T12. Lateral extracavitary only provided significantly increased exposure compared with CTV at T7–T10. The results of this study can be used preoperatively to determine the optimal approach based on quantitative

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The disclosure key can be found on the Table of Contents and at www.TheSpineJournalOnline.com.

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measurements and region-specific anatomical differences.

Keywords: Thoracic spine; Surgical approaches; Laminectomy; Transpedicular; Costotransversectomy; Disc herniation; Tumor; Vertebrectomy

Introduction

Ventral thoracic spinal pathologies such as tumors, infections, and disc herniations pose a challenge in surgical access given the surrounding rib cage, lungs, great vessels, and mediastinal structures [1,2]. Various surgical approaches to the ventral thoracic spinal canal have been developed to approach this area more safely including the anterior transthoracic, posterolateral transpedicular (TP), costotransversectomy (CTV), lateral extracavitary (LE), and minimally invasive variations [3–20]. Among the various posterolateral approaches, there have been numerous published clinical outcomes studies [4,5,10,21–26]. The optimal surgical approach is one that minimizes morbidity to both neural and extraneural structures. To date, there are no comprehensive quantitative studies comparing the exposure obtained by the various posterolateral approaches or assessing in a quantitative manner how regional anatomical differences in the thoracic spine affect exposure. A quantitative study would be of use to the spine surgeon in the process of selecting the optimal approach for a given thoracic ventral spinal canal lesion.

The purpose of this study was to measure the maximum approach angle and exposure of the ventral spinal canal obtained by various posterolateral approaches and to determine how regional anatomical differences in thoracic anatomy affect these measurements.

Methods

Materials and setup

Four fresh human thoracic specimens (C7–L1) free of any spinal disease or previous surgeries were used. Skin, subcutaneous fat, and paraspinal muscles were removed, with the intent that the optimal size and location of the incision should allow for unimpeded exposure only limited by bony anatomy. Variations in body habitus and incision location and size introduce too many variables that would preclude the ability to achieve our goal to measure the exposure and approach angle achieved by bony resection.

Microscrew fiducials (Stryker, Kalamazoo, MI, USA) were implanted at every thoracic level along the proximal rib and lamina bilaterally. Computed tomography scans with 1 mm slices were obtained and loaded into the navigational system (Stealth S7; Medtronic, Minneapolis, MN, USA). The specimen was then positioned on an immobile table and secured in place with a combination of several clamps. Navigation reference frame was fixed to the spine, microscrews were registered, and registration error was recorded. Before each subsequent surgical condition, navigational accuracy was reconfirmed before measurements.

Saline infusion model

The cranial and caudal ends of the thecal sac were dissected free. Intravenous tubing was inserted into the cranial end of the thecal sac and closed with 3-0 silk suture. The intravenous tubing was connected to an elevated saline bag. A ventricular catheter was inserted into the caudal end of the thecal sac and closed with another silk suture. This ventricular catheter was connected to an external drainage and monitoring system (Becker II; Medtronic) leveled with the thecal sac. Using this model, thecal sac inflation mimicking in vivo morphology and size was achieved with a pressure of only 2 to 3 cmH_20 (Fig. 1). At pressures more than this, there was no noticeable increase in thecal sac size. Attempts were made to achieve a pressure of 5 cmH_20, but this was not always achieved because of leakage.

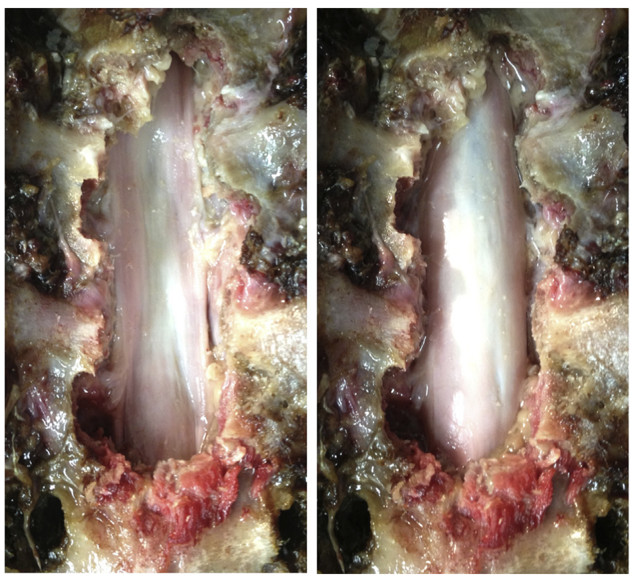

Fig. 1. Thecal sac before (left) and after (right) inflation using the infusion model at a pressure of 2 to 3 cmH_20.