Original Study

Posterolateral thoracic decompression with anterior column cage reconstruction versus decompression alone for spinal metastases with cord compression: analysis of perioperative complications and outcomes

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Background: The optimal surgical strategy for patients with spinal metastases remains unknown. The aim of this study was to determine if performing an anterior column reconstruction to a posterolateral approach adds to perioperative complications.

Methods: A retrospective review of all adult patients with spinal metastases who had a posterolateral approach for resection between January 2000 and December 2008. Perioperative complications and functional outcomes were determined.

Results: A total of 23 patients met the study criteria. Eleven patients underwent a costotransversectomy (CT) approach with anterior column reconstruction while 12 patients had a transpedicular (TP) approach without anterior column reconstruction. The mean age was 55.9 and 59.3 years in the CT and TP groups, respectively. There was no intraoperative death in either group. One death attributed to sepsis occurred in the TP group. A total of 5 (45.5%) complications occurred in the CT group and 7 (58.3%) in the TP group (P=0.68). An improvement in American Spinal Injury Association (ASIA) impairment scale grades was observed in 3 (27.3%) patients in the CT group and 1 (8.3%) in TP group. ASIA grades remained the same in 8 (72.7%) patients in CT and 10 (83.3%) patients in TP groups. No patient worsened in the CT group whereas 1 (8.3%) patient in TP group worsened. The median survival was 12.2 months in the CT group and 19.0 months in the TP group (P=0.37).

Conclusions: The addition of anterior column reconstruction does not appear to be associated with more operative or perioperative complications when compared to decompression alone. Anterior column reconstruction should not be aborted in fear of increasing perioperative complications.

Keywords: Spinal metastases; costotransversectomy (CT); transpedicular (TP); posterolateral

Submitted Aug 15, 2017. Accepted for publication Nov 14, 2017.
doi: 10.21037/jss.2017.11.08
View this article at: http://dx.doi.org/10.21037/jss.2017.11.08

Introduction

Surgical management of spinal metastases remains a palliative undertaking (1). The goals of surgery are aimed at improving the overall quality of life. Additionally, surgical resection serves to stabilize and improve neurological function, prevent local progression of tumor and provide pain relief (1). Although the vast majority of patients with spinal metastases ultimately succumb to complications or progression of their primary disease process, good functional and neurological outcomes have been reported with surgical treatment (2,3). Traditionally, most surgeons favored the anterior transthoracic approach to directly address ventral metastatic involvement (3-8). The abandonment of posterior laminectomy for assessing ventral spinal cord led to the development of posterolateral approaches such as the transpedicular (TP), costotransversectomy (CT) and lateral extracavitary approaches (9-14). While a few studies have reported favorable outcomes with posterolateral approaches, the morbidity and mortality still remain high with some studies reporting mortality rates of 6% to 11% (9-11,13-17). The reasons behind this high incidence of perioperative morbidity and mortality have not been fully elucidated but most likely multifactorial (9,12-14). In this study, we attempt to investigate whether the addition of anterior column reconstruction to a posterolateral approach in the surgical management of spinal metastases increases operative and perioperative morbidity and mortality.

Methods

A retrospective review of the medical records of all adult (age >18 years) patients who had surgical resection for spinal metastases between January 2000 and December 2008 at our institution was performed. Patients who underwent anterior transthoracic approaches and minimally invasive approaches were excluded. Clinical, radiographic, operative and pathologic reports were reviewed. The Charlson comorbidity index was used to classify each patient's comorbidities (18). We defined the preoperative and postoperative functional neurological status using the American Spinal Injury Association (ASIA) impairment scale (*Table 1*). Each patient's neurological status at their last follow-up encounter was assessed using the ASIA scale.

Operative technique

CT

The CT approach has been described elsewhere (19). An illustration is shown in *Figure 1A*. Briefly, patients were positioned prone on a Jackson table. Standard perioperative antibiotic agents were administered prior to skin incision. All pressure points were adequately padded. When appropriate, neurophysiologic monitoring was used. After a midline skin incision, bilateral subperiosteal muscle dissection was performed. The affected level was localized with fluoroscopy. Thoracic pedicle screws were placed bilaterally, usually 2 to 3 levels above and below the affected level. A laminectomy was then performed along with resection of the transverse process and the proximal 2–3 cm of adjoining rib. The pleura was then meticulously dissected off the vertebral bodies without violating the parietal pleura. The intercostal bundle was then identified and followed to identify the neural foramen. The intercostal artery and nerve root at the pathologically affected level were double ligated, and divided. Ligation of nerve root occurred proximal to the dorsal root ganglion. The ipsilateral pedicle was then removed revealing the thecal sac. The vertebrectomy was then performed using a combination of high-speed diamond drill and angled curettes. When appropriate, the same procedure was performed at the contralateral side to ensure circumferential decompression. The created defect was reconstructed using a titanium cage. The precontoured rod and cross links were then connected to the pedicle screws to complete the instrumentation. Chest tubes were not routinely inserted unless obvious violation of pleura occurred.

TP

A description of the TP approach has been performed elsewhere and will be described briefly (*Figure 1B*) (20). Patients were positioned in a prone position following induction of endotracheal anesthesia. All pressure points were adequately padded. When indicated, neurophysiologic monitoring was used. A midline incision was made followed by subperiosteal dissection to expose the posterior elements. The pathologic level was confirmed fluoroscopy. Depending on surgeon's preference, posterior pedicle screw instrumentation was next placed followed by laminectomy, facetectomies and pedicle resections using a high-speed drill. Working around the dura, the epidural tumor was then removed. In cases of nerve root involvement, the root was double ligated and resected proximal to the dorsal root ganglion. Posterior instrumentation was then completed. In the event of any potential violation to the pleura, chest tubes were placed. The wound was then closed in successive layers.

Table 1 ASIA impairment scale

Grades	Descriptions
A	Complete: no motor or sensory function is preserved in the sacral segments S4–S5
B	Incomplete: sensory but not motor function is preserved below the neurologic level and extends through the sacral segments S4–S5
C	Incomplete: motor function is preserved below the neurologic level, and the majority of key muscles below the neurologic level have a muscle grade less than 3
D	Incomplete: motor function is preserved below the neurologic level, and the majority of key muscles below the neurologic level have a muscle grade greater than 3
E	Normal: motor and sensory function is normal

ASIA, American Spinal Injury Association.

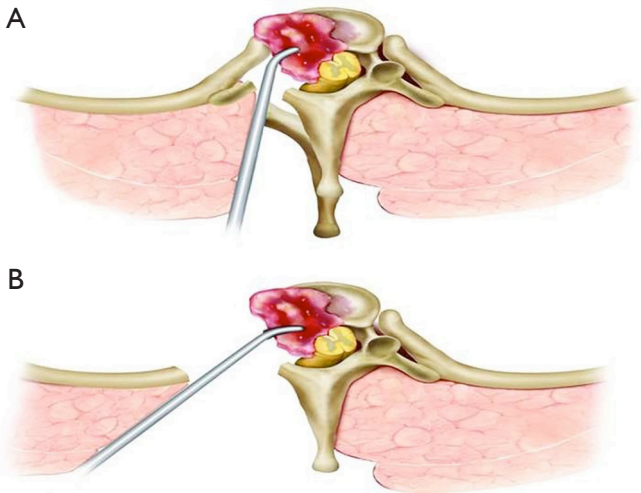

Figure 1 Illustration of surgical approach for tumor resection. (A) Artistic illustration of the costotransversectomy approach; (B) illustration of the transpedicular approach.

Table 2 Demographics

Variables	CT (with vertebrectomy)	TP (without vertebrectomy)
Total number of patients	11	12
Male	7	6
Female	4	6
Mean age (years)	55.9	59.3
Mean follow-up (months)	12.7	5.7
Average CCI	6.8	7.0

CT, costotransversectomy; TP, transpedicular; CCI, Charleston comorbidity index.

Statistical analysis

Statistical analysis was performed using GraphPad StatMate (GraphPad Software Inc., San Diego, California). The Fischer exacts test was used to determine statistical significance among the two groups. The Student's *t*-test was used to determine statistical significance among two pertinent variables of interest. The Kaplan-Meier survival curve was used to generate overall survival. Statistical significance was defined as $P<0.05$.

Results

Demographics

A total of 24 patients underwent a posterolateral approach for resection of spinal metastases during the review period. One minimally invasive case was excluded. As this is a study of perioperative complications, patients who were discharged to hospice or nursing home and thus did not have outpatient follow-up were included in the study. This yielded a total of 23 patients with spinal metastasis who underwent posterolateral approach with or without vertebral body resection and reconstruction (*Table 2*). Eleven patients underwent a single-staged CT approach with single or multilevel vertebrectomy and 12 patients underwent TP resection of ventral epidural metastases without a vertebrectomy. Both groups had posterior pedicle screw instrumentation. The mean age was 55.9 years in the CT group and 59.3 years in the TP group. The mean follow-up was 12.7 and 5.7 months in the CT and TP groups respectively.

Clinical data

Pain was the most common presenting symptom in both CT

(82%) and TP (83%) groups. Other presenting symptoms in CT group included weakness (45%), sensory deficits (36%) and incontinence (9%). In the TP group, 33% of patients presented with weakness, 25% with sensory deficits and 8% with incontinence. At time of surgery, 73% and 67% of patients were ambulatory in the CT and TP groups respectively. A total of 45% and 50% of patients received radiation treatment to their spinal tumors prior to surgical resection in the CT and TP groups, respectively. The indications for surgery consisted of pain, neurological deficit, spinal instability, need for histological diagnosis and tumor progression following radiation therapy. The choice of surgical approach was dictated by each treating surgeon and was not specified. The mean Charlson comorbidity index was 6.8 and 7.0 in the CT and TP groups, respectively. The clinical summaries of both groups are shown in *Tables 3,4*.

Radiographic data

Radiographic data was obtained from magnetic resonance imaging (MRI) with and without contrast from all patients. The extent of spinal tumor in the CT group consisted of two patients with solitary metastases and nine with multiple metastases. Nine patients in this group had three column involvements, 9 with >50% vertebral body height loss and 9 with >50% vertebral body involvement. Three patients within this group had tumors that involved transitional levels. All patients had radiographic spinal cord compression.

In the TP group, 12 patients had three column involvements, 3 with >50% vertebral body height loss and 5 with >50% vertebral body involvement. Three patients had tumors that involved transitional levels. All patients had radiographic spinal cord compression.

Tumor histology

Histological diagnosis was confirmed in all cases in both groups (*Table 5*). In the CT group, there were 3 breast carcinomas, 2 renal cell carcinomas, 1 non-small cell lung (NSCLC), 1 alveolar soft part sarcoma, 1 fibrohistiocytoma, 1 multiple myeloma, 1 undifferentiated sarcoma, and 1 diffuse large B-cell lymphoma. Tumors in the TP group consisted of 2 NSCLC, 2 prostate carcinomas, 1 renal cell carcinoma, 1 hepatocellular carcinoma, 1 multiple myeloma, 1 carcinoid tumor, 1 adrenal cortical carcinoma, 1 osteosarcoma, 1 squamous cell carcinoma and 1 tumor of unknown primary.

Level of surgery

The levels of surgery were grouped into upper thoracic (T1–T4), mid-thoracic (T5–T8) and lower thoracic (T9–T12) (*Table 6*). The operative levels within the CT group consisted of 1, 3 and 7 upper, mid and lower thoracic, respectively. In the TP group, the levels consisted of 5, 4 and 3 upper, mid and lower thoracic, respectively. One- and 3-level vertebrectomies were performed in ten and one patients in the CT group, respectively. In the TP group, six patients underwent 1- and 2-level TP decompressions without vertebrectomies, respectively. In both groups, posterior pedicle screw supplementation was added typically at 2 levels above and below the level of vertebrectomy or decompression.

Estimated blood loss (EBL) and length of stay

The average EBL was 1,477 and 1,341 milliliters (mL) for the CT and TP groups respectively. The difference in EBL did not reach statistical significance (P=0.83). The average length of stay was 10.3 and 8.9 days in the CT and TP group, respectively (P=0.63).

Perioperative complications

There was no intraoperative death in either group. One death attributed to sepsis occurred in the TP group. There was no perioperative death in the CT group. A total of 5 (45.5%) complications (major and minor) occurred in the CT group and 7 (58.3%) in the TP group (P=0.68) (*Table 7*). We observed 3 (27.3%) major (defined as any adverse event requiring additional surgical intervention or resulting in potential for long-term harm) and 2 (18.2%) minor (defined as any event not requiring additional surgical interventions, resulting in death or the potential for long-term harm) complications in the CT group. In the TP group, major complications occurred in 6 (50.0%) cases and minor complications in 1 (8.3%) patient. One patient in the CT group underwent revision surgery for wound dehiscence. Within the TP group, three patients underwent revision surgery for wound infection in 2 and instrumentation failure in 1.

Functional outcomes

Pre- and post-operative neurological status were graded using the ASIA impairment scale (*Tables 8,9*). Within the CT group, 1, 1, 5 and 4 patients presented with ASIA B,

Table 3 Summary of patients with in costotransversectomy group

Age (years)/ sex	Diagnosis	Symptoms	XRT preoperative	XRT postoperative	Levels involved	ASIA preoperative	ASIA postoperative	CMI	EBL (mL)	LOS (days)	Complications	Survival (months)	Follow-up (months)/ status
58/F	Breast carcinoma	Pain	Yes	No	T12	E	E	6	2,300	8	None	23.8	21.0/dead
72/M	RCC	Weakness/ sensory	Yes	No	T5	D	D	10	450	4	None	13.1	11.0/dead
49/M	Fibrohistiocytoma	Pain/ sensory	No	No	T6	D	D	6	600	13	PTX	0.5	0/dead
65/M	RCC	Pain	No	Yes	T11	E	E	7	3,000	27	Weakness/PTX	45.0	1.0/dead
32/F	Alveolar soft part sarcoma	Pain/ weakness/ sensory/ incontinence	Yes	No	T10	–	–	6	2,000	7	None	10.5	1.2/alive
73/M	Multiple myeloma	Pain	No	No	T10	E	E	7	1,200	3	None	23.6	0/dead
68/M	NSCLC	Pain	Yes	No	T4	E	E	8	1,000	5	Wound dehiscence	12.2	8.9/dead
42/M	DLBCL	Weakness/ sensory	No	No	T9–11	–	–	6	2,500	6	None	24.0	27.0/alive
64/F	Breast carcinoma	Pain	Yes	No	T7	D	D	7	800	14	PE	1.1	0/dead
26/M	Sarcoma	Pain/ weakness	No	Yes	T10	–	–	6	1,100	11	None	78.5	27.0/alive
66/F	Breast carcinoma	Pain/ weakness	Yes	No	T10	D	D	6	1,300	15	None	4.4	4.4/dead

F, female; M, male; RCC, renal cell carcinoma; NSCLC, non-small cell lung cancer; DLBCL, diffuse large B-cell lymphoma; XRT, radiation; CMI, Charlson comorbidity index; EBL, estimated blood loss; LOS, length of stay; ASIA, American Spinal Injury Association; PTX, pneumothorax; PE, pulmonary embolus.

Table 4 Summary of patients in transpedicular group

Age (years)/ sex	Diagnosis	Symptoms	XRT preoperative	XRT postoperative	Levels involved	ASIA preoperative	ASIA postoperative	CMI	EBL (mL)	LOS (days)	Complications	Survival (months)	Follow-up (months)/ status
84/M	Prostate	Pain	No	Yes	T2–3	E	E	6	200	5	None	10.0	5.0/dead
65/M	RCC	Pain	No	No	T5	E	E	7	7,200	2	None	15.0	2.0/dead
79/F	NSCLC	Pain	No	No	T5	E	E	7	600	12	None	28.6	0.3/dead
54/F	NSCLC	Pain/ sensory	Yes	No	T1–2	E	E	6	600	2	None	31.6	36.0/alive
44/M	HCC	Pain/ weakness	No	No	T11	C	C	3	1,000	13	PE/sepsis	0.3	0.3/dead
57/M	Multiple myeloma	Pain/ sensory	No	No	T12	D	C	6	1,400	16	Wound infection/ instrumentation failure	118.0	6.5/alive
70/M	Prostate	Pain/ weakness/ sensory	Yes	No	T2–3	B	C	6	600	23	Wound infection	108.5	1.0/alive
38/M	Carcinoid	Pain	Yes	No	T3	E	E	7	600	7	Stroke	23.0	0.2/dead
45/F	Adrenal cortical adenoma	Weakness	Yes	No	T4	C	C	6	500	9	None	4.6	1.0/dead
61/F	SCC	Pain	No	No	T7	E	E	9	600	6	None	8.8	1.8/dead
53/F	Osteosarcoma	Pain	Yes	No	T4	D	D	8	2,000	3	None	129.0	12.2/alive
61/F	Unknown primary	Weakness	Yes	No	T9–10	C	C	7	800	9	None	4.3	2.0/dead

F, female; M, male; RCC, renal cell carcinoma; NSCLC, non-small cell lung cancer; HCC, hepatocellular carcinoma; SCC, squamous cell carcinoma; XRT, radiation; ASIA, American Spinal Injury Association; CMI, Charlson comorbidity index; EBL, estimated blood loss; LOS, length of stay; PE, pulmonary embolus.

Table 5 Primary tumor histology

Histological diagnosis	CT (with vertebrectomy) (n)	TP (without vertebrectomy) (n)
Breast carcinoma	3	0
Renal cell carcinoma	2	1
Lung (NSCLC)	1	2
Prostate adenocarcinoma	0	2
Miscellaneous		
Hepatocellular carcinoma	0	1
Multiple myeloma	1	1
Osteosarcoma	0	1
Carcinoid	0	1
Squamous cell carcinoma	0	1
Adrenal cortical carcinoma	0	1
Fibrohistiocytoma	1	0
Lymphoma	1	0
Undifferentiated sarcoma	1	0
Alveolar soft part sarcoma	1	0
Unknown primary	0	1

CT, costotransversectomy; TP, transpedicular.

Table 6 Level of surgery, estimated blood loss and length of stay

Variables	CT (with vertebrectomy)	TP (without vertebrectomy)
Level of surgery (n)		
T1–T4	1	5
T5–T8	3	4
T9–T12	7	3
1 levels	10	6
2 levels	0	6
3 levels	1	0
Mean EBL (mL)	1,477	1,341
Mean LOS (days)	10.3	8.9

CT, cotransversectomy; TP, transpedicular; EBL, estimated blood loss; LOS, length of stay.

Table 7 Perioperative complications

Complications	CT (with vertebrectomy) (n)	TP (without vertebrectomy) (n)
Death	0	1
Major		
Bacteremia	0	1
Wound infection	0	2
Wound dehiscence	1	0
Neurological deficit	1	0
Stroke	0	1
Pulmonary embolus	1	1
Instrumentation failure	0	1
Minor		
Pneumothorax	2	0
DVT	0	1

DVT, deep vein thrombosis; CT, costotransversectomy; TP, transpedicular.

C, D and E, respectively. In the TP group, 1, 3, 2 and 6 patients presented with ASIA B, C, D and E, respectively. At the time of last follow-up, in the CT group, 5 and 6 patients were graded as ASIA D and E, respectively. In the TP group, follow-up ASIA grades consisted of 5, 1 and 6 ASIA C, D and E, respectively. An improvement in ASIA grades was observed in 3 (27.3%) patients in the CT group and 1 (8.3%) in TP group. ASIA grades remained the same in 8 (72.7%) patients in CT and 10 (83.3%) patients in TP groups. No patient worsened in the CT group whereas 1 (8.3%) patient in TP group worsened. At the time of data collection, 9 (81.8%) and 8 (66.7%) patients were deceased in the CT and TP groups, respectively. The median survival was 12.2 months in the CT group and 19.0 months in the TP group. A Kaplan-Meier overall survival curve is shown in *Figure 2*.

Discussion

The posterolateral approaches (CT, TP and lateral extracavitary) to the ventral thoracic spine have been used for decades now with favorable results (9,21). The impetus for their development stemmed out of the need to provide an alternative to the traditional anterior transthoracic approach for treating diseases located in the ventral thoracic

Table 8 Pre- and post-operative ASIA scores

Operative techniques	Grade A	Grade B	Grade C	Grade D	Grade E
CT (with vertebrectomy) (n)					
Preoperative	0	1	1	5	4
Postoperative	0	0	0	5	6
TP (without vertebrectomy) (n)					
Preoperative	0	1	3	2	6
Postoperative	0	0	5	1	6

CT, costotransversectomy; TP, transpedicular; ASIA, American Spinal Injury Association.

Table 9 Change in ASIA scores

Operative techniques	Improved	Remained same	Worsened
CT (with vertebrectomy) (n)	3	8	0
TP (without vertebrectomy) (n)	1	10	1

CT, costotransversectomy; TP, transpedicular.

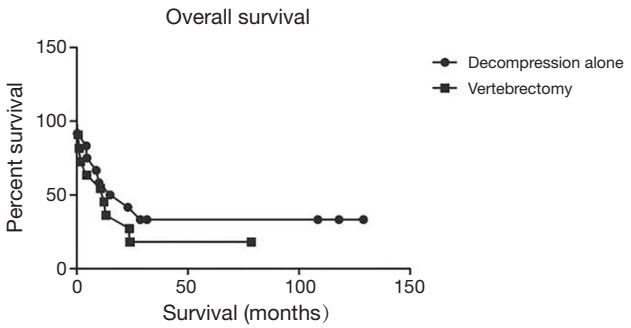

Figure 2 Kaplan-Meier survival curve for patients who underwent vertebrectomy or decompression alone for spinal metastases.

spine (22). Although the CT was originally developed for the treatment of Potts disease, modifications of the technique have evolved and expanded to include single and multilevel vertebral body resections with anterior cage reconstruction (22-24). The posterolateral approach offers several advantages over the anterior transthoracic routes such as the ability to perform vertebral body resections with posterior instrumentation in a single setting (20). Additionally, the need to traverse the thoracic cavity which may not be tolerated by the critically ill cancer patient is avoided with the posterolateral approach (14). Despite these advantages, several authors have reported significantly high operative morbidities and mortalities for unknown reasons (9-11,13-17).

The surgical decision-making process and the choice of surgical approach in a patient with spinal metastases is not always straightforward but it's generally advocated for (I) establishment of histological diagnosis, (II) management of intractable pain, (III) progressive neurological deficits, (IV) chemo and radio-resistant tumors and (V) correction of spinal instability (25-27). Spinal metastases often involve the vertebral body with ventral epidural compression and thus the decision to perform anterior column stabilization (i.e., vertebrectomy with cage reconstruction) in lieu of shorter life expectancy and patient co-morbidities is often contemplated. The determination of spinal instability in metastatic disease also remains a challenge and further complicates the surgical decision-making process. Siegal *et al.* proposed five criteria indicating spinal instability in metastatic disease based on columns of involvement and presence of iatrogenic instability from prior laminectomy or vertebrectomy (28). This criterion, however, does not include other elements involved in defining spinal instability such as the location of tumor at a transition level and overall radiographic spinal alignment. In an attempt to establish a comprehensive and standardized classification system, Fisher *et al.* undertook an evidence-based approach and expert consensus from the spine oncology study group to create a spine instability neoplastic score based on patient symptoms and radiographic criteria (29). Future studies utilizing this scoring system will elucidate its validity and applicability.

The difficulty in defining spinal instability in spinal

metastatic disease and deciding when to perform anterior column reconstruction is evident in this study in TP group. All patients in this group had three-column involvement with some patients having >50% vertebral body height loss, >50% vertebral body involvement and transitional level location of tumors. As this is a retrospective study, the surgical decision-making thought process was not always available in the records. Nevertheless, this patient group provides a unique opportunity to study the operative and functional outcomes in patients with spinal metastases who do not undergo anterior column reconstruction. Some of the drawbacks of not performing anterior column reconstruction include worsening of spinal instability, tumor recurrence and failure of posterior instrumentation. While these are valid concerns, some may argue that in this patient population with shorter life expectancies, performing a circumferential decompression with or without posterior stabilization may be adequate (20). Weller *et al.* (20) reported improved neurological outcomes in eight patients with spinal metastasis who underwent a unilateral posterolateral decompression without stabilization. They suggested this limited option for debilitated patients with life expectancies of less than 6 months. This notion is supported in this study by the observation that no patient underwent revision surgery for instrumentation failure, recurrent tumors or worsening of symptoms. Moreover, the ASIA scores, ambulatory status and overall survival were not significantly different between the two groups.

Whether or not performing vertebrectomies with cage reconstruction performed through the posterolateral approaches are associated with more operative and perioperative complications when compared with posterolateral decompression alone is also not well established. It is intuitive to assume that the addition anterior column reconstruction may be associated with increased operative and perioperative complications for a number of reasons including but not limited to (I) increasing length of case, (II) more blood loss, (III) potential risks to surrounding neurovascular structures and (IV) instrumentation failure. In this study the rate of complications of was comparable in both groups and to that of other reported studies (9-11,13-17). As expected, the average blood loss in patients undergoing a vertebrectomy was more than the group who had decompression alone although this difference was not statistically significant.

Moreover, the average length of hospital stay was similar in both groups. Although the number of patients in this study are too small to draw any impactful conclusions, it is noteworthy that performing single or multilevel vertebrectomies does not appear confer increased operative or perioperative complications. Thus, for patients for whom vertebrectomies are appropriate, one should not limit the operative intervention to decompression alone. In the same token, our data suggests that in this patient population with relatively shorter life expectancies, removing the compressive tumors and performing posterior stabilization alone may be adequate even in patients with three-column involvement with radiographic cues for spinal instability. This reinforces the need for well conducted studies designed to establish surgical guidelines in patients with spinal metastases.

There are several limitations in this study. First, as in any retrospective review, recall bias must be considered. Secondly, the number of patients is relatively small to generate statistical power. The heterogeneity in tumor histology also makes it difficult to draw solid conclusions as overall outcomes may have been impacted by the type of tumor.

Conclusions

The posterolateral approach for single or multilevel vertebrectomy with reconstruction does not appear to be associated with more operative or perioperative complications when compared with posterolateral approaches for decompression without anterior column reconstruction. When appropriate, anterior column reconstruction should not be aborted in fear of increasing operative or perioperative complications.

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: Approval was obtained from the Duke University Institutional Review Board prior to study (No. Pro00066331).

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Cite this article as: Elsamadicy AA, Adogwa O, Sergesketter A, Lydon E, Bagley CA, Karikari IO. Posterolateral thoracic decompression with anterior column cage reconstruction versus decompression alone for spinal metastases with cord compression: analysis of perioperative complications and outcomes. J Spine Surg 2017;3(4):609-619. doi: 10.21037/jss.2017.11.08