Indications and results of combined anterior-posterior approaches for spine tumor surgery

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Spinal instrumentation currently allows gross-total resection and reconstruction in cases of malignancies at all levels of the spine. The authors analyzed the results in 110 patients who underwent surgery for primary and metastatic spinal tumors over a 5 year period (1989-1993) at a single institution. Major primary sites of tumor included breast (14 cases), chordoma (14 cases), lung (12 cases), kidney (11 cases), sarcoma (13 cases), plasmacytoma (10 cases), and others (36 cases). Prior to surgery, 55 patients (50%) had received prior treatment. Forty eight patients (44%) were nonambulatory, and severe paraparesis was present in 20 patients. Fifty three patients (48%) underwent combined anterior-posterior resection and instrumentation, 33 (30%) underwent anterior resection with instrumentation, 18 (16%) underwent anterior or posterior resection alone, and the remaining six patients (5%) underwent posterior resection and instrumentation. Major indications for anterior-posterior resection included three-column involvement, high-grade instability, involvement of contiguous vertebral bodies, and solitary metastases. Postoperatively, 90 patients improved neurologically. The overall median survival was 16 months, with 46% of patients surviving 2 years. Fifty-three patients (48%) suffered postoperative complications. Despite the high incidence of complications, the majority of patients reported improvement in their quality of life at follow-up review. Our findings suggest that half of all patients with spinal malignancies require combined anterior-posterior surgery for adequate tumor removal and stabilization.

Key Words * spinal neoplasm * spinal cord compression * epidural tumor * spine instrumentation

During the past decade improvements in neurological diagnosis using magnetic resonance (MR) imaging, together with the development of instrumentation, have considerably expanded the role of surgery in the treatment of neoplasms of the spine.[44] Although the goal of surgery in the past was largely limited to providing histological diagnosis, neural decompression, and palliation of pain, it is now technically feasible to resect tumors completely from all levels of the spine while simultaneously restoring stability by reconstruction of the resected segments.[9,11,22] The impact of surgery on improving survival is clearly shown in the subset of patients with localized tumors and solitary metastases, in whom long-term palliation and "cures" are achievable if all gross tumor is surgically

removed.[5,39,42]

Currently, both external irradiation and surgical decompression are considered standard treatment modalities for symptomatic epidural cord compression from spinal metastases.[2,3,21,24,30,46] Surgical approaches have ranged from limited posterolateral decompression to more aggressive anterior approaches of vertebral body resection.[9,14,18,19,31,35,43,45] Although the published literature suggests that anterior approaches are more effective than posterior approaches in improving neurological deficits, there is concern about subjecting debilitated cancer patients to possibly increased morbidity and mortality from extensive surgery. Posterior approaches are more familiar to neurosurgeons, can be used along the entire spinal axis, and may allow circumferential decompression of the spine.[49] However, when performed in conjunction with instrumentation, the attendant morbidity rates may approach those of anterior surgery. As a result, even more limited decompression through the pedicle has been advocated for patients with limited life expectancies.[49]

The clinical spectrum of patients with spinal metastases is such that treatment has to be individualized for each patient.[4] In most patients, the choice of surgical approach should be based on the radiographically observed extent of the tumor, the desired goal of the therapy, and the ability of the patient to tolerate the proposed operation based on clinical and laboratory evaluation. Although a single approach may suffice in most patients, radiographic studies frequently demonstrate three-column involvement or marked instability of the spine. In such patients, a purely posterior or anterior approach does not provide sufficient access for tumor resection or correction of the instability. Thus, combined anterior-posterior approaches may be required. Although this concept is not new, and has been advocated in several small series in the literature, [19,32] no large series have analyzed long-term outcome and morbidity. Therefore, we have performed a retrospective analysis of our series of patients with spinal malignancies to determine the indications and results of this approach. Because surgery in cancer patients may be associated with considerable morbidity and prolonged hospitalization, we also analyzed outcome measures that included "quality of life." [7,8,26,34,37]

Clinical Material and Methods

Clinical Parameters

Over a 5 year period (January 1989-December 1993), a total of 110 patients with neoplastic cord compression underwent surgery performed by the senior author (N.S.) at Mount Sinai Hospital, New York. A retrospective review of the patients' charts was undertaken to determine important patient parameters; ongoing clinical and radiological follow-up review was performed in all patients who were followed jointly by the neurosurgery and oncology departments. During the last year of the study, a prospective analysis of outcome based on quality of life was undertaken. Assessment of the quality of life was made using the FACT-G scale[8] in patients shortly (within 1 month) after surgery and at periodic intervals. This scale is a subjective, brief yet sensitive, 28-item quality-of-life measure used for evaluating patients receiving cancer treatment. The questionnaire is administered by a nurse clinician and can be completed in 5 to 10 minutes. It evaluates five major parameters: physical, social, emotional, and functional well being, as well as the patient-physician relationship assessed purely from the patient perspective. Its reliability and sensitivity to change have been validated in other studies.[7,10,48] This quality-of-life assessment was begun prospectively in the last year of this study and performed postoperatively in the long-term follow up of surviving patients. The initial interview was conducted approximately 2 weeks after surgery; additional interviews were held at 3-month intervals during the

follow-up period. Forty patients completed the study, with the majority completing two or three interviews. The average score was used for each patient, and the overall mean and standard errors were calculated.

Because of the tertiary referral nature of our institution, our group included patients with complex spinal malignancies who were referred after their diagnosis was established by decompressive laminectomy. In addition, patients who had undergone prior surgery and radiation therapy were referred for treatment when they presented with local extensive tumor recurrence at their original site. Thus 55 patients (50%) in this study had undergone initial treatment elsewhere and demonstrated clinical and radiological evidence related to tumor progression. Of these, eight patients had undergone subtotal resection via laminectomy or partial resection via the anterior approach, eight patients had undergone surgery (laminectomy) in combination with radiation therapy, and 39 patients had undergone prior radiation therapy directed to the involved site.

TABLE 1 SITES OF PRIMARY TUMOR IN 110 PATIENTS REFERRED FOR SPINE TUMOR SURGERY		
Site	Total No. of Patients	No. of Patients Undergoing AP+I*
breast	14	7
chordoma	14	7
sarcoma	13	6
lung	12	4
kidney	11	6
plasmacytoma	10	2
colon/rectum	7	4
others	29	17
total	110	53
* AP+I = anterior-posterior resection with instrumentation.		

Fifty-three women and 57 men comprised the group of 110 patients. The median age of the patients was 58 years (range 28-85 years); 28 patients (25%) were over 65 years old. The primary sites of tumor are listed in Table 1, as well as the numbers of patients undergoing combined anterior-posterior resection. The most common primary sites included breast, lung, kidney, sarcoma, and colon-rectum. Patients with chordoma and plasmacytoma were included in this series because they often presented with radiological findings suggestive of metastases to the spine. The remaining patients fell into a miscellaneous group of primary sites including: lymphoma and malignant vascular (four cases each); esophagus, thyroid, primary site unknown (three cases each); prostate and carcinoid (two cases each); and uterus, cervix, larynx, salivary gland, hepatoma bladder, adrenal, and testes (one case each).

Clinical parameters evaluated prior to treatment included the patient's rating of pain, motor deficit, and ambulatory status. Pain was generally categorized as mild to none, moderate, or severe. Motor function was divided into two grades: nonambulatory paraparetic and ambulatory with varying motor deficits. In the majority of cases, these assessments were made after the patient had received full-dose corticosteroid therapy.

In 60 patients (55%) spinal involvement represented the first presentation of the malignancy; in the others, the onset to cord compression ranged from 6 months to 22 years. The major presenting complaint was progressive escalating pain in 102 patients (93%); this pain was either located in the back or associated with a radicular component. Neurological deficits resulting in loss of ambulation were noted

in 48 patients (44%); paraparesis was considered severe in 21 patients (19%). Sensory examination and autonomic dysfunction could not be accurately evaluated from chart review.

Radiographic Evaluation

The diagnosis of neoplastic cord compression was confirmed either by MR imaging or by computerized tomography (CT)-myelography in all patients. Computerized tomography using bone windows was performed at the site of compression to define the precise extent of bone destruction and to determine vertebral and pedicle diameters for placement of instrumentation. In patients with known hypervascular tumors (kidney, thyroid, plasmacytoma, and primary malignancies), spinal angiography was undertaken to perform pre-surgical embolization.[40] The extent of systemic disease was evaluated in most patients by CT scanning of the chest and abdomen, along with radionucleide bone scanning. Postoperatively, CT scans and plain spine x-ray films were obtained at regular intervals to document the completeness of resection and assess recurrences at the local site.

Indications for surgery

Indications for surgery included both "traditional" criteria, such as relapse after radiation therapy, unavailability of a histological diagnosis, and acute deterioration of the patient as well as the expanded indications previously defined: cases of solitary lesions, radioresistant tumors, and instability of the spine. In this study, curative resections were attempted in 29 patients with primary tumors of the spine (including chordomas, plasmacytomas, and bone sarcomas) as well as in 24 patients with solitary metastases to the spine (predominantly from the kidney, breast, thyroid, soft-part sarcoma, and a variety of other sites). The surgical approaches were tailored to the site of compression based on CT and MR studies, and the technical aspects of the surgical exposures have been described previously.[1,43,44] In this series, complex spinal instrumentation was used, as outlined in Table 2. The goal of each operation was gross-total resection of tumor with reconstruction of the spine.

TABLE 2	
TYPES OF INSTRUMENTATION USED IN 110 PATIENTS REFERRED FOR SPINE TUMOR SURGERY	
Type of Instrumentation*	No. of Patients
anterior instrumentation	
acrylic + Steinmann pins	24
Kaneda	11
Z-plate	12
TSRH	2
Morchet plates	7
Casper plates	6
interbody device (Harms cage)	12
posterior instrumentation	
TSRH	12
CD	7
Isola	4
Luque rods/rectangles	12
facet plates	4
cables	4
*CD = Cotrel-Dubousset instrumentation; TSRH = Texas Scottish Rite Hospital.	

The second major indication for surgery was instability of the spine. Although the criteria for spinal instability in trauma have been well established by Denis,[12] these may not always be relevant to

patients with spinal tumors. Siegal and Siegal[36] proposed several criteria for spinal instability in patients with tumors, which are outlined in Table 3.[36]

TABLE 3	
CRITERIA INDICATING SPINAL INSTABILITY IN METASTATIC DISEASE*	
1.	Anterior & middle column involvement or > 50% collapse of vertebral body height
2.	Middle & posterior column involvement or shearing deformity
3.	Three-column involvement
4.	Involvement of the same column in two or more adjacent vertebra
5.	Iatrogenic instability: Laminectomy performed to treat anterior &/or middle column disease Resection of > 50% of cut surface of the vertebral body
* Based on Siegal and Siegal.[38]	

In addition to these criteria, we believe that the extent of spine resection necessary to remove all gross tumor with negative surgical margins should also be taken into account. In this study, indications for anterior-posterior surgery included radiographic demonstration of three-column involvement, significant instability shown by translational deformity, marked kyphosis, involvement of more than one vertebral body, junctional sites such as the cervicothoracic or lumbosacral regions, or prior laminectomy, as well as potentially curative resections for solitary lesions (Figs. 1-4).

Fig. 1. Computerized tomography (CT) scans and plain x-ray film revealing a case of three-column involvement exhibited in cervical cancer metastases to L4-5 in a 52-year-old woman. Tumor resection and stabilization were performed in two stages. In the first, posterior resection with Texas Scottish Rite Hospital (TSRH) instrumentation was performed. One week later, anterior resection with reconstruction was conducted. *Left:* Axial CT scan showing extensive destruction of vertebral bodies and posterior elements and obliteration of the spinal canal. *Center:* Lateral x-ray film of the lumbar spine demonstrating the completed procedure with placement of a tibial allograft anteriorly and TSRH instrumentation posteriorly. *Right:* Postoperative axial CT scan showing gross-total resection of the tumor (representative single section shown).

Fig. 2. Magnetic resonance (MR) images and plain x-ray film obtained in a 47-year-old man with chondrosarcoma (Grade II) of C-6. *Left:* Axial MR image revealing a lobulated soft-tissue mass arising from C-6. The tumor involves the body, facets, and anterior tubercle and surrounds the vertebral artery (*arrows*). *Center:* Postoperative x-ray film showing fusion and instrumentation. Staged anterior-posterior resection was conducted in a single day. First, anterior vertebrectomy using an iliac crest bone graft, Morcher plates, and mobilization of the vertebral artery was performed; then, posteriorly, a hemilaminectomy was accomplished with posterior facet plates. To minimize the extent of cervical segments fused, screws were inserted through only one segment above and below the resected vertebra showing fusion and instrumentation. *Right:* Postoperative MR image obtained 18 months later showing no evidence of tumor recurrence.

Fig. 3. Studies obtained in a 52-year-old woman who developed postlaminectomy instability with kyphosis. *Upper Left and Right:* Axial computerized tomography scans showing involvement of T1-2 by breast cancer. The patient underwent a successful posterolateral decompression followed by external-beam radiation therapy. *Lower Left:* Sagittal T1-weighted magnetic resonance image obtained 14 months after surgery showing that the patient developed symptomatic cord compression from postlaminectomy instability and kyphosis. Staged correction was performed by means of an anterior three-level corpectomy with bone graft and Caspar plate fixation. *Lower Right:* Follow-up radiograph showing loosening of an inferior screw (*arrow*).

Fig. 4. Sagittal magnetic resonance image showing high-grade instability (fracture/dislocation with kyphosis). This 65-year-old woman with plasmacytoma of T2-3 was treated with radiation and chemotherapy. Two years later she presented with high thoracic kyphosis and "swan neck" deformity, due to a total collapse of T-2 vertebra and T1-2 subluxation (*arrows*).

In this series, translational instability was seen in four patients (4%), kyphosis caused by either multilevel involvement or postlaminectomy effect was noted in 15 patients (14%), and three-column destruction was noted in 38 patients (35%).

Fifty-three patients (48%) underwent anteriorposterior resection and instrumentation. The majority of anterior-posterior procedures were performed as staged procedures 1 week apart; approximately one-fourth of the patients underwent the anterior-posterior surgery on the same day. Reconstruction of the resected vertebral body was performed either by using polymethyl methacrylate (PMMA) or by using autografts or tibial allografts. Thirty-three patients (30%) underwent anterior resection with instrumentation, 18 patients (16%) underwent anterior or posterior resection only, and the remaining six patients (5%) underwent posterior resection accompanied by instrumentation. In the majority of patients who underwent anterior-posterior surgery with instrumentation, postoperative bracing was not used.

Postoperative irradiation of the spine using standard fractionation (generally 3000 cGy in 10 doses) was administered to 20 of the 56 patients who had not received prior radiation therapy. Reasons for not using irradiation included radioresistance of the tumor, use of bone grafts to reconstruct the spine, and early initiation of high-dose systemic chemotherapy in patients with other sites of involvement.

The presence or absence of surgical complications was documented as was the duration of survival. Survival was calculated for the entire group of patients according to histological subtype and type of surgery and stratified by subgroups according to whether preoperative paraparesis was present. Survival data were computed using the Kaplan-Meier product limit method, and comparisons between the groups were conducted using a commercially available statistical software package (SAS, version 5.8; SAS Institute, Inc., Cary, NC) to perform the log-rank and Wilcoxon tests. The presence or absence of

complications in relation to several previously noted variables were analyzed. These included age over 65 years, history of treatment, and the presence or absence of paraparesis. In previous work we noted that these variables were significantly associated with surgical morbidity and survival.[41,43]

RESULTS

Postoperatively, patients were judged to be improved if they became ambulatory or maintained ambulation following discharge. We consider maintenance of ambulation along with radiological evidence of tumor resection an "improvement" because these patients presented with escalating pain and radiological evidence of tumor growth compressing the spinal cord. In the overall group, 90 patients (82%) were considered to have improved and benefited from surgery; 20 patients (18%) were considered not to have improved because of postoperative morbidity, delayed hospital stays resulting from complications related to treatment, or their systemic cancer. Two patients suffered increased neurological deficit several days after surgery; these symptoms were secondary to loss of stability that occurred while the patients awaited the second stage of the planned procedure. Of the 48 nonambulatory patients, 32 (67%) became ambulatory after surgery; in the subgroup of 21 patients with severe paraparesis, 11 (52%) improved and became completely ambulatory following surgery. Although improvement in pain relief was measured subjectively, impressive resolution of pain was noted after surgery in 18 of 20 patients in whom escalating spinal and/or radicular pain was the major reason for operation. The mean score on the FACT-G scale was 83 ± 14.2 (mean $\pm$ standard error of the mean) in 40 patients. Because most patients were not evaluated preoperatively, the significance of this score was correlated with their clinical status. Our observations suggest that these scores indicate a positive outcome as viewed from the patients' perspective.

The overall median survival period was 16 months, with 46% of the patients surviving 2 years. If patients with chordoma and plasmacytoma were excluded from this determination, the median survival would have been 11 months with 36% surviving 2 years. The effect of paraparesis on survival was examined for the overall groups (excluding patients with chordoma and plasmacytoma). Forty-four patients who were paraparetic had a median survival of 6 months with a 2-year survival rate of 19%. Forty-two ambulatory patients had a median survival of 36 months, with a 2-year survival rate of 54%. Patients who underwent combined anterior-posterior surgery or anterior surgery had significantly better survival (median survival 16 and 12 months, respectively) than those undergoing posterior procedures alone (median 2 months). Although this difference in survival duration was statistically significant, it cannot be attributed to the surgery alone, because patients with localized disease were also selected for more aggressive surgical therapy. Patients with plasmacytoma and chordoma had the best overall median survival time (actuarial 5-year survival exceeding 5 years). In patients with solid tumors, the median survival duration of the 24 patients with solitary lesions was 36 months. Seven of these patients are still alive as of this writing with survival times ranging from 24 to 60 months.

Complication	Total No. of Patients	No. of Patients Undergoing AP+I
wound breakdown	18	15
infection	13	4
stabilization failure	11	4
excessive bleeding	10	6
vascular/visceral bleeding	6	3
respiratory failure	4	2
CSF leak	4	2

* Some patients experienced more than one complication. AP+I = anterior-posterior resection with instrumentation; CSF = cerebrospinal fluid.

Six deaths occurred within the 30-day perioperative period (mortality 5%). These included two intraoperative deaths caused by myocardial infarctions secondary to the stress of the procedure and preexisting coronary disease. Fifty-three patients (48%) experienced intra- or postoperative complications as outlined in Table 4. These included wound breakdown in 18 cases, stabilization failure in 11, infections in 13, excessive hemorrhage in 10, postoperative respiratory failure in four, intraoperative vascular/visceral injury in six, and cerebrospinal fluid leak in four patients (some patients had more than one complication). As shown in Table 4, a higher incidence of wound breakdown was seen in patients undergoing combined anterior-posterior surgery, whereas a higher incidence of stabilization failures was seen in those patients undergoing either anterior or posterior instrumentation alone. The major causes of stabilization failure included: collapse of the osteoporotic autograft used for reconstruction (three patients); pullout of posterior instrumentation due to progressive kyphotic deformity (four patients); failure of the PMMA construct following three-column tumor resection (two patients); and improper positioning of Steinmann pins (two patients).

The complication rate was clearly related to three major variables: the rate was 71% in patients aged over 65 years versus 43% in those 65 years or younger; the rate was 67% in patients with a history of treatment versus 33% in those undergoing *de novo* surgery; and the rate was 64% in the presence of paraparesis versus 39% in patients with normal ambulation. All three variables were significantly associated with the risk of postoperative complication ($p < 0.001$) according to a two-tailed chi-square test and Fisher's exact test. The complication rate was higher in those patients undergoing combined anterior-posterior surgery (33 of 53 patients; 62%) than in those patients undergoing other procedures (20 of 57 patients; 35%). The highest incidence of complications was seen in patients with either translational or kyphotic instability: 14 (74%) of 19 patients had complications. Twenty-two operations were necessary for treatment of complications: 12 for wound revision, five for infections, three for stabilization failures, and two for repair of esophageal injury.

The average length of stay in this group of patients was 24 days (range 7-120 days). The median hospital charge was \$55,500 and the average charge was \$103,000. This discrepancy is accounted for by the fact that 20% of patients accrued charges exceeding \$100,000 (data supplied by Mount Sinai Hospital). In 20 patients, morbidity from surgery clearly prolonged their length of stay in the hospital and adversely affected their quality of life. Although the complication rate affected the length of stay in this series, it did not exert a significant impact on long-term survival; 36% of the patients who suffered complications were among those surviving past 2 years. The length of stay was more than twice as long as those undergoing more limited surgery[49], but comparable to that reported by Cooper, *et al.*[7]

DISCUSSION

The surgical treatment of neoplastic cord compression continues to present a major therapeutic challenge to neurosurgeons because of the complexity of the clinical factors that have to be taken into account in the decision-making process.[3,4] Although it is generally accepted that laminectomy is of little value in the management of tumors resulting from anterior compression, it is still being recommended as a palliative procedure for patients in whom radiation therapy has failed or in whom a histological diagnosis is required.[2,3] Furthermore, it is a technically simple procedure familiar to all neurosurgeons, requiring no special equipment or expertise. In a large series of 398 patients, Bach, *et al.*, [3] reported improvement rates of 46% in patients who underwent laminectomy, 38% in patients who underwent radiation therapy, and 59% in patients who underwent a combination of laminectomy and radiation therapy. As with other retrospective series, the subsets of patients treated by the various treatment modalities varied, and the choice of treatment was based on the patient's pretreatment ambulatory status. Apart from neurological worsening, which occurred in 10% to 16% of cases, no other morbidity was mentioned. Less than 20% of the patients survived past 1 year, and no survival data exceeding 20 months were reported. Loss of stability following laminectomy has been implicated as a major reason for these poor results; findings from our series suggest that postlaminectomy kyphosis is also seen in patients who initially have undergone successful decompression for tumors.[16,20] To avoid the destabilizing effects of laminectomy, posterolateral approaches in conjunction with instrumentation have been advocated.[14,31,35] However, results obtained from direct anterior approaches using vertebrectomy and anterior reconstruction of the anterior and middle columns have produced the best results in terms of neurological improvement.[18,43] In a metaanalysis of the literature, Kostuik and Weinstein[22] noted that 80% of 427 patients treated by the anterior approach had a satisfactory outcome, whereas only 37% of 746 patients treated by posterior approaches had similar results. Although the short-term results achieved by posterolateral approaches seem encouraging, most of the published series have been small, with follow-up periods lasting less than 1 year. In the only series that provided long-term follow-up, Rompe and colleagues[31] reported on 50 patients with metastatic disease of the spine treated by dorsolateral decompression and Cotrel-Dubousset instrumentation. Among the 25 patients in that series suffering from neurological deficit, 13 improved, 10 remained unchanged and two developed an incomplete transient paraplegia. Twenty-three patients were alive after 1 year, and seven patients after 2 years. In the absence of a prospective controlled study, and knowledge of the variable criteria used for selecting those patients for the surgical procedures, it is not possible to compare survival data directly. The impact of neoplastic cord compression on overall survival was clearly demonstrated by Tomita, *et al.*:[46] regardless of the primary site and the extent of disease, the median survival of paraplegic or paraparetic patients was 6 to 8 weeks; if the patients became ambulatory, radiation therapy alone improved median survival to 6 months. Our data suggest that with complete tumor resection and stabilization, this median survival can be extended to 16 months, with one-third of the patients becoming long-term survivors. The impact of such an aggressive approach is clearly evident in patients with solitary metastases, in whom median survival time exceeded 3 years. We therefore believe that resection of solitary metastases to the spine should be considered in selected patients as a cancer therapy analogous to the standard oncological concepts of resecting metastases to other sites such as the lung and liver.[27,28] Whether these patients are "cured" requires longer follow-up review; however, our data are sufficiently encouraging to advocate our strategy of gross-total resection instead of debulking or decompressive procedures undertaken to achieve neurological palliation.

The concept of anterior-posterior surgery with instrumentation is based on experimental biomechanical

considerations, as well as on the goal of accomplishing total tumor resection. In a bovine corpectomy model, Heller, *et al.*, [19] studied the ability of various instrumentation systems to restore stability after destruction of the anterior and middle columns. Constructs included a Harms titanium cage, cross-linked anterior Texas Scottish Rite Hospital (TSRH) construct, posterior Luque rods with or without cross-links, and Luque rods embedded in PMMA. When compared to the intact state, only the combined anterior-posterior construct and the anterior TSRH construct were able to restore axial, sagittal, and torsional stiffness to levels equal to or higher than control levels. Harms [17] has suggested that anterior-posterior reconstruction should be used in all cases of tumors. Because 70% to 90% of the axial load passes through the vertebral body, the anterior construct should be strong enough to resist axial loads and torsional stresses; posteriorly, tensile stresses predominate and should be counteracted using a short segment compression construct. Cooper and associates [9] have suggested that the technique of reconstruction be based on the location of the tumor in the thoracic spine, as well as the number of columns involved. For three-column involvement between T-2 and T-10, they suggested vertebral body reconstruction and posterior instrumentation; between T-11 and L-4, they recommended anterior body reconstruction with both anterior and posterior instrumentation. Because metastatic disease in most cases involves both the vertebral bodies and pedicles (signifying three-column involvement), this would imply that all patients with metastatic disease would require combined anterior-posterior stabilization. Kostuik and Weinstein [22] therefore divided the three-column spine into six segments by subdividing each column into right and left halves; the spinal column was considered unstable if three to four columns were destroyed. In their series of 75 patients, 23 patients underwent anterior decompression and stabilization, 26 had posterior procedures, and the remaining 26 had combined anterior-posterior procedures. In our view, the rationale for combined anterior-posterior surgery should be based not only on biomechanical considerations, but also on the expected goals of therapy. In some instances, combined surgery may be the only method of restoring stability even if the expected survival is less than 1 year; however, in most instances, it should properly be used only in patients whose expected longevity justifies this extensive surgery.

The major impact of any treatment on the cancer patient is measured both in the duration and quality of survival. In this regard, our survival data in a large pool of patients, half of whom underwent unsuccessful surgery or radiation therapy, represent a major gain over the traditional 3- to 6-month median survival duration reported after more limited surgery or external radiation therapy alone. Although patient selection is clearly a factor in improved survival, more than half the patients were referred to our institution after exhausting the other available therapeutic options. However, this improvement in survival must be balanced against the considerable morbidity in this series. Most cancer patients, especially those undergoing therapy, are immunologically compromised hosts with poor bone marrow reserve; spinal cord compression frequently results in their experiencing an acute neurological deterioration and surgery often has to be performed on an emergency basis. Reported morbidity rates following surgery for spinal cord compression have ranged from 16% to 37% and are clearly influenced by prior treatment. In addition, most patients with spinal cord compression have to undergo surgery on an emergency basis, further increasing the probability of encountering complications. In a survey of oncological surgical emergencies at Memorial Sloan Kettering Cancer Center, Turnbull and Starnes [47] noted that salvage rates were disappointingly poor. In 36% of their patients, death occurred prior to discharge from the hospital and the 1-year survival was only 32%. That cancer patients receiving chemotherapy are acutely vulnerable to insults necessitating surgery was shown by the fact that 45% of the patients underwent surgery in this setting. A similar experience was reported by Ferrara and coworkers [15] who noted that 19 of 21 patients suffered a total of 51 complications. Our data indicate

that patients undergoing anterior-posterior surgery have a much higher incidence of surgical complications[6], nevertheless, the majority of these complications can be successfully managed and one-third of the patients derived long-term palliation with improvement in their quality of life. A clearer understanding and better perioperative management of these patients can minimize this high morbidity. Although infections and sepsis are common in the cancer patient,[29] our findings suggest that shortening operating times by using experienced surgical teams can substantially reduce morbidity from infections. In addition, whenever anterior-posterior surgery has to be performed in the patient who has undergone radiation therapy, the potential for wound breakdown is high. Thus, incorporating plastic closures using a myocutaneous flap will significantly reduce the incidence of wound breakdowns.[23,38] Finally, because morbidity is also related to the presence of preoperative paraparesis, earlier neurosurgical referral and use of the proper surgical approach at the time of initial operation will do much to reduce the morbidity.

At present, progressive increases in health care expenditures have resulted in marketplace and political pressures to deliver health care more economically.[6,32] With the advent of managed care and capitation programs, health care providers have to incorporate the cost of expensive procedures into balancing the benefits of palliative surgical treatment in the care of the cancer patient.[32,33] Our retrospective study was not designed to evaluate the costs of treating spinal cord compression by surgery because in the majority of our cases, no other effective therapeutic option was available. Whether the increase in long-term survival in this series can be justified in light of the high cost of treatment needs to be answered on a prospective basis by comparing the overall cost effectiveness of treating patients with spinal metastases by initial radiation therapy or posterolateral decompression or with initial definitive surgery, because prior treatment is a major contributing factor to morbidity in salvage surgery. Data are currently being collected in a more recent series of surgically treated patients to answer these important questions.

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