Lateral parascapular extrapleural approach to the upper thoracic spine

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The upper thoracic vertebrae are difficult to approach surgically because of the narrowing of the thoracic inlet, the proximity of the brachial plexus, and the parascapular shoulder musculature. A novel lateral parascapular extrapleural approach to the upper thoracic vertebrae is described. The parascapular shoulder musculature (trapezius, levator scapulae, and rhomboid muscles) is reflected off the spinous processes to the scapula as a musculocutaneous flap, preserving the neurovascular supply. The paraspinal musculature is mobilized and retracted, and the upper dorsal ribs are removed with caution to avoid injury to the C-8 and T-1 nerve roots. The rami communicantes are transected, and the sympathetic chain is displaced anterolaterally. The T2–4 vertebrae can be approached unobstructed. The T-1 nerve root obstructs posterolateral access to the T-1 vertebra, necessitating an inferolateral approach underneath the T-1 nerve root axilla.

Four patients with compressive myelopathy from upper thoracic vertebral metastases underwent neural decompression, vertebral reconstruction, and posterior spinal fixation with this approach. Their postoperative neurological status was either unchanged or improved. Complications included radiographic pleural effusion and superficial wound dehiscence; one patient required posterior spinal reinstrumentation for progressive kyphosis. One patient developed pneumonia 7 days postoperatively which was unresponsive to appropriate treatment.

It is believed that the anatomical limitations to this region have been overcome, and that excellent exposure of the T1–4 vertebrae for neural decompression and vertebral reconstruction can be performed safely. A major advantage is that posterior spinal fixation can be carried out simultaneously.

Key Words: thoracic spine · surgical approach · spinal neoplasm · spinal stabilization

The thoracic spine remains a challenge to approach surgically because of the small spinal canal, encasement by the thoracic cage, and the pleural and mediastinal cavities. The middle thoracic vertebrae (T5–10) have been reached successfully using either a lateral extracavitary approach as described by Larson, et al.,4 or a transthoracic approach. The costotransversecotomy approach has been used for anterolateral thoracic disc herniations and limited posterolateral vertebral decompression.

The upper thoracic vertebrae (T1–4) present unique anatomical challenges to obtaining surgical access. The thoracic cage narrows to reach the thoracic inlet, resulting in intimate associations between the superior mediastinal structures and the vertebral column. Techniques that have been described to expose these vertebrae include the supraclavicular,5,10 transmanubrial,3,11 and transthoracic (through the third rib)4,6,9 approaches. All of these give excellent access to a limited part of the upper thoracic spine but none provides access to all of the vertebrae.

We describe a lateral parascapular extrapleural approach to the upper thoracic spine which allows excellent exposure of each vertebra for neural decompression, corpectomy, and vertebral reconstruction, and allows simultaneous posterior spinal fixation. This is an anatomically guided procedure; an in-depth description of the anatomical considerations will be presented in a separate paper (DD Dietze, et al., in preparation).

Clinical Material and Methods

Case Material

Four patients with compressive myelopathy from upper thoracic vertebral metastases underwent neural decompression, vertebral reconstruction, and posterior spinal fixation. These patients (two men and two women) were in good general health and ranged in age
from 46 to 63 years. Each patient presented with complaints of progressive neurological decline in sensation or strength, or with increasing pain. Neuroradiographic evaluation, including plain spine roentgenograms, magnetic resonance imaging with and without gadolinium enhancement, and selected computerized tomography scans showed destructive lesions of the vertebrae with anterior extradural spinal cord compression (Fig. 1).

All patients had known primary cancers: parotid acinar-cell adenocarcinoma, renal-cell carcinoma, or breast carcinoma; one patient had three primary carcinomas (nasopharyngeal, prostate, and undifferentiated small-cell carcinomas). The patient with known breast cancer had previously been treated empirically with chemotherapy and external beam irradiation, and the patient with multiple carcinomas had previously received external beam irradiation. Progressive neurological decline prompted surgical intervention. The pathological diagnosis was consistent with the known primary tumor in all but one case where a metastatic adenocarcinoma was found in a patient with known renal-cell carcinoma.

Surgical Procedure

Anesthesia and Positioning. General anesthesia is used with a double-lumen endotracheal tube inserted under endoscopic guidance to allow selective lung collapse during the operation. The patient is positioned prone on chest roles with arms tucked to the side. All patients wear Foley whole-leg pneumatic stockings, and an arterial line and appropriate large-bore intravenous access line are placed intraoperatively. All patients receive an intraoperative intravenous antibiotic (1 gm oxacillin) and steroid bolus (10 mg dexamethasone). Somatosensory evoked potential monitoring is performed continuously throughout the operation.

Skin Incision and Musculocutaneous Flap. The entire posterior aspect of the neck and back from the nuchal line to the intergluteal fold is prepared for surgery. A midline incision is made extending from three spinous processes above to three spinous processes below the level of the lesion, which is then curved gently to the scapular line on the side of the desired surgical approach (Fig. 2). This incision is made to the deep fascia with minimal subcutaneous undermining.

The deep fascia is incised over the spinous processes and sharply dissected off them so that the trapezius muscle can be identified. The trapezius and rhomboid muscles are then dissected off the spinous processes in the subperiosteal plane, while the muscle layers are identified on edge as they are stripped. The interspinous ligaments are left intact. A plane of loose areolar tissue is located between these shoulder muscles and the muscles of the back proper, which permits blunt dissection with the surgeon's finger. The skin and trapezius and

![Fig. 1. Preoperative sagittal (left and center) and axial (right) T1-weighted magnetic resonance images demonstrating a destructive lesion of the T-4 vertebra with ventral extradural thecal sac compression and right posterolateral extradural extension.](image-url)

![Fig. 2. Illustration of the surgical incision for an approach from the left side to a pathological process of the upper thoracic vertebral region. Note the superficial landmarks: C-7 spinous process, superior (Sup.) scapular angle (T-3), and inferior (Inf.) scapular angle (T-7).](image-url)
rhomboid muscles are reflected together toward the medial border of the scapula as a musculocutaneous flap. The inferior fibers of the trapezius muscle must be transected in order to reflect this flap, and care is taken to leave a cuff of identifiable muscle for reapproximation at wound closure. Also, care is taken to protect the superior fibers of the latissimus dorsi muscle while transecting the inferior fibers of the trapezius muscle. Reflection of the musculocutaneous flap is limited by the superior and lateral extents of the skin incision and the medial border of the scapula. The medial border of the scapula falls laterally with mobilization of the trapezius and rhomboid muscles. This provides the surgeon with an excellent exposure of the upper dorsal rib cage and dorsal vertebral elements (Fig. 3A).

Generally, when the musculocutaneous flap is turned, a thin quadrilateral muscle superficial to the thoracolumbar fascia is also reflected. This is the serratus posterior superior muscle, which has an obscure function but is believed to assist in lifting the posterior rib cage during inspiration.

**Exposure of the Dorsal Rib Cage and Spinal Elements.** The deep cervical fascia and thoracolumbar fascia cover the splenius and erector spinae muscles of the back proper, which are completely dissected off the spinal processes and dorsal spinal elements subperiosteally. This paraspinal muscle mass is mobilized and retracted dorsally and medially over the spinous processes to give direct lateral exposure of the dorsal spinal elements (Fig. 3B).

**Opening of the Thoracic Cage.** The thoracic cage is opened dorsally by removing two or three ribs from their costotransverse and costovertebral articulations to the posterior bend of each rib. The ribs to be removed are chosen to give maximum exposure of the pathological vertebral. To expose a vertebral body, the corresponding rib and the rib below must be removed (thus, to expose T-3, the third and fourth ribs must be removed); to allow adequate working room a third rib, generally the next lower, can be removed. The same strategy is applied in the case of disease at multiple levels.

Intraoperative fluoroscopy is used to verify the ribs appropriate for removal. The intercostal muscles and neurovascular bundles are stripped subperiosteally off the ribs. The costotransverse and costovertebral ligaments are excised to free the rib head and neck. The ipsilateral lung is collapsed to minimize the risk of pleural injury. The dorsal rib is cut as far laterally as possible, generally just lateral to the posterior bend and, with the cut end protected, the rib head and neck are worked free. Further sharp excision of the superior costotransverse and radiate ligaments is generally required to free the rib head and neck. The rib is removed in toto and is soaked in antibiotic solution for possible use as an intervertebral strut or posterior fusion graft.

The intercostal neurovascular bundles are dissected free, and the intercostal muscles are removed. The intercostal veins are sacrificed, and the intercostal nerves and arteries are ligated and transected, leaving the sutures long for later retraction.

**Lateral Vertebral and Thecal Sac Exposure.** The intercostal nerves and arteries are traced to the vertebral foramen. The sympathetic chain and posterior intercostal vasculature are identified on the lateral vertebral surface. The rami communicantes are transected and the segmental vasculature is sacrificed. The sympathetic chain is displaced anterolaterally in a subperiosteal dissection revealing the vertebral body, pedicle, and foramina. The pathological process becomes clearly visible and a biopsy is sent for pathological identification. Before tumor removal, the posterolateral thecal sac is identified after removal of the transverse processes, lamina, and pedicles with a high-speed drill. The nerve roots serve as an invaluable guide for decompression and for avoidance of dural injury. Direct visualization of the neural elements is always possible (Fig. 3C). After posterolateral decompression, the lung may be re-expanded for a short time, and the hip graft can be taken for posterior spinal fusion.

**Tumor Removal and Vertebral Reconstruction.** The lung is collapsed and protected with a moist lap. The tumor is removed and complete corpectomy(ies) performed. Depending on the pathology, this can be performed with either a high-speed drill or curetage. The anterior longitudinal ligament and, if possible, the posterior longitudinal ligament are preserved and serve as protective barriers to the thecal sac and superior mediastinal structures (Fig. 3D). Vertebral reconstruction is performed using a rib graft strut if the pathological process is benign (for example, in cases of infection or compression fracture) or using Steinmann pins and methyl methacrylate if the pathological process is malignant (Fig. 3E). The nerve roots are ligated proximal to the dorsal root ganglion and the nerve is removed with the dorsal root ganglion. Ligation of the spinal nerves proximal to the dorsal root ganglion should prevent neurinoma formation and postoperative neuralgia.

Appropriate posterior spinal fixation is performed using a fixed, semirigid rectangular system which allows both axial and transverse corrective forces (Cotrel-Dubousset or Texas Scottish Rite Hospital instrumentation). An autologous hip graft is used for posterior spinal fusion (Fig. 3F).

**Wound Closure.** Prior to wound closure the operative field is filled with saline to check for evidence of an air leak. If an air leak is present, a small (No. 22 or 24 French) chest tube should be placed and brought out percutaneously in a posterolateral position below the incision. The wound is then copiously irrigated with antibiotic solution and inspected for any bleeding. Two Hemovac drains (No. 5 French) are placed; one is placed alongside the vertebral reconstruction and

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*J. Neurosurg.* Volume 75 / September, 1991 351
FIG. 3. Operative drawings illustrating the procedure. A: Reflection of the musculocutaneous flap consisting of skin, subcutaneous fascia, and the trapezius and rhomboid muscles (M's). The medial border of the scapula falls laterally with this mobilization, providing excellent exposure of the dorsal rib cage and dorsal vertebral elements. Note the identifiable cuff of inferior fibers of the trapezius muscle left to allow approximation at wound closure. B: Mobilization and retraction of the paraspinal muscle mass dorsally and medially over the spinous processes providing direct lateral exposure of the dorsal spinal elements. The quadrilateral area of thoracic cage, outlined with broken line, will be removed to gain exposure of the vertebral bodies. C: The surgeon's operative view of T2-3 vertebral pathology through the thoracic cage when the second, third, and fourth ribs are removed. The rami communicantes are transected, and gentle retraction of the intercostal nerves exposes the anterolateral thecal sac. The superior mediastinal structures are anterior to the vertebrae, and the ipsilateral lung is collapsed to assist in exposure. D: Operative field after neural decompression and corpectomy. The anterior longitudinal ligament is preserved as a protective barrier to the superior mediastinal structures, and the posterior longitudinal ligament is preserved if it is not involved with the pathological process. The sympathetic chain is preserved by displacing it anterior to the vertebral bodies. The thecal sac and neural elements are visualized at all times during decompression. E: Operative field demonstrating the vertebral reconstruction using Steinmann pins. Methyl methacrylate will be used to reconstruct the vertebral body. Note that the spinal nerves are sacrificed proximal to the dorsal root ganglion to avoid neurinoma formation. F: Operative field after methyl methacrylate vertebral reconstruction demonstrating posterior segmental fixation using Cotrel-Dubousset instrumentation. An autologous hip graft will be placed for posterior spinal fusion.
Lateral extrapleural approach to the thoracic spine

Examination. Physical examination disclosed bilateral mastectomy defects and disuse atrophy of the right trapezius and rhomboid muscles with associated minimal weakness of neck extension. Neurological examination showed dysesthesias of the lower extremities, 4/5 weakness of the antigravity muscles, and bilateral Babinski signs.

Operation. Neural decompression and tumor resection was accomplished via T-2 and T-3 corpectomies. Vertebral reconstruction was performed using Steinmann pins and methyl methacrylate, and posterior spinal fixation was performed using Cotrel-Dubousset instrumentation and autologous iliac crest bone graft. A right-sided lateral parascapular extrapleural approach was utilized without complication. The pathological diagnosis was poorly differentiated carcinoma. Continuous intraoperative somatosensory evoked potentials remained stable. Intraoperative blood loss was 1500 cc, and the operative time was 10 hours.

Postoperative Course. The patient’s neurological examination was objectively unchanged, but she considered that her pain and motor strength were improved. Extubation occurred within 24 hours after surgery, and Hemovac drains were removed at 48 hours. A clamshell orthosis was fitted and she was transferred to the ward on postoperative Day 4, at which time mobilization and aggressive physical therapy was begun. On postoperative Day 5 it was noted that the wound margins appeared dusky. The wound was treated with hyperbaric oxygen, but on postoperative Day 7 a small superficial dehiscence (about 4 cm in length) occurred. There were no signs of infection. The wound dehiscence was successfully treated with wet-to-dry dressings, and the patient was discharged home on postoperative Day 10. Follow-up appointments in the clinic over 6 months have revealed complete wound closure without evidence of infection, and with resolution of her dysesthesias. Her motor strength remains unchanged.

Operative Results

Postoperative Examination

The postoperative neurological examinations of the four patients treated with this approach were objectively unchanged from the preoperative baseline. However, all believed that their sensation was much improved and their pain markedly lessened. Three patients were discharged from the hospital ambulatory and self-supportive by postoperative Day 10. The average follow-up period for these patients was 7 months (range 5 to 10 months).

Blood Loss

Intraoperative blood loss averaged about 2 liters as a result of slow continuous loss from the mobilized muscles, tumor corpectomy and iliac crest, posterior spinal element decortication, and tumor removal over a 10- to 12-hour period. No acute blood loss occurred at any

Illustrative Case

This 53-year-old black woman presented with bilateral lower-extremity pain and right-sided lower-extremity weakness. On neuroradiographic imaging she was found to have destructive lesions of the T-2 and T-3 vertebrae (Fig. 4). Medical history revealed bilateral breast carcinoma, which had been treated empirically with chemotherapy followed by external beam irradiation. Her lower-extremity weakness continued to progress slowly, and she was transferred for further evaluation. Her medical history was also pertinent for insulin-dependent diabetes.

Fig. 4. Postoperative plain roentgenograms, anteroposterior (A) lateral (B) views, demonstrating Cotrel-Dubousset posterior spinal instrumentation with corrected vertebral alignment.
time during surgery, but the most significant loss took place during removal of the tumor. Epidural venous bleeding was not a problem, as reported by Larson, et al.7 All patients received appropriate intraoperative and postoperative transfusions of packed red blood cells, fresh frozen plasma, and platelets. The average postoperative Hemovac drainage over 48 hours was 500 cc. Close hemodynamic monitoring and coagulation profiles were performed in the intensive care unit. No patient developed a coagulopathy, and no patient has developed hepatitis or acquired immunodeficiency syndrome.

Complications and Mortality

All four patients had some radiographic pleural effusion immediately postoperatively. This finding was not clinically significant, with the possible exception of a transient mild hypoxia in one case. All patients were extubated within 24 hours. One patient (presented above), an insulin-dependent diabetic who had a previously irradiated operative field, developed a small superficial wound dehiscence on postoperative Day 7 without associated wound infection. This wound dehiscence healed with conservative care and a short course of hyperbaric oxygen. Another patient developed acute bilateral pneumonia that was unresponsive to aggressively intensive management and led to a fatal outcome. This was unanticipated as his condition had been remarkably stable for the first 3 postoperative days. Autopsy findings showed bilateral acute and subacute fulminating pneumonia of the lower lobes and the right upper lobe. There was no evidence of pulmonary embolus or myocardial infarction.

Potential complications that did not occur included wound infection, incomplete neural decompression, vertebral reconstructive graft expulsion, esophageal erosion, chest wall and mediastinal arm hagialysis, postoperative intercostal neuralgia, Horner’s syndrome or sympathopathy, C-8 and T-1 nerve root deficits, lower brachial plexus trunk deficit, functional shoulder deficits, vascular spinal cord injury, cerebrospinal fluid leak, pneumothorax, and paradoxical thoracic cage respiratory movements.

One patient developed progressive kyphosis over three segments of fixation with sublaminar wire stabilization. This system probably failed because it did not span enough segments to decrease the transverse forces on the sublaminar wires thus preventing fatigue. Biomechanical studies have shown that a system providing both axial and transverse corrective forces allows the greatest correction of kyphosis with the least risk of instrumentation fatigue or failure.12-14 Cotrel-Dubousset and Texas Scottish Rite Hospital instrumentation using pedicle screws and lamina and transverse process hooks are versatile systems for posterior spinal instrumentation, providing both axial and transverse corrective forces. Five-segment fixation is employed incorporating two segments above and two segments below the pathological lesion. For T-1 or T-2 lesions, the posterior spinal instrumentation extends up to the C-6 or C-7 level, respectively. In these unique situations, sublaminar wires are used to stabilize the posterior spinal instrumentation at the C-6 and C-7 levels. With this modified fixation system, this patient with progressive kyphosis has since done exceptionally well (Fig. 4).

Discussion

Surgical access to the upper thoracic vertebrae remains a technical challenge because of the anatomy of the superior mediastinum, the compactness of the thoracic inlet, and the limitation imposed by the shoulder musculature. Fortunately, pathological processes to this area are uncommon, but the occurrence of thoracic spinal metastasis has increased (up to 10% of spinal metastases7). Other pathological processes involving the thoracic vertebrae are bacterial and tuberculous infections, primary bone tumors, meningeal tumors, vascular malformations, primary bone disease (with pathological fractures), congenital connective-tissue/skeletal disorders (the mucopolysaccharidoses), and traumatic vertebral fractures. Such disorders commonly cause compressive myelopathy. Neural decompression and spinal reconstructive surgery to the upper thoracic spine should be a part of the neurosurgeon’s repertoire.

We describe a novel lateral parascapular extrapleural approach to the upper thoracic spine. This technique is an anatomically guided approach, which minimizes the risks of a functional shoulder deficit or injury to the lungs and superior mediastinal structures, and allows direct exposure for neural decompression, removal of the pathological process, vertebral reconstruction, and posterior spinal fixation in a single surgical procedure. This technique has evolved from previous surgical experience with Pott’s disease,1,2,3 and the lateral extracavitary approach described by Larson, et al.7

The complications in the four patients treated with this approach include one superficial wound dehiscence and one death from pneumonia; both occurred in high-risk patients. Wound complications (including effusion, dehiscence, and infection) and pneumonia associated with respiratory distress syndrome and death, have been reported with the lateral extracavitary approach. The potential risks of pneumothorax, T-1 nerve root injury, Horner’s syndrome, sympathectomy, and intercostal neuralgia did not occur. These complications have been reported with transmanubrial and transthoracic approaches. The lateral parascapular extrapleural approach avoids the superior mediastinal structures that are manipulated with the other approaches, and avoids recurrent laryngeal nerve palsy as reported from anterior approaches. No shoulder morbidity occurred from partial mobilization of the scapula. We believe that this procedure can be performed safely with less anatomical risks than other approaches to the upper thoracic vertebrae.

The lateral parascapular extrapleural approach provides excellent exposure of all the upper thoracic ver-
Lateral extrapleural approach to the thoracic spine
tebrae (T1–4) for neural decompression, corpectomy, and vertebral reconstruction, and has the added advantage of allowing simultaneous posterior spinal fixation. All patients undergoing multiple hemilaminectomies or corpectomies with vertebral reconstruction by means of this procedure (which also disrupts the dorsal support of the thoracic cage) should undergo posterior spinal fixation to prevent progressive kyphosis and preserve maximum neurological function. Multilevel disease is not a contraindication to this approach. However, it is difficult to manage disease extending into the C-7 vertebra, which is better approached by a transmanubrial exposure. The disadvantages of the procedure described here are the prolonged surgery (10 to 12 hours) and blood loss (approximately 2000 cc). A detailed discussion of the anatomy and the relative merits of this, the transmanubrial, and the transthoracic approaches for diseases of the upper thoracic spine will be provided elsewhere (DD Dietze, et al., in preparation).

References

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