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SURGERY

Four- and Five- Level *En Bloc* Spondylectomy for Malignant Spinal Tumors

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Study Design. Retrospective study.

Objective. To report results of 4- and 5-level *en bloc* spondylectomy (EBS) in the treatment of malignant spinal tumors.

Summary of Background Data. EBS is widely used to avoid local recurrence in the treatment of spinal malignant tumors. Four- and 5-level EBS are aggressive procedures associated with complications and morbidity.

Methods. We conducted a retrospective study of all patients treated with minimum 4-level EBS. Patient and surgical data were noted. Radiographs, magnetic resonance images, and computed tomographic scans were studied for local recurrence, graft, and instrumentation failures at subsequent follow-up. Type of excision was classified into intralesional, marginal, and wide margins. Complications were divided into major or minor and were further classified as intraoperative, early, and late postoperative. At the last follow-up, the patients were classified as alive with no evidence of local or systemic disease, alive with evidence of local or systemic disease or both, dead with evidence of local disease, or systemic disease or both, and dead without evidence of local and systemic disease.

Results. Nine patients were identified who required a minimum 4-level *en bloc* resection. Five males and 4 females. Average age was 41.66 years (11–66). There were 8 primary malignant tumors: 3 chordomas, 3 osteosarcomas, 1 chondrosarcoma, 1 primary lung tumor and 1 metastatic alveolar soft part sarcoma. Six were operated with 4-level *en bloc* and 3 with 5 levels. The mean surgical time was 713 minutes and estimated blood loss was 4.5 L. Mean follow-up was 27.7 months (8–84). At the last follow-up, 6 patients were alive with no evidence of local or systemic disease, 1 alive with evidence of systemic disease, 1 dead with evidence of local disease, or systemic disease or both, and 1 DNLS. Only 1 (11%) patient had a local recurrence. Three patients with Frankel D had full neurological recovery. Histopathological assessment showed marginal margins in 7 patients and wide in 2. There were 9 major and 9 minor complications in 7 patients. Five of 7 patients (71%) with complications, had fully recovered from their complications at the last follow-up.

Conclusion. Multilevel EBS, can be offered to a patient to prevent local recurrence of disease. Even in experienced hands, the risks of intra- and postoperative complications are high (78%). However, most of the patients with complications, recovered completely (71%). Although the surgery itself may prove beneficial, patients should be well informed regarding the morbidity associated with it.

Key words: multilevel, *en bloc* spondylectomy, malignant tumors, complications.

Level of Evidence: 4

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Total *en bloc* spondylectomy (EBS) was developed on the basis of Enneking principles,[1] to resect *en bloc* the spinal tumor, achieving safe histopathology margins, reducing the recurrence rates, and thus increase patient survival. Over the years, it has proved its efficacy in local disease control and increasing survival rates.[2–11]

The complexity of this procedure further increases when the tumor involves more than 1 level because it requires manipulation of the vital structures and a combined anterior and posterior approach. Boriani *et al*[12] in their experience with 135 *en bloc* resections noted that the combined approach and the number of resected spine segments were independent predictors of major complications, but they also noted that complications were much higher in local recurrences and revision surgical procedures and advocated a primary, safe margin surgery for local control. Majority of *en bloc* spondylectomy (EBS) procedures are for single-level disease. Various authors have described multilevel *en bloc* resections.[13–19] However, the majority are case reports. Multilevel *en bloc* resections are technically more demanding and morbid, due to the proximity of neurovascular structures, visceral organs, need for an anterior and

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posterior approach, increased blood loss, surgical time, and risk of complications. With a multispecialty team approach (aid of general surgeons, thoracic surgeons, vascular surgeons, plastic surgeons, otorhinolaryngeal surgeons), judicious preoperative assessment, discussions with oncologists, and radiotherapists, multilevel total EBS could be offered to a patient to increase survival rates.

We report our experience of 4- and 5-level EBS in 9 patients with malignant tumors of the spine.

MATERIALS AND METHODS

We conducted a retrospective study of all patients treated with minimum 4-level EBS at a single institution. The senior surgeon operated all patients. Patient and surgical data (age, type of tumor, previous surgical procedures, surgical time, approach, blood loss, total blood transfused, type of instrumentation, type of bone graft, length of interbody cage) were noted. Radiographs, magnetic resonance (MR) images, and computed tomographic (CT) scans were studied for local recurrence, graft, and instrumentation failures at subsequent follow-ups. Compartmental tumor involvement was classified according to the surgical strategy classification of Tomita *et al*.[20] The revised prognostic score by Tokuhashi *et al*[21] and the score by Tomita *et al*[20] were evaluated for metastatic lesions. Resected tumor data were studied with respect to histopathology margins. All resected specimen were subjected to CT scan and/or MRI to confirm radiological margins (Figures 1, 2). Type of excision was classified into intralesional, marginal, and wide margins. Tumor dimensions and volume were noted. Treatment with radiotherapy and chemotherapy was assessed. Complications were divided into major (altering the expected course of recovery) or minor as suggested by McDonnell *et al*.[22] They were further classified as intraoperative, early postoperative (within 30 d), and late postoperative (30-d postsurgery). Patients were followed up at 3 months for the first 2 years and then 6 monthly. At the last follow-up, patients were classified as alive with no evidence of local or systemic disease, alive with evidence of local or systemic disease or both, dead with evidence of local disease or systemic disease or both, and dead without evidence of local and systemic disease.

Surgical Decision Making

Surgical decision making in aggressive procedures such as multilevel EBS, is best achieved, with a formation of multispecialty team including the primary spine surgeon, approach related surgeon, oncologist, radiotherapist, and anesthesiologist. After thorough discussion, patients were offered a multilevel *en bloc* surgery based on type of tumor and staging, as evident from the histopathology reports of biopsy, whole body CT, MRI of whole spine, bone scintigraphy, and positron emission tomography scans. The indications for surgery were similar to that suggested by Tomita *et al*.[20,6]

The surgical approach and technique was decided on the basis of the location, size of tumor, involvement of surrounding

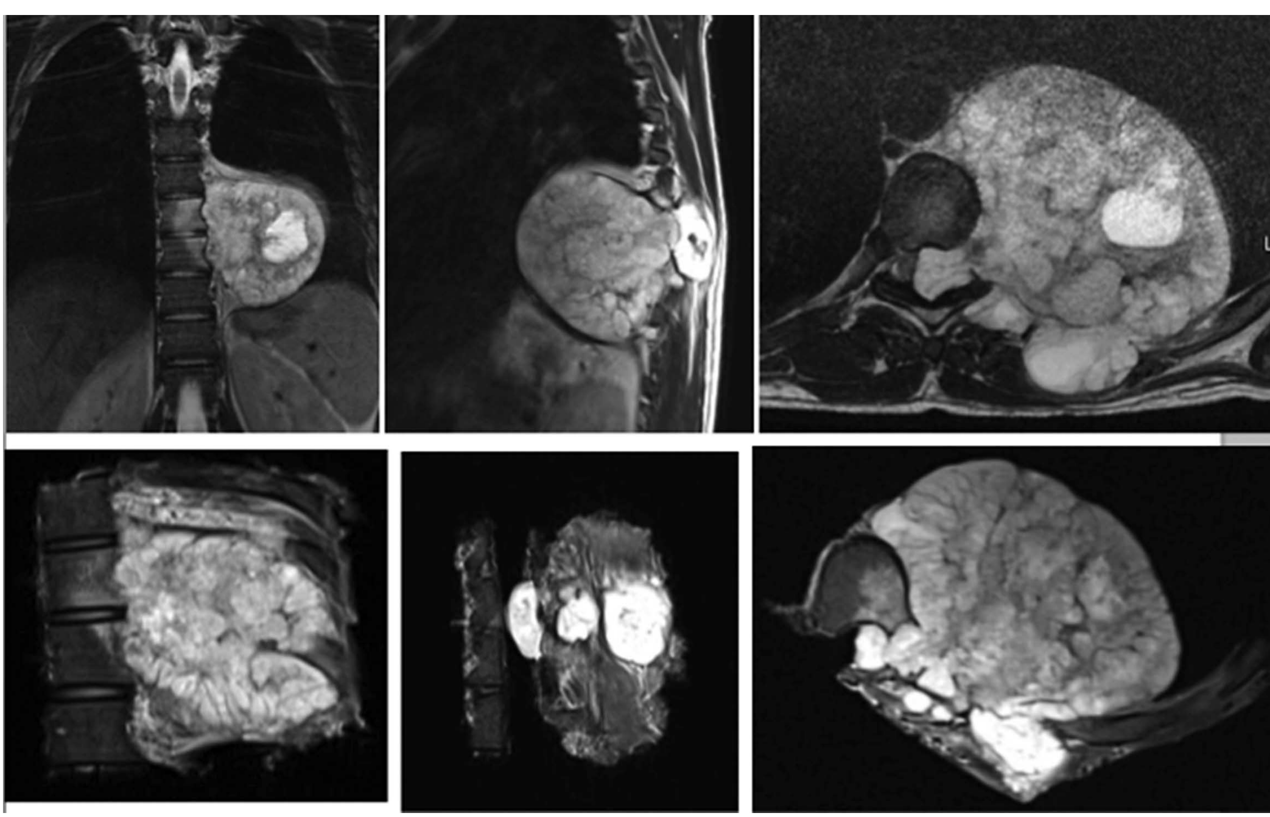

Figure 1. A 23-year-old male was diagnosed as having chondrosarcoma. Top (L to R), coronal, sagittal, and axial MRI showing tumor from T7–T10. Patient was operated with an anterior thoracotomy release and posterior 4-level *en bloc* resection. Bottom (L to R), coronal, sagittal, and axial MRI of resected specimen. Continued in Figure 2. MRI indicates magnetic resonance images.

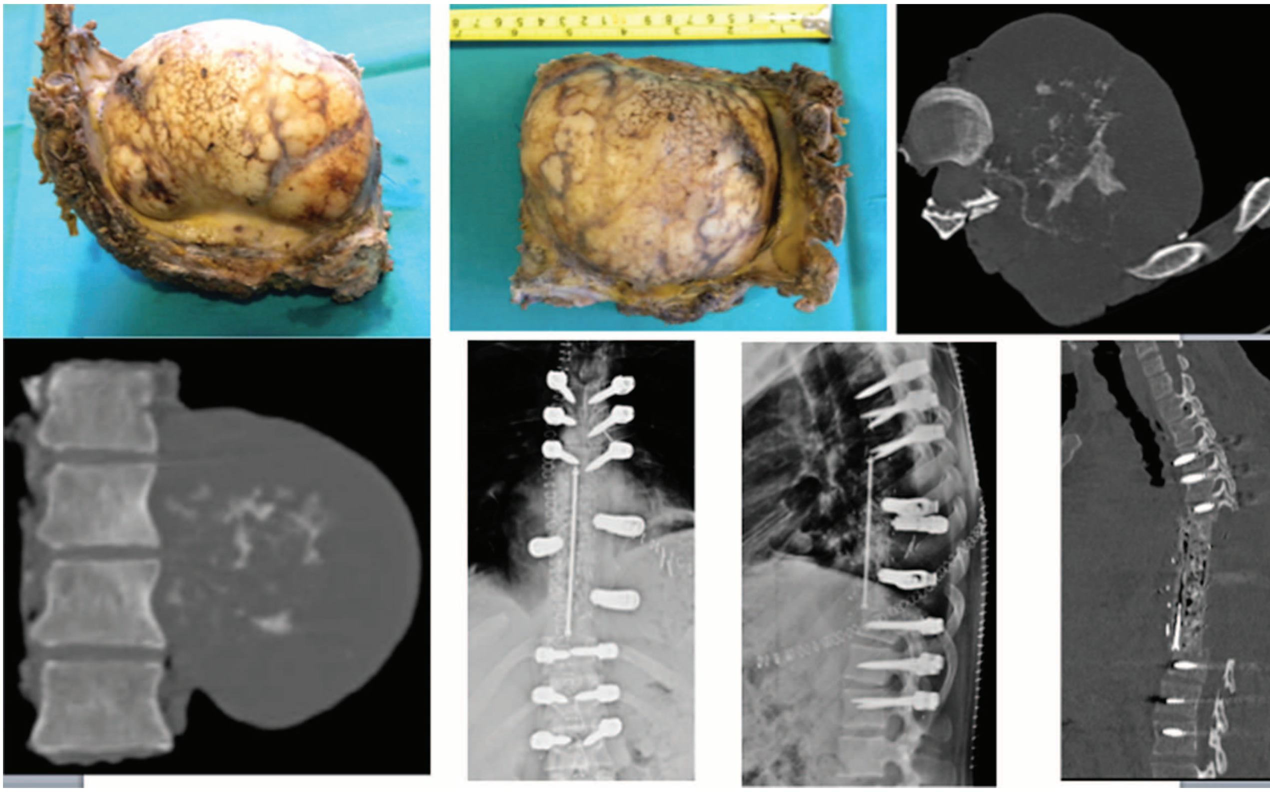

Figure 2. Top (L to R), resected tumor specimen measured 12×6×2 cm. Axial CT scan of the specimen. Bottom (L to R), coronal CT scan of the resected specimen. AP and lateral postoperative radiographs, showing fixation with carbon cage and pedicle screws. Postoperative sagittal CT scan showing complete resection of tumor and carbon cage packed with iliac crest bone graft. CT indicates computed tomography; AP, anteroposterior.

neurovascular structures, as evident on radiological studies. Guidance from approach related surgeons was used in decision making and surgery. After the surgical plan was confirmed the patients were thoroughly briefed regarding the procedure and the morbidity associated with it. If preoperative radiotherapy would be required, depending upon tumor histology, then the patients were subjected to surgery after 30 days but no later than 40 days postradiotherapy. Preoperative spinal angiography was performed in all cases to study the anatomy of Adamkiewicz artery. In one case, we had to sacrifice bilateral vertebral arteries. In this patient preoperatively, we verified the competency of collateral circulation of basilar artery by a balloon occlusion test. The procedure was performed in the angiography operating room with the patient awake and in continuous neurological control. A balloon occlusion test was performed first on right and then left vertebral arteries and finally, bilateral at the same time. The validity and the presence of collateral circulation of the basilar artery were verified and the procedure ended with the final closure of the vertebral arteries with platinum coils. The patient did not have any neurological symptoms or deficits post this procedure.

Surgical Procedure

Surgery for multilevel EBS consists of 3 parts. First is release of surrounding neurovascular structures from the tumor (mainly anterior approach), followed by pedicle screw (thoracic, lumbar) or cervical lateral mass screw insertion and *en bloc* resection of tumor (posterior approach) and finally reconstruction of the anterior defect.

In most of the cases, we released the neurovascular structures using primarily an anterior approach, except in one case where we released posteriorly first and then resected the tumor anteriorly (case example 1 mentioned in the forthcoming text). If any surrounding structures were involved in the tumor, then a partial or full resection of that structure was undertaken with the aid of another specialist surgeon (*e.g.*, in 1 case partial lung resection was undertaken by a thoracic surgeon, adventitia of the aorta was resected in another by a vascular surgeon). Once release was completed, a gauze piece would be placed anterior to the tumor, protecting the neurovascular structures and surrounding organs, which would later be accessible and removed from the second posterior approach. After completing the anterior release, patient was positioned prone for the posterior *en bloc* resection. We generally prefer a same-day anterior posterior procedure unless the patient is hemodynamically unstable after the first procedure. Posterior procedure includes insertion of pedicle screws, removal of the laminae, bilateral costotranversectomy (in thoracic spine, usually for a 4-level resection 5 to 6 ribs are removed bilaterally), resection of the nerve roots, and release of the dura from the tumor. The pedicles were then removed using high-speed burrs, curettes, or ultrasonic scalpel. In case of pedicle involvement, they were left *in situ* and removed *en bloc* with the tumor. A temporary rod was then fixed on

TABLE 1. Individual Patient Tumor Histology, Frankel Grade, Neurology, and Status at the Last Follow-up

No.	Age/Sex	Tumor Histology	No. of Levels Affected	Area	Frankel Grade		Follow-up, mo	Status at Last Follow-up
					Preop	Postop		
1	64/M	Chordoma	4	Thoraco lumbar	E	D	84	AS
2	58/M	Chordoma	4	Cervical	E	E	26	ANLS
3	12/F	Osteosarcoma	4	Cervical	E	B	9	DLS
4	44/M	Osteosarcoma	5	Cervicothoracic	E	B	13	ANLS
5	11/M	Osteosarcoma	5	Cervicothoracic	D	E	26	ANLS
6	66/F	Chordoma	5	Thoracic	E	E	54	ANLS
7	23/M	Chondrosarcoma	4	Thoracic	D	E	8	ANLS
8	36/F	Metastatic alveolar soft part sarcoma	4	Thoracic	D	E	18	ANLS
9	61/F	Primary lung CA	4	Thoracic	E	E	12	DNLS

ANLS indicates alive with no evidence of local and systemic disease; AS, alive with evidence of systemic disease; DLS, dead with evidence of local and systemic disease; DNLS, dead without evidence of local and systemic disease; preop, preoperative; postop, postoperative.

1 side. Malleable retractors were placed anterior to the vertebral bodies, protecting the surrounding neurovascular structures. The caudad and cephalad discs were then removed, and the tumor along with the vertebral bodies and other structures involved (lung, aorta, nerve roots, *etc.*) were removed *en bloc* from posteriorly. Using large towel clips that hold the vertebrae and applying a rotating maneuver, aids in posterior *en bloc* removal of the tumor. Once the tumor is resected it is

TABLE 2. Surgical Data of All Patients

No.	Resected Levels	Approach	Surgical Time, min	Blood Loss, L	No. of Roots Sacrificed	Other Structures Resected	Type of Anterior Reconstruction	Chemo	Radio
1	T10–L1	Thoracotomy and posterior	740	9	U T10–L1	Adventitia of aorta, part of diaphragm, ribs	Carbon cage	…	…
2	C2–C5	Posterior and transmandibular	600	4	B C2–C5	U vertebral artery	Iliac graft with plate	…	…
3	C2–C5	Anterior SM and posterior	780	1.5	B C2–C5	B vertebral arteries	Titanium cage	Preop	…
4	C6–T3	Anterior SM thoracotomy and posterior	600	5	U C7–T3	U vertebral artery, ribs	Rib	Preop	…
5	C5–T2	Anterior SM and posterior	720	2.5	U C6–T3	U vertebral artery, ribs	Rib	Preop	Preop
6	T5–T9	Thoracotomy and posterior	600	4.5	B T5–T9	Ribs	Carbon cage	…	…
7	T7–T10	Thoracotomy and posterior	720	7	B T7–T10	Ribs	Carbon cage	…	…
8	T3–T6	Thoracotomy and posterior	880	2.5	B T3–T6	Part of lung, ribs, part of dura	Carbon cage	Preop	Preop
9	T1–T4	Thoracotomy and posterior	780	7	B C8–T4	Lung, ribs	Ribs	Preop	Preop

C indicates cervical; T, thoracic; L, lumbar; U, unilateral; B, bilateral; SM, sternocleidomastoid approach; preop, preoperative.

TABLE 3. Histopathology Margins and Tumor Dimensions

No.	Tumor Size, cm	Tumor Volume, cm^3	Histopathology Margins	Margins at Dura/Roots
1	15×10×8	1200	M	W
2	7×4×5	140	M	W
3	5×4×3	60	M	I (C3 root)
4	12×9×7	756	M	W
5	6×7×3	126	M	W
6	13×5×5	325	W	W
7	12×6×2	144	W	W
8	10×6×4	240	M	I (dura*)
9	11×7×5	385	M	W

*Part of dura was excised en bloc with the tumor.

I indicates intralesional; M, marginal; W, wide.

sent for CT scan to confirm the margins achieved. The caudad and cephalad endplates are then curetted to prepare a vascular bed for fusion. In cases where only half of the vertebral bodies were removed, the posterior vertebral osteotomy was done using ultrasonic scalpel and osteotomes while maintaining anterior control and protection of the major surrounding organs with malleable retractors. The gauze piece that was placed during the anterior procedure was then removed, and a thorough wash using normal saline was given.

Anterior reconstruction in thoracic and lumbar spine was then performed using stacked carbon cages (Ostapek, coLigne, Biomet, Zurich, Switzerland) filled with iliac crest and rib autograft. For cervical spine reconstruction we used rib strut grafts, titanium cages with anterior cervical plates. Iliac crest or rib grafts were also placed posteriorly over the lamina or intertransverse area for additional fusion. The rods were then applied and compressed. We also used false pedicles connecting the cage anteriorly and rod posteriorly. This was mainly done to prevent the lung falling onto the dura. Drains were placed and skin closed in layers. Postoperatively, patient was transferred to intensive care unit for continuous monitoring.

RESULTS

Out of 70 patients treated with multilevel EBS, 9 patients were identified who required a minimum 4-level *en bloc* resection: five males and 4 females. Mean age was 41.66 years (11–66). There were 8 primary malignant tumors (3 chordomas, 3 osteosarcomas, 1 chondrosarcoma, 1 primary lung tumor encroaching the spine) and 1 metastatic alveolar soft part sarcoma (Table 1). The region involved were 2 cervical, 2 cervicothoracic, 4 thoracic, and 1 thoracolumbar. All classified as type 6 lesions according to Tomita *et al*[20] surgical classification. Two patients were previously operated at another institution, and so had a tumor histopathological diagnosis. The other 7 patients underwent preoperative biopsy. Six were operated with 4-level *en bloc* and 3 with 5 levels. Eight patients underwent a same-day anterior posterior surgery, and 1 patient underwent a

TABLE 4. Table Showing Complications Encountered and Final Recovery

No.	Complications	Intraoperative	Early Postoperative	Late Postoperative	Total Hospital Stay, d	Final Recovery From Complications
1	2 major 1 minor	Massive blood loss	Neurological deterioration, hypotension		42	Full recovery
2	2 major 1 minor	Dural tear	Deep wound infection	Construct failure with loss of correction	22	Full recovery
3	1 major 3 minor	Dural tear	Quadriplegia	Dysphagia, pneumonia	22	Died at 9 mo due to disease with partial recovery of quadriplegia
4	1 major 2 minor	Dural tear	Quadriplegia	Pneumonia	39	Did not recover
5	1 major 1 minor		Dysphagia on artificial respiration	Neuropathic pain	53	Full recovery
6	Nil				23	Full recovery
7	Nil				22	Full recovery
8	1 major		Meningocele		40	Full recovery
9	1 major 1 minor	Dural tear	Tracheostomy artificial respiration		24	Full recovery

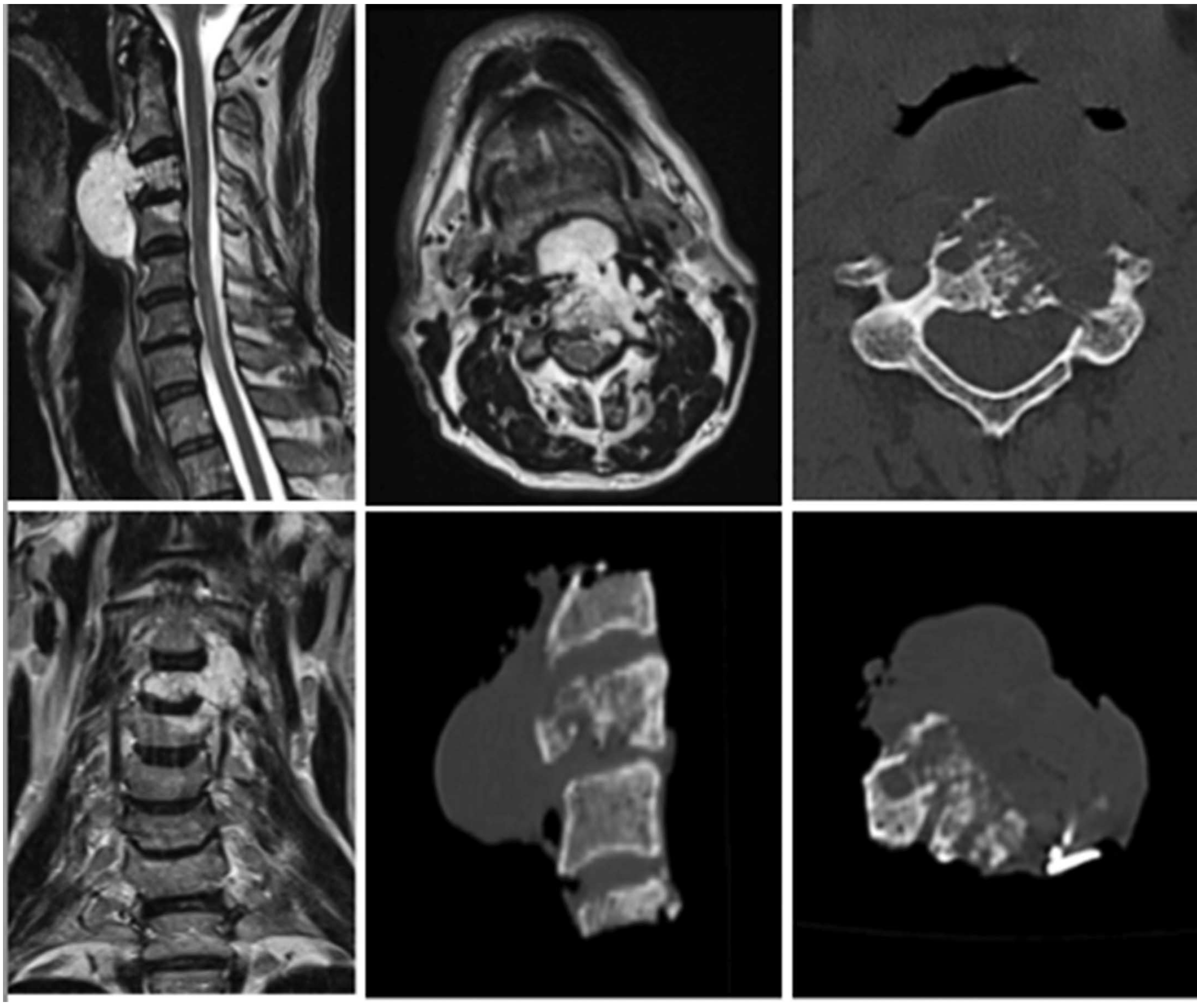

Figure 3. Top (L to R), sagittal and axial MRI showing tumor extending anteriorly from base of C2 to C5. Axial CT scan showing destruction of bone and involvement of left vertebral artery. Bottom (L to R), coronal MRI showing tumor extension on left side. Sagittal and axial CT scans of resected specimen. MRI indicates magnetic resonance images; CT, computed tomography.

posterior first and anterior after 2 days. The mean surgical time was 713 minutes (600–880) and estimated blood loss was 4.5 L (1.5–9). Individual surgical details are mentioned in Table 2. Five patients were subjected to preoperative chemotherapy and 3 to radiotherapy. Mean follow-up was 27.7 months (8–84 mo). At the last follow-up, 6 patients were alive with no evidence of local or systemic disease, 1 patient alive with evidence of systemic disease, 1 died at 9 months of systemic disease and also had evidence of local recurrence, 1 died at 12 months without evidence of local and systemic disease (Table 1). Only 1 (11%) patient had a local recurrence. Three patients with Frankel D had full neurological recovery.

The mean size of resected specimen was 8.7 × 6.4 × 4.6 cm, and mean tumor volume was 375 cm^3 (60–1200). Histopathology assessment showed marginal margins in 7 patients and wide margins in 2 patients. Report also showed intralesional at the dura in 1 patient and root in another (Table 3).

In total, there were 18 complications in 7 patients (78%). There were 9 major (massive blood loss, cord injury, neurological deterioration, deep wound infection, construct failure, and meningocele) and 9 minor complications (4 intraoperative dural tears, 2 patients had postoperative dysphagia, 2 pneumonia, 1 neuropathic pain). The mean hospital stay was 31.88 days (22–53). One patient did not recover from his quadriplegia and is alive free of disease. One patient with postoperative quadriplegia (partial recovery) and who had intralesional margin at 1 nerve root in histopathology died at 9 months secondary to lung metastasis with evidence of local disease. The other 5 patients (71%) fully recovered from their complications at the last follow-up (Table 4).

Case Example 1

A 58-year-old male, presented with symptoms of pain in the cervical spine and difficulty in swallowing since 5 months without neurovascular deficit. MRI and CT scan showed pathological fracture at C3 with prevertebral mass extending from base of C2 to upper endplate of C5, involving the left vertebral artery and nerve roots (Figures 3, 4). He underwent an open biopsy, which revealed the tumor to be a chordoma. The tumor extended 2 cm anteriorly, hence after discussion

Figure 4. Top (L to R), postoperative radiographs and CT scan. Bottom (L to R), radiographs at final follow-up. CT indicates computed tomography.

with a otorhinolaryngeal surgeon, a decision was made to release the tumor posteriorly from the dural sac, cut the nerve roots (C2–C5) and instrument from the occiput to T1, followed 2 days later by a *en bloc* excision anteriorly, *via* a tongue and mandible splitting approach. Four-level *en bloc* (C2–C5) resection was carried out. The left vertebral artery was sacrificed. Reconstruction anteriorly was done using iliac crest bone graft and plate. Intraoperatively, patient had a dural tear that was repaired. The total surgical time was 600 minutes for each procedure with 3.5 L of blood loss. Postoperative period was uneventful. Patient was discharged after 22 days and did not undergo any adjuvant chemo or radiotherapy. The tumor specimen was 7 × 4 × 5 cm and volume was 140 cm^3. Histopathological results showed marginal margins. After 2 months, patient developed deep wound infection, which was debrided, and intravenous antibiotics were given for a month. At 8 months, postsurgery patient returned with construct failure. Subsidence of graft anteriorly and screw loosening with rod breakage. He was subjected to another surgery with change of implants and anterior reconstruction with cement. At 26 months, the patient is alive with no evidence of local or systemic disease and is able to carry out all activities of daily living.

Case Example 2

A 12-year-old female, with neck pain, was diagnosed after an open biopsy as having radiation-induced osteosarcoma (she had previously undergone radiation for a primary soft tissue tumor) with pathological fracture of C3 and tumor extending from C2–C5 on the left side (Figure 5). She was treated with a 4-level EBS (half of odontoid to C5 with bilateral vertebral arteries) after preoperative chemotherapy and occlusion of bilateral vertebral arteries by radiologist. She was operated with a same-day anterior release (presternocleidomastoid vertical approach) followed by posterior release, *en bloc* resection and instrumentation (anterior reconstruction with titanium mesh cage packed with iliac crest graft and posterior instrumentation from occiput to T6 with rib strut grafts from occiput

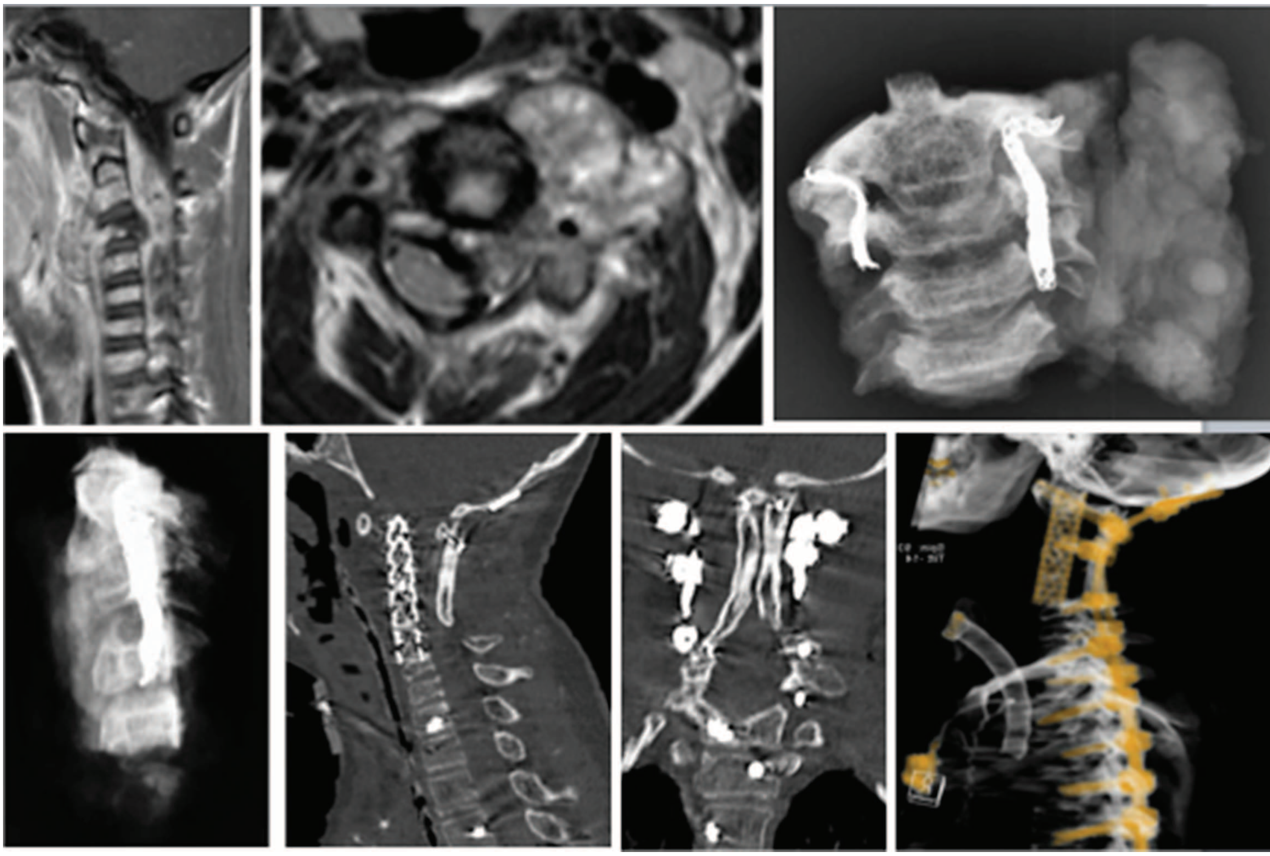

Figure 5. Top (L to R), sagittal and axial MRI showing tumor extending from C2–C5. Coronal CT scan of resected specimen showing *en bloc* resection from C2–C5 with bilateral vertebral arteries. Bottom (L to R), sagittal CT of resected specimen. Postoperative, sagittal, coronal (posteriorly, rib graft used from occiput to C5) and 3D reconstruction. MRI indicates magnetic resonance images; CT, computed tomography.

to C5 bilaterally). Bilateral vertebral arteries and C2–C5 nerve roots were resected. Total surgical time was 780 minutes, and blood loss was 1.5 L. Intraoperatively, there was a dural tear, which was repaired. The tumor size was 5 × 4 × 3 cm and volume was 60 cm^3. Histopathology report indicated marginal margins at the spine but intralesional at C3 nerve root. Postoperatively patient developed incomplete quadriplegia and was kept on artificial respiration. Later, she developed dysphagia and pneumonia, which resolved. She was discharged in 22 days with a tracheostomy. The patient partially recovered from quadriplegia but died after 9 months secondary to lung metastasis and with local recurrence of tumor.

Case Example 3

A 66-year-old female diagnosed after a CT trocar biopsy as having chordoma involving spinal segments from T5–T9. She underwent a 5-level *en bloc* resection by a same-day anterior release (thoracotomy approach) with posterior *en bloc* excision from T5–T9, after resecting 5 ribs, and 5 nerve roots bilaterally (T5–T9). Anterior reconstruction was performed using stacked carbon cage packed with iliac crest bone graft and posterior pedicle screw instrumentation. The surgical technique used, was on the principles of Roy-Camille.[2] Total surgical time was 600 minutes with 4 L blood loss. The excised specimen measured 13 × 5 × 5 cm and 325 cm^3 in volume. Histopathology report showed marginal margins. Postoperative recovery was uneventful, and she was discharged in 23 days. At the 54-month follow-up, she is alive without any evidence of local or systemic disease and plays golf regularly (Figures 6–8).

DISCUSSION

Radical resections are frequently carried out for malignant tumors involving long bones with good success rates.[23] In the spine, radical resection is rarely possible, hence wide or marginal resection is often the goal to achieve safe margins. Total EBS has stood the test of time in achieving this goal.[2–11] However, due to the complex spinal anatomy further altered by the tumor itself, morbidity associated with this procedure is relatively high. Also adding to this complexity, is fibrosis caused by preoperative radiotherapy or repeat surgical procedures, involvement of neurovascular and visceral structures. Multilevel spondylectomy, may be compared with the tip of an iceberg that hides underneath the gravest complexities imagined. However, this iceberg has to be encountered and passed, with the safest approach possible, or the ship may sink and succumb to the tumor.

Druschel *et al*[16] reported 2 cases of recurrent spinal sarcoma treated with 4-level total EBS. Both patients showed a good functional outcome without neurological deficits,

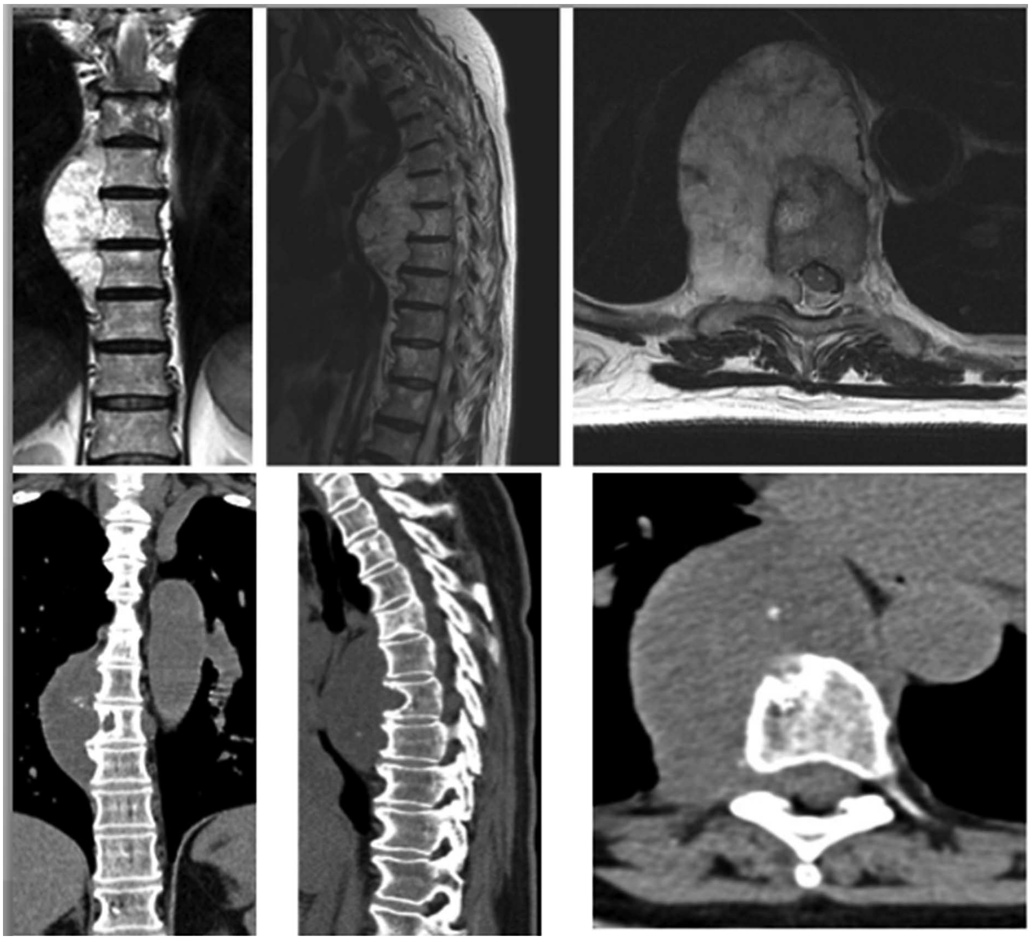

Figure 6. Coronal, sagittal, and axial MRI (top L to R) and CT (bottom L to R) showing chordoma extending from T5–T9. MRI indicates magnetic resonance images; CT, computed tomography.

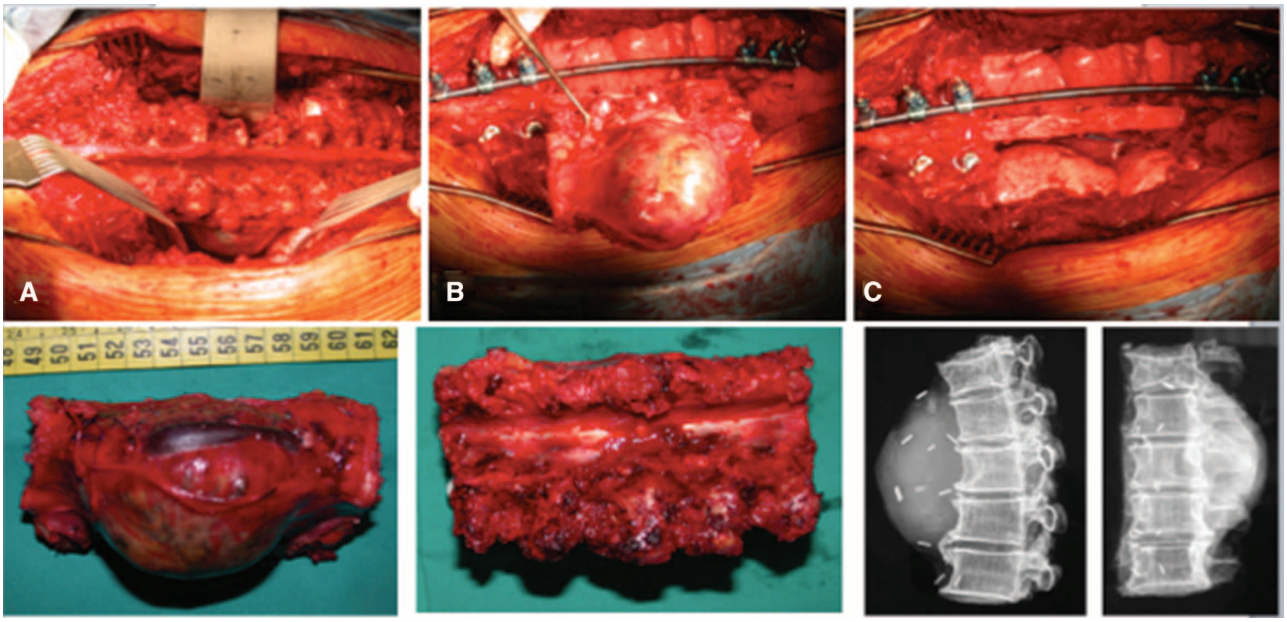

Figure 7. Top (L to R), **A**, Intraoperative images showing preparation and release posteriorly for 5-level *en bloc* resection. The spatulas were placed anterior to the vertebrae protecting the vascular structures. **B**, *En bloc* resection of the tumor. **C**, The left lung is visualized in the field after tumor removal. Bottom (L to R), images of the resected specimen and sagittal and coronal CT scan of the resected tumor. CT indicates computed tomography.

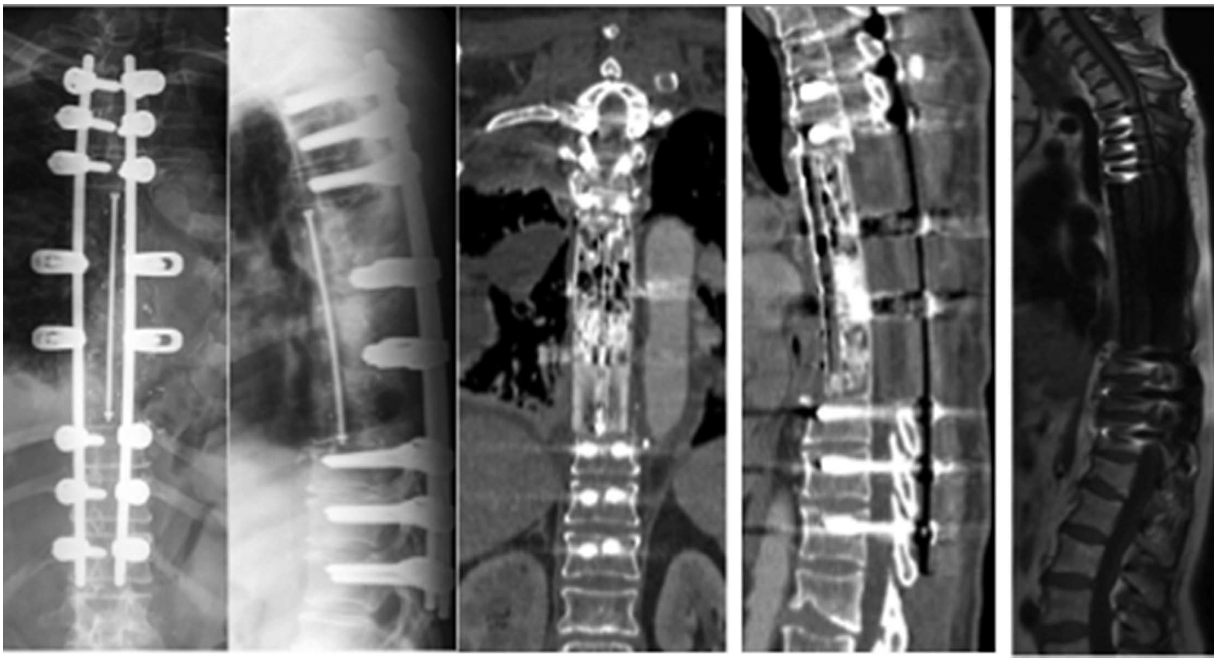

Figure 8. Postoperative radiographs, CT scan, and MRI showing anterior reconstruction with stacked carbon cage packed with bone graft. MRI indicates magnetic resonance images; CT, computed tomography.

except those resulting from oncologically scheduled resection of thoracic nerve roots. At a follow-up of 13 months, there was no local recurrence or distant metastasis. Chanplakorn *et al*[14] reported a case of recurrent epithelioid sarcoma treated with a 6-level *en bloc* resection. There was no recurrence of tumor at 26 months and no major complications reported, except proximal junctional kyphosis at the last follow-up. Boriani *et al*[12] in their study on morbidity of *en bloc* resections in spine in 134 patients, had only 4 patients who were treated with a minimum of 4-level *en bloc*. There were 29 patients treated with a 2- or 3-level *en bloc* and the rest were single level. They concluded that combined approach and multilevel surgical procedures were independent predictors of major complications. Disch *et al*[19] in their report on multilevel EBS in 20 patients had 4 patients treated with a 4-level thoracic *en bloc* resection. Three patients had no evidence of disease at the final follow-up, and 1 patient was alive with evidence of disease. Surgical margins achieved were marginal in 3 and wide in one. The authors have mentioned complications in general for all cases. No specific mention of complications related to 4-level *en bloc* procedures. However, they reported that all major and minor complications that appeared because of the extensive resections were reversible in the course of the hospital stay except in 1 case of a persisting neurological deficit based on a spinal cord ischemia. In our series, 1 patient treated with a 4-level thoracolumbar *en bloc* resection had neurological deterioration that completely recovered. Two patients who had cervical *en bloc* resections had postoperative quadriplegia (1 partial recovery). Postoperative neurological deterioration has been attributed to spinal cord ischemia caused because of ligation of segmental vessels and nerve roots.[24–27] However, we did not have any neurological deficits in 6 patients, in spite of extensive surgery and root resections. Murakami *et al*[28] retrospectively studied neurological status in 79 patients postspondylectomy. None of the patients had neurological deterioration postsurgery.

The limitation of this study is the small number of patients. There are larger studies on EBS,[12,28] however the percentage of multilevel (4 levels or more) resections in these studies are also limited. Our series reports a complication rate of 78% (7 of 9), but 71% of patients with complications (5 of 7) completely recovered. A total of 89% of the patients had no local recurrence at final follow-up and are alive. Only one patient (11%) had infection and instrument failure. There were no intraoperative deaths or complications secondary to vertebral artery occlusions, lung resections, or aorta dissections.

CONCLUSION

Multilevel EBS, can be offered to a patient to prevent local recurrence of disease. Even in experienced hands, the risks of intra- and postoperative complications are high. However, most of the patients with complications, recovered completely. A decision for surgery should be made after a thorough discussion with the oncologist, approach surgeons, anesthesiologist, radiotherapist, and most importantly the patient. Although the surgery itself may prove beneficial, patients should be well informed regarding the morbidity associated with it.

➢ Key Points

- ❑ Multilevel EBS, can be offered to a patient to prevent local recurrence of malignant tumors.
- ❑ Four- and 5-level EBS are aggressive procedures associated with complications and morbidity.

- Most of the patients with complications, recovered completely.
- Multispecialty team approach is necessary for decision making and reducing risks.

References

1. Enneking WF, Spanier SS, Goodman MA. A system for the surgical staging of musculoskeletal sarcoma. 1980. *Clin Orthop Relat Res* 2003;415:4–18.
2. Roy-Camille R, Saillant G, Bisserie M, et al. Resection vertebrale totale dans la chirurgie tumorale au niveau du rachis dorsal par voie posterieure pure. *Rev Chir Orthop* 1981;67:421–30.
3. Stener B. Total spondylectomy in chondrosarcoma arising from the seventh thoracic vertebra. *J Bone Joint Surg Br* 1971;53:288–95.
4. Boriani S, Biagini R, De Iure F, et al. En bloc resections of bone tumors of the thoracolumbar spine. A preliminary report on 29 patients. *Spine* 1996;21:1927–31.
5. Tomita K, Kawahara N, Baba H, et al. Total en bloc spondylectomy for solitary spinal metastases. *Int Orthop* 1994;18:291–8.
6. Kawahara N, Tomita K, Murakami H, et al. Total en bloc spondylectomy for spinal tumors: surgical techniques and related basic background. *Orthop Clin N Am* 2009;40:47–63.
7. Chi JH, Sciubba DM, Rhines LD, et al. Surgery for primary vertebral tumors: en bloc *versus* intralesional resection. *Neurosurg Clin N Am* 2008;19:111–7.
8. Melcher I, Disch AC, Khodadadyan-Klostermann C, et al. Primary malignant bone tumors and solitary metastases of the thoracolumbar spine: results by management with total en bloc spondylectomy. *Eur Spine J* 2007;16:1193–202.
9. Krepler P, Windhager R, Bretschneider W, et al. Total vertebrectomy for primary malignant tumours of the spine. *J Bone Joint Surg Br* 2002;84:712–5.
10. Sakaura H, Hosono N, Mukai Y, et al. Outcome of total en bloc spondylectomy for solitary metastasis of the thoracolumbar spine. *J Spinal Disord Tech* 2004;17:297–300.
11. Liljenqvist U, Lerner T, Halm H, et al. En bloc spondylectomy in malignant tumors of the spine. *Eur Spine J* 2008;17:600–9.
12. Boriani S, Bandiera S, Donthineni R, et al. Morbidity of en bloc resections in the spine. *Eur Spine J* 2009;19:231–41.
13. Samartzis D, Marco R, Benjamin R, et al. Multilevel *en bloc* spondylectomy and chest wall excision via simultaneous anterior and posterior approach for Ewing sarcoma. *Spine* 2005;30:831–837.
14. Chanplakorn P, Chanplakorn N, Pongtippan A, et al. Recurrent epithelioid sarcoma in the thoracic spine successfully treated with multilevel total en bloc spondylectomy. *Eur Spine J* 2011;20: S302–8.
15. Kato S, Kawahara N, Murakami H, et al. Multi-level total en bloc spondylectomy for solitary lumbar metastasis of myxoid liposarcoma. *Orthopedics* 2010;33:446.
16. Druschel C, Disch AC, Melcher I, et al. Surgical management of recurrent thoracolumbar spinal sarcoma with 4-level total en bloc spondylectomy: description of technique and report of two cases. *Eur Spine J* 2012;21:1–9.
17. Matsumoto M, Ishii K, Takaishi H, et al. Extensive total spondylectomy for recurrent giant cell tumor in the thoracic spine. *J Neurosurg Spine* 2007;6:600–5.
18. Hardes J, Gosheger G, Halm H, et al. Three-level en bloc spondylectomy for desmoplastic fibroma of the thoracic spine. *Spine* 2003;28:E169–72.
19. Disch AC, Schaser KD, Melcher I, et al. Oncosurgical results of multilevel thoracolumbar en-bloc spondylectomy and reconstruction with a carbon composite vertebral body replacement system. *Spine* 2011;36:E647–55.
20. Tomita K, Kawahara N, Kobayashi T, et al. Surgical strategy for spinal metastases. *Spine* 2001;26:298–306.
21. Tokuhashi Y, Matsuzaki H, Toriyama S, et al. Scoring system for the preoperative evaluation of metastatic spine tumor prognosis. *Spine* 1990;15:1110–3.
22. McDonnell MF, Glassman SD, Dimar JR, et al. Perioperative complications of anterior procedures of the spine. *J Bone Joint Surg Am* 1996;78:839–47.
23. Ruggieri P, Bosco G, Pala E, at al. Local recurrence, survival and function after total femur resection and megaprosthetic reconstruction for bone sarcomas. *Clin Orthop Relat Res* 2010;468:2860–6.
24. Kawahara N, Tomita K, Baba H, et al. Cadaveric vascular anatomy for total en bloc spondylectomy in malignant vertebral tumors. *Spine* 1996;21:1401–7.
25. Nambu K, Kawahara N, Kobayashi T, et al. Interruption of the bilateral segmental arteries at several levels: influence on vertebral blood flow. *Spine* 2004;29:1530–4.
26. Fujimaki Y, Kawahara N, Tomita K, et al. How many ligations of bilateral segmental arteries cause ischemic spinal cord dysfunction? An experimental study using a dog model. *Spine* 2006;31: E781–9.
27. Kato S, Kawahara N, Tomita K, et al. Effects on spinal cord blood flow and neurologic function secondary to interruption of bilateral segmental arteries which supply the artery of Adamkiewicz: An experimental study using a dog model. *Spine* 2008;33: 1533–41.
28. Murakami H, Kawahara N, Demura S, et al. Neurological function after total en bloc spondylectomy for thoracic spinal tumors. *J Neurosurg Spine* 2010;12:253–6.