Strategy for the treatment of patients with spinal neoplasms

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Progress in oncological therapy within the last decade has enhanced the survival time of patients suffering from tumorous osteolyses of the spine. While the necessity of surgical intervention is often settled by acute clinical symptoms, the extent of surgery is certainly co-determined by the patient's expectations and the time of survival to be expected. We therefore developed a specific tumor algorithm for operations on the spine with special emphasis on prognosis and the attainable quality of life. The results of 154 patients with tumorous osteolyses of the thoracic and lumbar spine, who were treated according to our algorithm, underline the unequivocal advantages of initially posterior procedures.

Keywords: spinal neoplasms; internal spinal fixation; spinal surgery; posterior vertebral stabilisation

Introduction

Two decades ago, cancer mortality of male patients (aged 35–64), suffering from bone cancer, amounted to 2.14 deaths per 100,000. Since then, developments in both chemotherapy and radiotherapy as well as progress in surgery reduced the death rate to 0.85/1000,000.¹ Considering the fact that about 5% of all patients with systemic cancer develop compression of the spinal cord, and that more than 50% of the patients lose the ability to walk,² the development of new surgical techniques and the introduction of new stabilising instrumentations has gained high importance in spine surgery.^{3,4} Meanwhile, surgery could be established as a sufficient tool in the overall treatment of patients with tumor involvement of the spine.^{5–8}

In the majority of cases, the neurological problems and the progressive vertebral instability are caused by expansive growing tumor masses starting from the preferred location of the tumor, which is the vertebral body itself.⁹ In a strictly oncological meaning, the curative and radical resection of a spinal tumor is impossible and long-term recovery must be doubted. With a limited primary stability as well as due to a prolonged postoperative recuperation, operations via an anterior approach show considerable disadvantages. In accordance with the predominant aim of tumor surgery, which is to optimize the quality of life of these patients, we developed a different algorithm, which is now presented.

Tumor algorithm

The complete tumor algorithm, as used now for more than 5 years routinely in our department,¹⁰ is represented in Figure 1.

If a tumorous osteolysis of the spine is present, the imaging techniques are performed first. Plain X-ray in two planes and computer tomography of the affected area including the adjacent upper and lower vertebrae are obligatory. Depending on the acuteness of surgical intervention, other imaging techniques such as MRI, bone scan and myelography are optional.

Initially, two predominant questions besides the neurological situation must be clarified: the situation of the spinal canal and the stability of the spine itself. If the spinal canal is narrowed extensively (Figure 2), the indication for an immediate operation is given. If the spinal canal is free, an imminent or already existing instability of the spinal column might lead to immediate surgery as well. With a free spinal canal and with stable conditions of the vertebrae, the biopsy of the tumor might represent the only initial surgical step.

We always carry out the immediate operation via a posterior approach. This includes laminectomy over the affected vertebrae as well as the reduction of tumor masses in order to decompress the neural structures. The posterior stabilisation with the spinal fixator, developed by one of the authors,³ is obligatory in order to guarantee sufficient postoperative stability. The application of an intrathecal catheter with a subcutaneously placed port system serves treating further tumor pain. The biopsy of the tumorous tissue for the histopathological examination and classification of the tumor is self-evident.

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Due to the posterior instrumentation, a high initial stability can be guaranteed thus giving time for enhanced diagnostic or therapeutical steps. Further radiological procedures such as angiography including embolisation and MRI, if not done before, as well as further laboratory tests can be carried out. Together with a team of radiotherapists and oncologists of the University of Ulm, the further treatment is discussed after the arrival of the histopathological findings. This discussion is focused on the question of the survival time and of the life expectancy, because the first surgical step of posterior stabilisation already represents an adequate palliative procedure.

If the survival time is expected to last no longer than 6 months, the operation described before is the only surgical intervention. The postoperative care includes the supply with aids given only temporary without individual adaptation. Regarding the prognosis, a nursing situation at home is aspired to. In some cases, preterminal hospitalisation cannot be

avoided. If needed, voiding of the bladder is provided by urethral or suprapubic catheter drainage. If paraplegia occurs, a consiliary outpatient service by a specialised team of our or any other SCI-center takes place.

Example 1

This treatment was performed in a 60-year-old male patient suffering from a metastasis of a highly malignant pleuramesothelioma at level L5. After posterior stabilisation, he survived for 5 months keeping his walking ability with postoperatively reduced pain and he then died due to multiloculated metastatic spread (Figure 3).

Surgical treatment is enhanced in patients with an estimated life expectancy of more than 6 months. If the prognosis covers a survival time up to 24 months, a second operation using an anterior approach is carried out. Surgery includes the total or subtotal resection of the affected vertebra and the subsequent alloplastic replacement of the vertebral body with a combined metal-cement fixation. The majority of aids is still temporary in the postoperative course and, similar to the first group, a nursing situation at home should be provided. If necessary, urinary drainage requires the application of a suprapubic catheter. The prolonged life expectancy, however, justifies a short period of rehabilitation in a SCI center.

Example 2

Following this modification of treatment, a 61-year-old woman with generalized plasmocytoma affecting the 4th lumbar vertebra as well as the skull and bone marrow, underwent first a posterior stabilisation L3–L5 and 6 weeks later the vertebrectomy and alloplastic compound replacement including the implantation of a Harms cage by an anterior approach (Figure 4). Preoperative neurological symptoms with both weakness of the muscles innervated by the nerve root L4 and hyporeflexia of the patellar tendon reflex improved in the postoperative course.

If the time of survival is estimated to last longer than 24 months, the second operation is modified. Taking the better prognosis into account, the anterior procedure includes the vertebrectomy followed now by autogeneic bone grafting. Individual aids are required in the postoperative rehabilitation phase. Both complete urological rehabilitation and competent extensive rehabilitation in a SCI center for paraplegia should be carried out. Finally, the patient must regain maximum individual independence.

Example 3

This group is represented by a 60-year-old man suffering from a plasmocytoma being exclusively localized to L1. Disturbed micturition and a rapidly

Figure 1 Tumor algorithm (VBR = vertebral body replacement)

Figure 2 Remarkable narrowing of the spinal canal due to a metastasis of an adenocarcinoma of unknown origin

Figure 3 Postoperative X-ray of a 60-year-old man with a L5-metastasis of an adenocarcinoma of unknown origin; exclusively posterior operation with laminectomy, transpedicular internal fixation with the Kluger spine-fixator, screwed faced joints and intrathecal catheter

increasing paraplegic situation existed preoperatively due to tremendous narrowing of the spinal canal. Following a two-stage posterior-anterior surgical procedure with initial posterior stabilisation and subsequent anterior autogenic bone grafting in combination with a space-keeping Harms cage, a clear neurological and functional improvement with regaining walking ability occurred postoperatively in the course of an extensive rehabilitation program. This patient was free from tumor recurrence over 4 years until he died due to acute metastatic spread 51 months after surgery (Figure 5).

Materials and methods

In the main, following this algorithm when treating patients suffering from tumorous osteolyses of the spine, 154 patients (84 men, 70 women) were operated on in our clinic within a period from January 1985 to June 1996. According to our earlier mentioned tumor algorithm, 104 patients belonged to group 1 (exclusively posterior approach), 20 patients got a secondary anterior procedure with an alloplastic replacement of the vertebral body (group 2) and 12 patients had an additional anterior approach with an autogeneic vertebral body replacement (group 3). 18 patients were treated by posterior transpedicular biopsy alone.

The patients' mean age amounted to 52.7 years, ranging from 7.4 years to 85.4 years. There was a period of 5.9 months (range 2 weeks–84 months) between the first clinical symptoms at the spine and the diagnosis of a tumor. Metastases were found in a mean interval of 21.7 months (range –36 months–132 months) after the identification of the primary tumor. In 57 cases, no primary tumor was known before the first operation was carried out.

Besides the cervical spine (16 cases), the thoracic (57 cases), thoracolumbar (18 cases) and lumbar spine (61 cases) were the predominant regions affected by tumor lesions. The distribution of the involved vertebrae showed a clear preference for the lower thoracic and upper lumbar spine as is already known from the literature.¹¹ While most patients presented one (70 cases) or two (49 cases) affected vertebrae, up to six vertebrae could be affected. In 27 cases, the primary tumor was located in the spine itself, whereas in 127 cases an extravertebral location existed with a distribution preferring the breast and the urogenital tract. However, no primary tumor could be established at all in 13 cases. Additional extravertebral metastases occurred in 87 cases (45 bilocular and 42 multilocular) with a preference for bony structures, lymph nodes and the liver.

Benign lesions existed in 23 cases and were

Figure 4 Postoperative X-ray of a 61-year-old woman with generalized plasmocytoma including vertebra L4; initial posterior stabilisation with transpedicular internal fixation L3-L5 (a), 6 weeks later vertebrectomy from anterior with alloplastic compound replacement including the implantation of a Harms cage (b)

outnumbered by 131 malignant affections, thus representing a benign/malignant ratio of approximately one to six. The pathohistological examination of the surgical specimen resulted in 98 carcinoma and

33 other malignant tumors including osteosarcoma, chordoma, malignant schwannoma and Ewing's sarcoma. The remaining 23 benign histological findings included eosinophilic granuloma (three

Figure 5 X-ray and CT-scan of a 60-year-old man with incomplete paraplegia suffering from a plasmacytoma being exclusively localised on L1 (a). 4 weeks after posterior stabilisation with internal fixation Th12 - L2 and decompression by tumor-reduction via laminectomy, an anterior vertebrectomy and VBR with a cage filled with autogeneic cancellous bone was carried out (b)

cases), aneurysmal bone cyst (five cases), osteoidosteoma (five cases), osteochondroma (three cases), hemangioma (three cases) and others.

All patients except one suffered from pain prior to surgery. Another leading preoperative symptom was neurological dysfunction. Only 53 patients were free from any neurological symptoms, whereas 76 patients showed a sensory and/or motor dysfunction with varying expression. However, all of them were still able to walk. Thirty three patients had developed incomplete paraplegia with the majority of them having osteolyses in the thoracolumbar junction. One complete transverse lesion, ranked 'A' in Frankel's classification, occurred in a 76-year-old man suffering from prostate cancer. For an accurate evaluation of the neurological function, the established classification of the American Spinal Injury Association was used.

Altogether 195 operations were performed on those 154 patients. One sixth of the operations consisted of transpedicular biopsies through an exclusively posterior approach, and the majority of operations were posterior stabilisations including the surgical steps as mentioned above in the tumor algorithm. Twenty eight patients underwent secondary anterior surgery with alloplastic or autogeneic replacement of the vertebral body, and in 12 cases with already preoperatively known tumor histology, a simultaneous posterior and anterior double approach was carried out (Table 1).

Results

Considering the group of patients with a malignant tumor, the mean survival time amounted to 16.4 months (range 0.1–80.4 months). Fifty two patients being still alive presented a mean survival time of 23.4 months (range 3.2–76 months). Seventy nine patients had already died within the period of investigation and they had lived after surgery on an average of 11.8 months (range 1–62.7 months). Seven patients died within the first month after surgery due to tumor-related or non-tumor-related reasons. This represents a 30-day mortality rate of 4.5% in those patients with malignant affection. If separating into the groups according to the expected survival time and therefore to the various types of surgical procedures (see tumor algorithm), the mean survival time of those patients undergoing only the stabilisation from posterior ($x=13.9$ months; range 0.5–56.0 months) is less than the survival time of those being additionally operated on from an anterior route with alloplastic ($x=18.2$ months; range 0.25–48.0 months) or autogeneic replacement of the vertebral body ($x=41.7$ months; range 11.8–80.4 months). All patients being operated for with benign lesions are still alive except for one 53-year-old man, who died 2 years after surgery due to other reasons independent from the tumorous disease and operation.

The patients stayed for an average of 47 days in our hospital before discharge. However, no differentiation

of this data could be done due to the mixed pattern of cases including patients without and with more or less neurological deficits. In addition, some patients from external hospitals remained postoperatively in our intensive care unit only until their vital parameters were stabilized, and then they were transferred back to their home hospitals as soon as possible.

The severity of the different operating procedures is illuminated when analyzing two intraoperative parameters, which are the duration of the operation and the intraoperative blood loss (Table 2). Both parameters increase from originally little values (blood loss 270 ml/operating time 76 min) in exclusively posterior biopsies up to extensive ones (7075 ml/364 min) in the cases with a simultaneous anterior-posterior double approach. However, the complication rate did not rise in the latter.

All 53 patients with inconspicuous preoperative neurology remained unchanged after surgery and did not develop neurological alterations in the immediate postoperative course. Fifty nine patients with preoperative neuropathological symptoms including 21 patients with an incomplete paraplegia improved after surgical intervention. The patient with a complete paraplegia remained unchanged. Nine patients deteriorated in the postoperative follow-up. One 12-year-old boy deteriorated neurologically immediately after the posterior decompression and subtotal posterior vertebrectomy of an aneurysmatic bone cyst at level T4 developing an incomplete hemiparesis; however, already 6 months after the operation, a neurologically documented complete restoration has occurred. In one case of a 73-year-old man suffering from prostate cancer, incomplete paraplegia changed slowly into a complete form. Regarding the fact that this patient died 2 months

Table 1 Number of cases per operative procedure (195 operations in 154 patients)

Exclusive biopsy through posterior approach	33
Posterior stabilisation	122
Anterior stabilisation	28
Simultaneous posterior-anterior procedures	12

Table 2 Average intraoperative blood loss and operating time in proportion to the surgical procedure (range in parentheses)

	Blood loss (ml)	Operating time (min)
Posterior biopsy	270 (10–1400)	76 (10–180)
Posterior stabilisation	1800 (50–9000)	166 (45–375)
Anterior stabilisation	1780 (150–6500)	203 (70–510)
Double approach	7075 (1300–22000)	364 (235–585)

after the operation due to multilocular metastatic spread, no further diagnostic studies were possible to clarify the reason for the neurological deterioration. The remaining seven patients, with a slow deterioration of neurological functions in the long-term follow-up, showed recurrence of the tumor with invasion of the spinal canal as documented in CT scan. In these cases, which were partially treated by an additional anterior approach, tumor surgery was only of palliative character. Focusing on the ASIA classification, an overall increase of value from 93.3 points (range 50–100 points) preoperatively to 95.4 points (range 50–100 points) postoperatively occurred in the motor score with 97.3 points preop to 100 points postop in the benign cases and 92.6 points to 94.6 points in the malignant cases. The sensory contact score rose from 104.6 points (range 48 to 112 points) preoperatively to 106.9 points (range 48 to 112 points) postoperatively (combined contact and pin-prick score: 209.1 points preoperatively vs 213.9 points postoperatively). Values differed between benign cases (108.2 points preoperatively vs 112 points postoperatively) and malignant cases (103.9 points preoperatively vs 106.1 points postoperatively).

Including the nine cases with neurological deterioration as mentioned above regarding complications, 23 complications occurred in 154 patients with 195 operations thus representing a complication rate of 11.8% (including the 30-days mortality group into the complications, the complication rate would reach 15.4%). Complications included six infections (two deep, four superficial on preradiated areas; infection rate=3.1%), four thromboses and five pulmonary affections. One hundred and thirty four patients (87%) did not develop any complication.

Discussion

Tumor invasion of the spine confronts the spinal surgeon with a number of delicate general and specific problems.¹² The establishment of the diagnosis is difficult due to masked symptoms and is therefore often postponed. In correspondence with others,⁸ the delay of diagnosis of tumorous lesions of the spine amounted in our case material to approximately 6 months. Considering the nearby located spinal cord, neurological difficulties are always imminent due to the potency of growth of the tumor, and most of the patients show some kind of neurological problems as the initial symptoms. From a technical point of view, most of the operations demand a high training standard of surgical abilities. With less than 10% of all vertebral metastases requiring surgical intervention,^{5,8} therefore, accurate diagnosis and distinct indications are imperative.

Similar to others,^{6,13,14} an imminent or already existing neurological deficit, in a varying extent, is one of the leading indications. Destruction of the vertebral structures leads to a progressive instability of the vertebral column and later on to an increasing

dislocation, thus requiring surgical intervention. Further indications are uncontrollable pain resistant to any other kind of treatment, radioresistance of the tumor, verification of the diagnosis and the facilitation of the nursing situation.

With the majority of tumorous osteolyses being located in the vertebral body, an initially anterior approach seems to be logical and is often recommended as the only acceptable surgical access.^{5,14–16} It guarantees a direct approach to the affected tumor location and enables a total tumor extirpation in most cases. However, a radical removal of the tumor, in a strictly oncological meaning, is impossible. Moreover, exclusively anterior instrumentations can supply an only limited primary stability and are insufficient in the lower lumbar spine.⁵ Regarding the fact that many tumor patients present a reduced state of health, the prolonged recovery following those operations due to the intraoperative stress (own results,¹⁷) and the increased morbidity rate are of importance.

Important innovations in posterior implants came from various SCI centers^{3,4} offering the possibilities of both segmental intraspinal exploration and recalibration of the spinal canal. Moreover, these internal implants with transpedicular fixation guarantee a high initial stability without the need of postoperative bracing for a period of at least 6 months. In addition, the posterior stabilisation offers the technical advantage of smaller approaches and shorter exposures ventrally, if subsequent anterior procedures are required. Decompression by laminectomy alone, thus producing an instability by itself, is obsolete.¹⁸ Complete vertebrectomy with the removal of the tumor can be performed through both anterior⁵ and posterior¹⁹ approaches; intraabdominal and chest complications can be avoided by using the latter. Regarding our own complication rate of 15%, posterior operations do not represent a higher risk for complications in comparison with anterior procedures.^{2,7,16} Operations through the posterior approach are less invasive with the patients being hospitalized postoperatively for a shorter period¹⁷ and due to little operative stress, rehabilitation usually is quicker.

The high initial stability of posterior implants gives time for both further diagnostic steps and additional therapeutic procedures such as radiotherapy and chemotherapy. Moreover, in cases with a limited prognosis, this first surgical step already possesses the character and the quality of a sufficient palliative treatment. Pointing out, that no primary tumor site could be established in approximately 8% of our cases, the flexibility of our algorithm is obvious and is confirmed particularly regarding the acute onset of neurological symptoms. In addition with a longer lasting prognosis, the posterior procedure offers all kind of treatment options in a flexible strategy. With a prognosis of survival of more than 6 months, an additional anterior stabilisation should be carried out due to the expected fatigue behaviour of posterior implants. Independent from the type of anterior

procedure (autogeneic or alloplastic replacement of the vertebral body), however, no additional anterior stabilising implant is required.

Recently, other authors^{18,20,21} with a much smaller number of patients (11, 1 and 25 cases) presented similar strategies in treating tumors on the spine. Especially with regard to the acute development of neurological symptoms, which always requires an immediate action even if the patient is in bad shape, they recommend the posterior procedure as the treatment of choice. Shimizu *et al*¹⁸ who prefer the combination of laminectomy and posterior internal fixation with a postoperative ambulatory period of approximately 4.5 months followed by anterior or combined anterior-posterior surgery with autogeneic bone grafting, advocate additionally the posterior decompression and stabilisation as a valuable therapy for multiple spinal metastases for slow growing or controllable tumors. Olerud²⁰ postulates an indirect anterior decompression by means of ligamentotaxis. Direct anterior decompression is also possible through the posterior approach.^{19,22} All authors, however, point out the necessity for an additional anterior stabilisation with a longer lasting survival time.

Conclusion

Tumor surgery on the spine represents mostly a treatment of metastases and therefore is often of a palliative character. It is not clear, whether a prolonged survival rate is due to surgery, improved diagnostic methods or progress in oncological radio- and chemotherapy. With an unknown precise time of survival, operative treatment should be strictly dedicated to the major aim of tumor surgery, which is, in consideration of the patient's expectations, an improvement of the quality of life. With both little operative stress and morbidity as well as with the guarantee of a high initial stability including sufficient reduction, our tumor algorithm, as illustrated here, serves this philosophy. Prospective studies over the next years will have to confirm its efficiency.

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