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Original Article

Modified lateral extracavitary approach for vertebral column resection and expandable cage reconstruction of thoracic spinal metastases

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Abstract

Background: Spinal metastasis is common and can be associated with considerable morbidity. Vertebral resection and reconstruction have been shown to preserve neurological function and decrease pain. Most commonly, two-stage, combined anterior/posterior approaches are performed to surgically address significant vertebral metastasis. Recently, single-stage posterior approaches for vertebrectomies have been performed more often as a result of advances in instrumentation and anesthesia. The objective is to describe a series of patients with metastatic thoracic spine tumors who were treated using a modified, lateral extracavitary approach for a posterior-only vertebral column resection and expandable cage reconstruction.

Methods: A retrospective analysis of 21 cases and 20 patients was performed.

Results: The average estimated blood loss and length of surgery were 1700 ml (range, 200–7600 ml) and 6.8 h (range, 4–9 h), respectively. The mean follow-up was 14 months (range, 4–30 months). One patient had a permanent neurological deficit as a result of a postoperative hematoma. Of the five patients who were unable to walk prior to surgery, two regained the ability to ambulate. The total complication rate was 43% with majority being minor. A total of 94% of patients had durable preservation of the neurological function.

Conclusion: The posterior approach for vertebral column resection and reconstruction is a viable alternative to the standard combined approach. We demonstrate the feasibility of performing the lateral extracavitary approach through a midline incision from T1 to T12. This less invasive approach continues to evolve as instrumentation becomes more advanced and possesses significant advantages in the oncologic setting.

Key Words: Lateral extracavitary approach, metastasis, spine, vertebrectomy

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INTRODUCTION

Spinal metastasis causes significant morbidity in 5%–10% of patients with cancer. Improved imaging techniques and an increased use of surveillance imaging have led to earlier diagnoses of spinal metastases which allow for minimally invasive treatments such as radiation therapy and kyphoplasty. Still, approximately 25,000 patients per year in the United States present with extensive spinal involvement and resultant spinal cord compression or instability.[7] These patients remain a therapeutic challenge, with surgery as a necessary component of their management.

The ideal technique for spinal cord decompression remains poorly defined due to a dearth of prospective data. However, it is clear that isolated laminectomies are not adequate. In a randomized controlled trial, Young *et al*.[37] and Shen *et al*. demonstrated that patients who underwent isolated laminectomies had outcomes no better than those who were treated with radiation alone.[12,14,15,23] In retrospect, this result comes as no surprise because the spinal cord is usually compromised anteriorly, as the epidural extension often arises from the vertebral body. In these situations, circumferential decompression would then seem to be optimal. In fact, Patchell *et al*. provided Class 1 data supporting the approach of vertebrectomy followed by radiotherapy for spinal metastases with spinal cord compression.[16,18,29]

In Patchell's landmark study, the anterior resection was performed using a separate approach, other than the one used for the laminectomy and pedicle screw fixation. These combined approaches can be daunting because of the long duration of the procedure and associated morbidity of anterior or lateral approaches to the upper thoracic and lumbosacral regions.[1,20,28,32] To decrease the morbidity of circumferential resection, single-stage, posterior approaches for vertebrectomies have been developed. However, experience is limited as these procedures have been regarded as technically difficult.[32]

We describe here our experience with posterior-only, single-stage vertebral column resection in 18 patients. To our knowledge, this is the largest single-institution study in which the lateral extracavitary approach followed by expandable cage reconstruction was used to treat spinal oncologic pathology. Furthermore, we demonstrate the feasibility of using this technique in the upper spine. We hypothesized that advantages to this approach include decreased invasiveness, and duration of surgery.

MATERIALS AND METHODS

Patients

This study was a single-institution consecutive case review of 21 patients with a wide range of spinal oncologic pathology, who were treated with posterior-only, single-stage vertebral column resection and expandable cage reconstruction. The patients, 7 women and 13 men, were treated between January 2008 and December 2010. The neurologic status was classified using the American Spinal Injury Association (ASIA) impairment scale. Pre- and postoperative neuroimaging was done in all cases which included preoperative CT, MRI, and radiographs, with postoperative CT scans for each patient [Figure 1]. Postoperative radiation was performed after suture removal at approximately 3 weeks.

The indications for all patients were the presence of spinal cord compression and/or spinal instability. Patients with hematological malignancies, not having received radiation, were excluded. In spinal metastatic disease, operative intervention is purely palliative; as such, it is imperative to consider lifespan and tumor histology. The literature supports the decompression of spinal cord compression for patients with greater than 3-month survival; we generally use survival greater than 6 months as our criterion.

Operation

Preoperative spinal embolization was not performed for any of our procedures. A modified lateral extracavitary approach was used in all cases and anterior reconstruction was performed with *in situ* expandable cages (Globus, Stryker). In brief, patients underwent general anesthesia and were placed on a radiolucent operating table in the prone position. A posterior midline incision (a deviation from the classical lateral extracavitary approach) was used to expose the relevant lamina and facets [Figure 2 a-g]. Laminectomies were then performed at the level of the vertebrectomy and at the level above. The superior and inferior facets of the vertebrectomy level were drilled away. The inferior facet of the level above and the superior facet of the level below were also removed without damaging the attached pedicles. By removing these structures, the relevant disc spaces, pedicles, and nerve roots were fully exposed.

When considering the potential sacrifice of a thoracic nerve root, it is important to be cognizant of the level and the no. of levels. The T1 nerve root must be preserved due to hand innervations. We sacrifice unilateral thoracic nerve roots for single-level vertebrectomies without preoperative angiogram. If multiple levels are required or if operating in the thoracolumbar region, we obtain spinal angiography to attempt visualization of the artery of Adamkiewicz. All patients receive electrophysiological neuromonitoring.

The lateral extracavitary approach is usually performed on the right side to avoid the aorta. Approximately 2 cm of the rib distal to the transverse processes of the level of the vertebrectomy as well as the rib at the level below were exposed. The transverse processes at those levels were then removed. At approximately 1.5 cm, distal to the lateral tip of the resected transverse processes, a plane was developed between the pleura and the rib. The proximal ribs could then be removed in a piecemeal fashion. Of note, a Cobb elevator was often useful to dissect the tissue away from the rib head and lateral vertebral body. The removal of the rib heads exposed the lateral aspect of the disc space above and below.

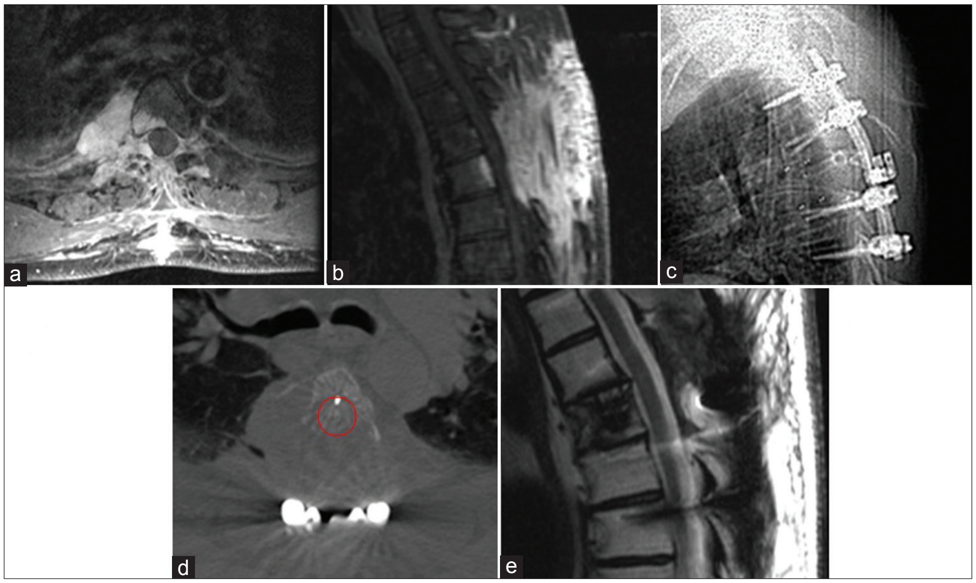

Figure 1: Preoperative and postoperative images of a patient with a recurrent T5 hemangioendothelioma who underwent T5 corpectomy and reconstruction. (a) Preoperative axial MRI images with gadolinium reveal spinal and paraspinal enhancement representing recurrent tumor and postsurgical effects. (b) Preoperative sagittal MRI images. (c) Lateral CT scout view revealing pedicle screw instrumentation. The expandable PEEK cage is radiolucent. (d) Axial CT at the level of the corpectomy illustrates partial corpectomy, cage (red outline) with the bone graft placed anteriorly. (e) Postoperative T2 sagittal MRI shows adequate decompression of the spinal cord

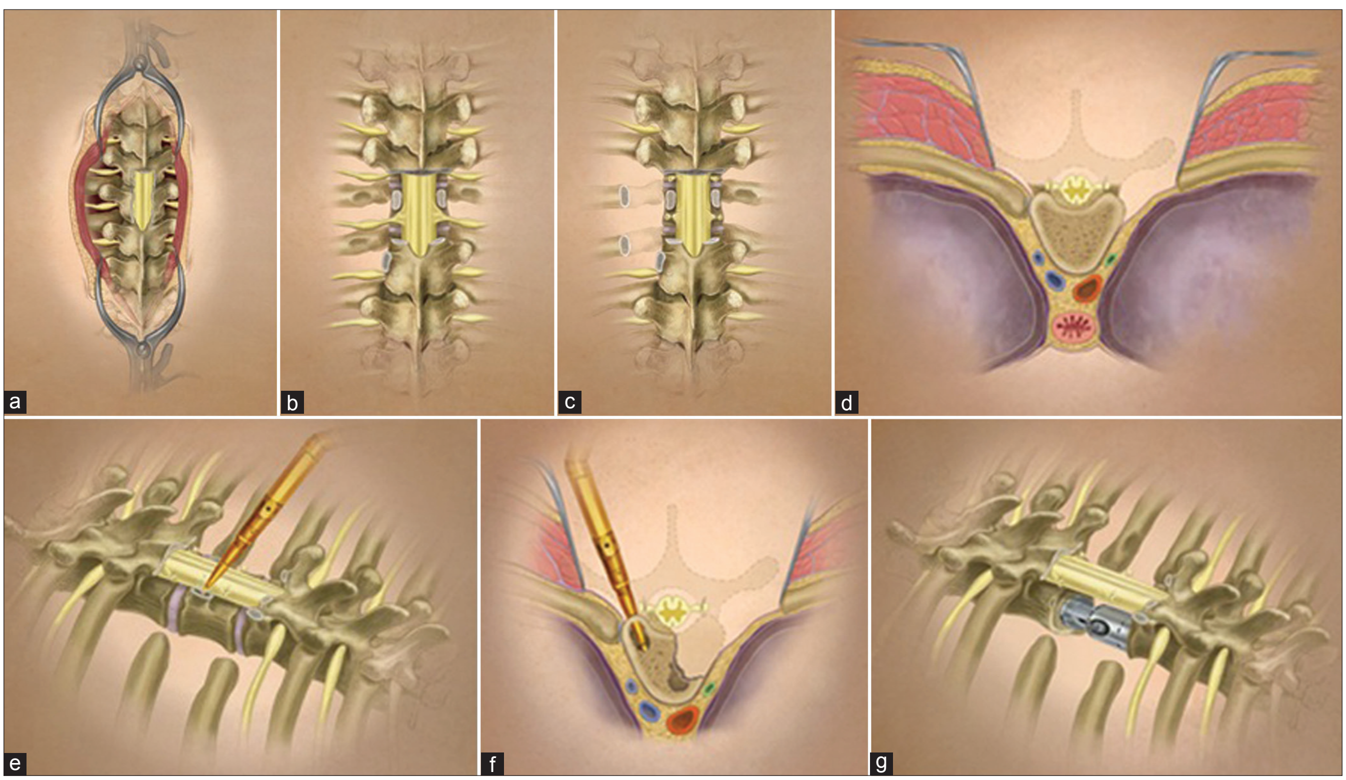

Figure 2: Illustration of steps for the lateral extracavitary approach. (a) Laminectomies are performed at the level of the vertebrectomy and the level above. (b) Surrounding facets are removed to expose the disc spaces. (c and d) The transverse processes, a small segment of the ribs, and rib heads are resected on the side of the approach at the level of the vertebrectomy and the level below to allow lateral access to the relevant disc spaces. Nerve roots are sacrificed to optimize working space. (e and f) A posterior lateral approach is performed on one side. A contralateral transpedicular approach is utilized to complete the corpectomy. (g) The lateral extracavitary approach allows standard straight inserters to be utilized

The pedicles were then removed bilaterally and vertebrectomy or corpectomy could be performed using the extracavitary approach on the right. We recommend performing a transpedicular approach on the contralateral side which allows complete vertebral segment removal. The placement of the expandable cage should then be straightforward; an angled holder for the cage was extremely helpful to place the cage in the midline. No patients received postoperative bracing.

RESULTS

The histopathology of the lesions is shown in Table 1. The most common primary site was the lung. Fifteen single-level, four two-level, and two three-level vertebral column resections were performed in 20 patients. There were no rostral/caudal limitations, and we operated from T1 to T12.

In all cases, circumferential vertebral column resection was achieved, and full decompression could be performed using the posterior-only approach. None of our patients required a separate anterior procedure. The average estimated blood loss (EBL) and length of surgery were 1700 ml (range, 200–7600 ml) and 6.8 h (range, 4–9 h), respectively. One patient was lost to follow-up. For the remaining, the mean follow-up time was 14 months (range, 4–30 months).

Five patients had severe lower extremity paresis and were unable to walk prior to surgery. Two out of those six regained the ability to ambulate. Another patient, who was paraplegic prior to decompression, did recover significant functions, but remained wheelchair bound.

One patient had a neurological deficit postoperatively. This patient was intact immediately after surgery; however, he developed coagulopathy and an epidural hematoma over the next 24 h. Despite evacuation, patient's paralysis did not resolve.

In the remaining patients who were neurologically intact preoperatively, all but two were able to ambulate on postoperative day 3. In one of these two patients, the delay in ambulation was attributed to extreme discomfort resulting from extensive tissue dissection necessary for a C5–T9 fusion. The other patient was debilitated by exacerbation of chronic pulmonary problems. Ninety-four percent of patients had durable preservation of the neurological function.

There were no perioperative deaths. All patients were discharged either to rehabilitation or home with average hospitalization duration of 7.8 days (range, 4–15 days). Twelve patients (60%) underwent postoperative radiation, and in all cases in which radiation was performed, treatment was instituted at least 21 days postoperatively to allow for wound healing. Complications included hematoma evacuation (1), dehiscence (1), delayed hardware failure (subsidence that did not require revision; 2), and wound infections (2) requiring washout. One instance of wound infection requiring a washout occurred 6 weeks after

Table 1: Demographics, operative parameters, and surgical outcomes

Age (years) sex	Histology	Thoracic level (s)	Operating room time (h)	Estimated blood loss (ml)	Length of stay (day)	Function preoperative	Complications
64/Male	Plasmacytoma	T1	6	850	6	Intact	–
54/Female	Breast	T4	5	850	6	Intact	Infection, washout
58/Male	Lung	T6	5	1400	5	Intact	–
59/Female	Lung	T2–3	7	1600	7	Intact	–
68/Male	Hemangioma	T5	4	800	6	Intact	–
48/Male	Hepatobilliary	T6	6	1500	9	Paraplegic	–
53/Male	Lung	T9	7	600	6	Intact	–
65/Male	Salivary	T7	7	900	9	Intact	–
60/Male	Skin squamous cell	T2–3	8	2500	7	Intact	Pneumonia, dehiscence
56/Female	Cervix	T1–3, T7	9	1100	8	Intact	–
48/Male	Hemangioendotheloma	T5	8	900	7	Intact	–
73/Male	Melanoma	T4	7	3000	7	Intact	–
73/Male	Melanoma	T8	9	7600	10	Intact	Hematoma, paralysis
58/Male	Renal	T11–12	8	800	7	Intact	Subsidence
75/Female	Lung	T4	7	400	6	Intact	Pneumothorax
46/Male	Renal	T8	9	1000	9	Intact	Pleural effusion, subsidence
64/Female	Lung	T8	9	1400	7	Intact	Pneumonia
56/Male	Myeloma	T11	4	200	4	Paraparetic	Infection, Neutrapenia
80/Male	Prostate	T9–8	5	2800	9	Paraparetic	–
75/Female	Renal	T7	6	6000	13	Paraparetic	Lost to follow-up
67/Female	Lung	T1–3	6	1000	15	Paraparetic	Gastrointestinal bleed, atrial fibrillation

surgery in the setting of CMV-associated neutropenia. There were no cases of DVT, pulmonary embolism, ileus, or CSF leak, and 1 case of pleural effusion, 1 of pneumothorax, and 2 cases of pneumonia. (0). Altogether, the total complication rate was 43%.

DISCUSSION

The surgical management of spinal tumors is indicated for preserving or restoring neurological function and alleviating pain in patients whose life expectancy exceeds 3 months. This assessment of prognosis and individualizing of care for cancer patients is optimally performed with a multidisciplinary approach. Class I evidence exists for anterior decompression and postoperative radiation in the setting of spinal cord compression from nonhematological malignancies.[29]

Typically, this requires a transthoracic approach to access the anterior spinal column with subsequent posterior instrumentation (since most lesions also include the pedicle).[21] As such, there are two requisite incisions and additive risks from each approach. The anterior approach has the particular challenge of late visualization of the neural elements.[6,8,9,13,22,26,30,31,33] However, it does allow for the placement of a sizeable anterior graft with potential benefits in reduced subsidence and is a surgical technique with which most spinal surgeons are relatively facile.

The posterior approach to the anterior spine has long been an attractive option for spinal surgeons. The lateral extracavitary approach was developed in part by Norman Capener and then modified by Sanford Larson and others.[10,24] Many of its advantages arise from the ability to avoid morbidity associated with anterior or lateral incisions. This is particularly important in the oncologic setting because many of the patients have already had interventions such as surgery, chemotherapy, or radiation that can compromise pulmonary function or increase the difficulty of gaining exposure. Though versatile, the lateral extracavitary approach is technically challenging, associated with high blood loss and wound-healing problems, and anterior cage placement is often smaller than that in traditional anterior exposure. Additionally, this technique has not been traditionally used in the upper thoracic spine (T1–3).

In our series, we successfully used the lateral extracavitary approach to perform circumferential vertebral column resection for spine tumors from T1 to T12, with an anterior expandable cage and supplemental instrumented posterior arthrodesis at least two levels above and below through the same exposure. In transition zones (cervicothoracic and thoracolumbar) or in zones with poor bone quality, additional points of fixation were used.

The average blood loss was 1700 ml. This compares favorably to the 2486-ml mean EBL reported by Xu *et al.* who used transpedicular or lateral extracavitary approaches.[36] It is also in the range of values reported by Lu *et al.* (1857 ml)[27] and Wang *et al.* (1500 ml)[35] both of whom used the transpedicular approach which generally requires less dissection as the rib heads are preserved. In a series of 32 patients who underwent a lateral extracavitary procedure, Khoo *et al.* reported an average EBL of 595 ml. Only 11 out of the 32 patients had tumors which may account for their relatively low blood loss.

There was one serious complication in our series. The complication was paraplegia occurring on postoperative day 1. Undetected coagulopathy resulted in an epidural hematoma. Unfortunately, due to language barriers the worsening neurological exam was not recognized until significant time had passed. Emergent evacuation of the hematoma did not restore the patient's neurological function.

Additionally, we had three wound infection/dehiscence cases requiring washout or repair. Two of the three patients with wound issues had prior radiation. Furthermore, one of these two patients developed the infection in the setting of chemotherapy-associated neutropenia. Three patients also had pulmonary problems including one who had a small pneumothorax that did not require treatment. These complication rates are comparable to those reported in other series using the lateral extracavitary approach or combined anterior/posterior approach.[34,36]

Our technique was different than the classical lateral extracavitary approach performed through a paramedian incision. The incision and subsequent maneuvers that we employed are similar to those described by Snell *et al.*[34] It was critical that we used a midline incision: this allowed us to work without significant impedance from the scapula. Furthermore, the midline approach facilitated a contralateral transpedicular approach that was necessary for circumferential decompression in our experience. Of note, lesions as high as T1 were accessible. To our knowledge, we are the first to use this approach at the cervicothoracic junction.

An advancement that has made the lateral extracavitary approach for tumor resection less difficult is the increasing sophistication of expandable cages that allow for easier insertion. Furthermore, *in situ* expansion allows for the distraction and correction of deformity. This approach also avoids complications related specifically to methylmethacrylate (thermal injury, extravasation, dislodgement) and strut grafts.[2-5,11,17,19,25] Balancing the advantages of expandable cages is the potential for subsidence. Whether this occurs due to overexpansion, poor bone quality, or as a result of the use of smaller cages is unclear. In our series, subsidence occurred twice after 18 procedures.

CONCLUSION

The reemergence of the lateral extracavitary approach for single-stage vertebrectomy in spinal oncology reflects incremental improvements in technique, more advanced spinal instrumentation, and enhanced anesthesia capabilities. This technique potentially decreases operative time and provides a less invasive approach than the traditional combined anterior/posterior approach. The capability to perform the vertebrectomy or corpectomy without traversing the thorax or abdomen is especially important in cancer patients who have often had previous surgery or disease in those areas. Dedicated spinal instrumentation for the lateral extracavitary approach would further decrease the technical challenges. Ultimately, a prospective randomized clinical trial comparing the two approaches would provide the most definitive data.

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