Treatment of Spinal Tumors in a High Volume Center has Direct Impact on Local Recurrence, Morbidity, and Mortality

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Objective of the Study: En bloc resections of spine tumors aim at locally controlling the disease for both improving the patient's quality of life as well as improving mortality. The purpose of this study was to compare the outcome between patients who were initially treated in a high volume specialized center, and patients who initially underwent either invasive diagnostic procedure or an initial surgical attempt to treat the disease in a different center.

Materials and Methods: A retrospective study of 1681 patients affected by spine tumors—treated from 1990 to 2015 by the same team.

Results: A total of 220 en bloc resections that were performed on 216 patients during that period. Most of the tumors were primary—165 cases (43 benign and 122 malignant), metastases occurred in 55 cases. One hundred sixty-eight patients (77.8%) were solely treated in the institute and were considered non-contaminated cases (NCCs) and 48 (22.2%) were previously treated elsewhere and were considered contaminated cases (CCs). Median follow-up was 45 months (0–371). Thirty-three local recurrences (15.28%) were recorded. Fourteen patients (29.17%) from the CC and 19 (11.31%) from the NCC group. A total of 153 complications were observed in 100 out of 216 patients (46.2%). Sixty-four of these patients (30%) suffered 1 complication, while the rest had 2 or more. Twenty-eight (58%) of the CC group and 72 (42.85%) of the NCC group, had at least 1 complication. Sixty patients died as a result of the disease during the follow-up period. Twenty-one (43.75%) and 39 (23.21%) patients died in the CC and NCC cohorts, respectively. CC, surgical margins of the resected tumor—intralesional, marginal, and malignant tumors, were statistically significant independent risk factors for local recurrence of the tumor. Contamination, local recurrence, neoadjuvant radiotherapy, the number of level resected, and metastatic tumors compared with primary malignant tumor, were shown to be independent risk factors for patient's death.

Conclusions: It is apparent that there is a substantial added risk in performing either invasive diagnostic procedures or attempting a surgical resection of the tumor in a nonspecialized center. This risk includes both higher recurrences of the tumor as well as increased mortality. It is therefore reasonable to conclude that the whole treatment, from biopsy to resection, should be performed in the same center, and this center should be a high volume, specialized in treating these type of spine pathologies. The surgeon who treats the patient first has a great responsibility, as it is the first treatment that most affects prognosis. To reduce the chance of local recurrence, morbidity, and mortality, all invasive diagnosis and treatment, should be performed by an experienced team, as the consequences are dramatic.

Key Words: en bloc resection, spine tumors, outcome

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Primary bone tumors of the spine are very rare[1]: they comprise only 10% or less of all bone tumors. In the United States about 7500 new cases are estimated per year. The overall world occurrence can be expected to be 2.5–8.5 cases per million inhabitants per year. Compared with primary spinal tumors, metastatic tumors are much more common in the spine, being the most common skeletal region for secondary tumors. The occurrence of spinal metastases in the clinical course of common solid tumors is reported 20%–70%, therefore a 30–50 times more frequent incidence is reported compared with primary bone tumors of the spine.

The occurrence of other spinal pathologies such as lumbar stenosis, cervical radiculopathy, and acute spinal cord injury is estimated at 300 cases, 83 cases, and 5 cases per 100,000 persons per year, respectively,[1] being much higher. These figures of low relative prevalence explain why these tumors are often unsuspected, and misdiagnosed in many cases, an unfortunate reality resulting in incorrect treatment.

En bloc resections[2] are the procedures aimed at surgically removing a tumor in a single, intact piece, fully encased by a continuous shell of healthy tissue, which is

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defined as the "margin." These operations can also be performed in the spine,[3–9] where anatomic and surgical constraints make them technically demanding. Either multiple surgical approaches or a widely enlarged single posterior approach must be planned for the complete removal of the tumor without violation of its margins. The requirement of a margin encasing the tumor can, at times, be met by resecting relevant anatomic structures[10–15] (pleura, dura, muscles, nerve roots, nerves, vessels, and so on). Intentional transgression of oncological principles[2,5,16] may be considered, the advantage in terms of reduced morbidity and better functional results being weighed against the higher risk of recurrence.

En bloc resection has proved effective in improving the prognosis of primary bone tumors of the spine[7,16–19] and the quality of life of patients with some isolated metastases such as renal cell carcinoma[20,21] and thyroid cancer.[22] The local control of the disease is markedly increased when margins are tumor free, where if an en bloc resection is achieved the local control rises to 92.3% in giant cell tumor (GCT),[23] to 78% in chordoma (CH)[17] and to 82% in chondrosarcoma (CHS),[18] compared with the local control achieved in the same studies by intralesional surgery: 72.2% in GCT,[21,23] 22% in CH,[17] and 0% in CHS.[18] In a recent study, reporting a series of 103 patients, both marginal and intralesional resections were shown to be an independent risk factors for local recurrence with hazard ratio of 9.45 and 38.62, respectively.[16]

The low prevalence of these pathologies combined with the complexity of the preoperative as well as the intraoperative decision making and the highly demanding surgical procedure, suggests that the advantage in treating these pathologies in a high volume experienced center might effect the patient's outcome both in terms of morbidity as well as mortality. Furthermore, it is postulated that not only the major surgical treatment, but also the invasive diagnostic procedures might also affect the patient's outcome. This assumption is demonstrated by a case of a 49-year-old male, submitted to biopsy in a nonspecialized center by laminectomy. The diagnosis was CH, however, the laminectomy had contaminated the epidural space and notwithstanding en bloc resection a recurrence occurred exactly at the site of the biopsy. Later on, despite all surgical and proton therapy administered, treatment was not effective in preserving the patient from disease progression and death. (Figs. 1–4).

The goal of this study was to evaluate whether concentrating the entire treatment (starting from the diagnostic invasive procedures) in a single center has an effect on patient outcome. For that purpose, a comparison between 2 cohorts of spine tumor patients that were treated with the oncological potential of local tumor control and perhaps healing was made. The first cohort comprised oncological cases that were solely treated in such a high volume center including the entire invasive diagnostic and surgical procedures, the second cohort comprised patients that were partially treated in another institution and were referred to this high volume center for the completion of treatment.

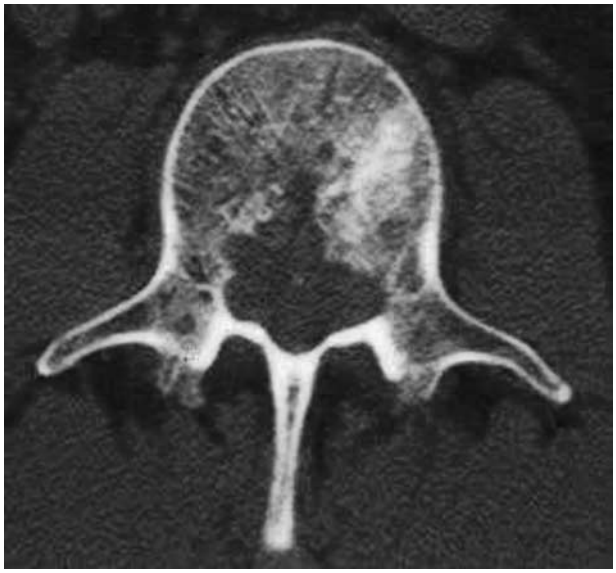

FIGURE 1. Prebiopsy computed tomography—axial image showing the location of the initial tumor to be biopsied, the biopsy was performed through an open laminectomy, thus violation of the tumor and seeding of tumor cells in epidural space.

MATERIALS AND METHODS

From January 1990 to July 2015, 1681 consecutive patients with spine tumors were diagnosed and treated in the same institution. Two hundred twenty en bloc resections were performed on 216 patients by the senior author (S.B.) and his team. All cases underwent full

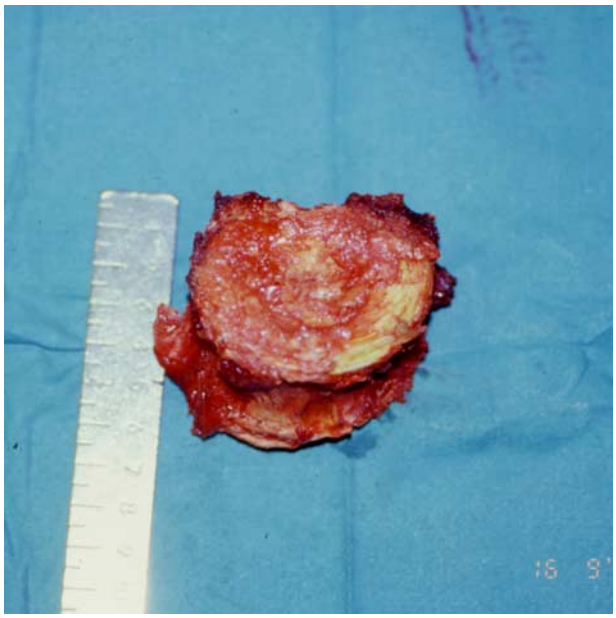

FIGURE 2. Image of the vertebra removed completely during en bloc resection.

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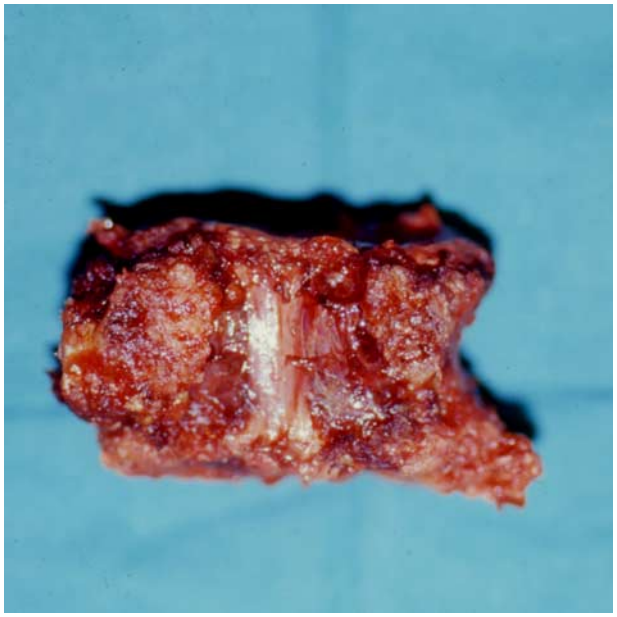

FIGURE 3. Posterior wall of the removed vertebra—note the tumor invasion to the epidural space—at the site of the open biopsy.

clinical radiographic and histologic study, and were classified according to the Enneking staging system[2] and the Weinstein, Boriani, Biagini surgical staging system.[24] Surgery was planned accordingly. From the beginning of the period, all available data were inserted into a purpose-built database for use in a prospective study. The decision to attempt a resection en bloc was made in every case treated in the institution based on the primary pathology, the staging and surgical classifications, and the patient's medical condition and prognosis.

Inclusion criteria for performing an attempt of en bloc resection were as follows:

(1) According to the Enneking classification[2]:
   (a) Benign stage 3.
   (b) Malignant stage 1 A and B.
   (c) Malignant stage 2 A and B.
(2) Surgical feasibility based on the Weinstein, Boriani, Biagini staging system.[24]

Exclusion criteria:

(1) All cases that did not meet the inclusion criteria.
(2) Medically unfit for surgery based on the anesthetic preoperative evaluation (mostly American Society of Anaesthesiologist, 4–5).

Cases that were both diagnosed and treated in full at the authors' institution were classified as "noncontaminated cases" (NCC) and comprised the first cohort. Conversely, patients who were referred for treatment following an initial diagnostic measures that included open biopsy or were treated surgically at another institution were grouped in the category "contaminated cases" (CC) for analysis, and comprised the second cohort.

Patient outcome factors that were reviewed for this study included disease parameters including local recurrence and mortality from the disease, and patient morbidity including intraoperative, early and late postoperative complications.

The complications were divided into major and minor as described by McDonnell et al[25]: any complication that appeared to substantially alter an otherwise full and expected course of recovery was considered to be a "major" complication; others were regarded as "minor." Complications were also correlated with the type of resection and the approach adopted: single posterior approach or combined anterior and posterior approaches in the same surgical session. No resection was staged in >1 operation.

FIGURE 4. Magnetic resonance image demonstrating the recurrence of the tumor at the site of the biopsy.

Statistical Analyses

Continuous variables were expressed as mean ± SD, if Gaussian, or as median and 25th–75th percentile, if skewed. Normality of distribution was assessed by means of the Kolmogorov–Smirnov test. Categorical data were shown as absolute and relative frequencies.

A logistic regression analysis was applied to find predictors of local recurrence, complications, and death, considering sex, age, staging, contamination, surgical approach and neoadjuvant and adjuvant therapy (chemical and radiation) as covariates. The multivariate model included only covariates with a $P = 0.10$ in univariate analysis and was adjusted for location and number of resected levels. Calibration and discrimination of the multivariable model were evaluated by means of the Hosmer–Lemeshow test and the c-statistic, respectively.

A regression analysis was performed to estimate the risk of local recurrence due to contamination.

A 2-sided $P = 0.05$ was considered to be significant.

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For all analyses, SPSS 23.0 statistical software was used (SPSS Inc., Chicago, IL).

Terminology for resections[2,24]:

(1) Intralesional excision: defined as piecemeal removal of the tumor was further subcategorized into:
   (a) Intracapsular: where tumor removal was incomplete, thus gross or histologic remnants inside the tumor capsule could be expected.
   (b) Extracapsular: where the whole tumor mass was removed together with the peripheral tissue (3–5 mm or more of healthy peripheral tissue).

(2) En bloc resection: Complex surgery aimed at removing en bloc the whole tumor mass, including a cuff of healthy tissue encasing the tumor. The histopathologic evaluation of the resected specimen enabled en bloc resections to be further subclassified as:
   (a) Intralesional, if the tumor was violated by planned or unplanned transgression to spare important neurovascular structures, thereby causing tumor spillage.
   (b) Marginal, if a very thin shell of normal tissue covered the tumor.
   (c) Wide, if a thick layer of peripheral healthy tissue, a dense fibrous cover (eg, fascia), or an anatomic barrier not yet infiltrated (eg, pleura), fully covered the tumor.

RESULTS

From January 1990 to July 2015, 1681 consecutive patients with spine tumors were diagnosed and treated in the same institution. A total of 220 en bloc resections were performed on 216 patients during that period. All cases with an attempt of resecting a tumor en bloc, as decided by the team were included in this study for analysis. Decision was based on the patient's pathology, staging, surgical feasibility of removing the tumor en bloc as described in the methods.

The study group consisted of 113 male and 103 female patients with an average age of 44.1 ± 18 (range, 3–82 y). The median follow-up (FU) was 45 months (last clinical FU examination or until death: range, 0–371 mo). FU was available for at least 24 months in 139 cases (63.2%); 25 of the remaining 81 died <2 years after surgery, 7 from complications and 18 from the disease. A total of 61 patients died from the disease. Most of the tumors were primary—162 cases (43 benign and 119 malignant), metastases occurred in 54 cases. The location of the tumor was lumbar in 114 cases, thoracic in 95, and cervical in 11. A single (posterior or anterior) approach was adopted in 81 procedures, whereas 139 involved a combined anterior and posterior approaches under the same anesthesia. No resection was staged in >1 operation.

Surgical Margins

With regard to the margins determined by the pathologist following the examination of the final specimen, "wide" was obtained in 128 cases; "marginal" in 61 patients, and "intralesional" in 31 cases.

Contamination

Of the 216 patients reviewed for this study, 168 patients (77.8%) were solely treated in the Attributing Author's Institute and were defined "noncontaminated cases" (NCC) and 48 (22.2%) were previously treated elsewhere and were defined "contaminated cases" (CC). Comparison of these 2 groups with regard to categorical parameters—sex, malignancy of tumor (primary benign, malignant, or metastatic), and ordinal parameters—age, had no statistically significant difference when performing the χ^2 test and the t test, respectively. The distribution of pathologies and staging between the 2 groups was similar with regard to the common pathologies (CH, CHS, osteogenic sarcoma, GCT, metastatic renal cell carcinoma, osteoblastoma), other pathologies (met thyroid, angio sarcoma, and met liposarcoma) were not referred from other institutions. FU was available for at least 24 months in 111 patients (66%), and 26 patients (54%) in the NCC, and CC groups, respectively. The distribution of FU times appeared to be without significant difference (Fig. 5).

Local Recurrence

Thirty-three local recurrences (15.28%) were recorded after a median FU of 45 months (range, 0–371 mo). Fourteen patients (29.17%) from the CC and 19 (11.31%) from the NCC group suffered from local recurrence of the tumor.

Morbidity and Mortality

A total of 153 complications after en bloc excision were observed in 100 out of 216 patients (46.2%). Sixty-four of these patients (30%) suffered 1 complication; 25 (11.1%) had 2 complications; 6 (3.2%) had 3 complications; 3 (1.4%) had 3, and 2 (0.4%) had 5 complications.

Of the 48 patients in the CC group, 28 (58.33%) had at least 1 complication whereas in the NCC group, of the 168 NCC patients, 72 (42.86%) suffered from at least 1 complication. A total of 48 complication occurred in these 28 patients of the CC group, 39 major, and 9 minor. This is compared with a total of 105 complication occurring in the 72 NCC group (66 major and 39 minor).

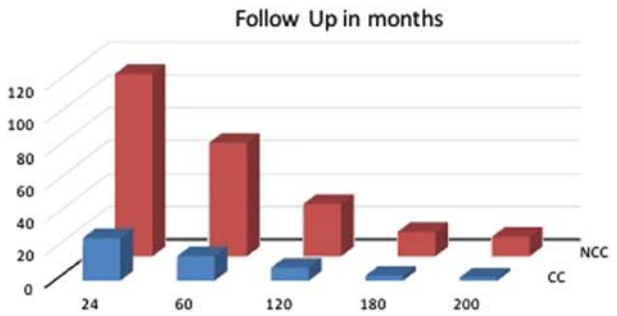

FIGURE 5. Follow-up distribution, in months. CC indicates contaminated group, NCC, noncontaminated group.

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Sixty patients died as a result of the disease during the FU period. Twenty-one (43.75%) and 39 (23.21%) patients died in the CC and NCC cohorts, respectively.

Statistical Analysis

The multivariate model used to predict local recurrence, complications and mortality, included age, sex, oncological stage as described by Enneking, type of tumor (benign, malignant, and metastatic), contamination, surgical approach (single or combined), surgical margins (intralesional, marginal, and wide) number of levels resected, neoadjuvant and adjuvant chemo and radiotherapy treatment. The models calibration (Hosmer–Lemeshow test = 0.694, $\chi^2 = 5.58$, the Omnibus test of models coefficients—$\chi^2 = 34.9$, $P = 0$).

Contaminated cases [odds ratio (OR), 4.43, $P = 0.005$], surgical margins of the resected tumor—intralesional (OR, 7.28, $P = 0.002$), marginal (OR, 2.69, $P = 0.031$), and malignant tumors (OR, 7.09, $P = 0.022$), were statistically significant independent risk factors for local recurrence of the tumor (Table 1).

As the distinction between marginal and wide excision is difficult and at most times requires a postoperative pathologic examination, thus in a surgeon's point of view—irrelevant to the intraoperative decision-making process, the 2 groups marginal and wide margins were combined for statistical analysis. In this multivariate analysis—still intralesional showed statistically significant increased risk for local recurrence (OR, 4.54, $P = 0.008$; Table 1).

When applying the multivariate model for assessment of risk factors for complications to occur, there was no statistically significant risk for complications to occur in the CC group compared with the NCC group.

TABLE 1. Recurrence Analysis

	Multivariate Analysis		
Covariates	**OR**	**95% CI**	***P***
Age (y)	1.021	0.98–1.04	< 0.001
Male	1.47	0.56–3.8	0.427
Tumor type			
Benign	Reference	Reference	Reference
Malignant	7.09	1.16–90.9	0.022
Metastatic	1.34	0.09–1.96	0.829
Contamination	4.439	1.562–12.621	0.005
Stage—Enneking	1.32	0.845–2.087	0.218
Surgical approach	1.609	0.507–5.106	0.42
No. levels resection	0.801	0.459–1.398	0.435
Complete vertebrectomy	1.742	0.567–5.354	0.333
Surgical margins			
Wide	Reference	Reference	Reference
Marginal	2.69	1.101–7.35	0.031
Intralesional	7.28	2.05–16.94	0.002
Surgical margins			
Wide + marginal	Reference	Reference	Reference
Intralesional	4.54	1.497–13.69	0.008
Neoadjuvant CHT	2.602	0.478–14.177	0.269
Neoadjuvant RT	2.315	0.456–11.744	0.311
Adjuvant CHT	0.759	0.235–2.45	0.644
Adjuvant RT	1.035	0.274–3.903	0.96

CHT indicates chemotherapy; CI, confidence interval; OR, odds ratio; RT, radiotherapy.

TABLE 2. Mortality Analysis

	Multivariate Analysis		
Covariates	**OR**	**95% CI**	***P***
Age (y)	1.022	0.994–1.052	0.118
Male	1.342	0.593–3.037	0.48
Tumor type			
Metastatic	2.67	1.035–6.901	0.042
Contamination	2.56	1.214–5.871	0.022
Stage—Enneking	1.245	0.81–1.914	0.318
Local recurrence	7.4	2.024–20	0.001
Surgical approach	1.2	0.466–3.088	0.706
No. levels resection	1.87	1.11–3.17	0.018
Complete vertebrectomy	1.62	0.582–4.545	0.354
Surgical margins			
Wide	Reference	Reference	Reference
Marginal	1.91	0.598–6.06	0.275
Intralesional	2.54	0.934–6.909	0.068
Surgical margins			
Wide + marginal	Reference	Reference	Reference
Intralesional	2.69	0.903–8	0.075
Neoadjuvant CHT	1.21	0.332–4.445	0.769
Neoadjuvant RT	5.91	1.517–23.25	0.01
Adjuvant CHT	2.252	0.852–5.95	0.102
Adjuvant RT	1.85	0.682–5.05	0.225

CHT indicates chemotherapy; CI, confidence interval; OR, odds ratio; RT, radiotherapy.

The multivariate model used to predict death from the disease included adjustment for age, sex, oncological stage as described by Enneking, type of tumor (benign, malignant, metastatic), contamination, surgical approach (single or combined), number of levels resected, whether complete vertebrectomy was performed, neoadjuvant and adjuvant chemo and radiotherapy treatment. The models calibration (Hosmer–Lemeshow test = 0.155, $\chi^2 = 11.91$, the Omnibus test of models coefficients—$\chi^2 = 53.56$, $P = 0$).

When applying the multivariate model to predict death from the disease, contamination (OR, 2.56, $P = 0.022$), local recurrence (OR, 7.4, $P = 0.001$), neoadjuvant radiotherapy (RT) (OR, 5.91, $P = 0.01$), and metastatic tumors compared with primary malignant tumor (OR, 2.67, $P = 0.042$), were shown to be independent risk factors for patient's death. The number of level resected showed a statistically significant protective factor for death (OR, 0.533, $P = 0.018$; Table 2).

All other variables were not shown to be statistically significant risk factors for patient's death.

DISCUSSION

A review of a series of 220 consecutive en bloc resections was performed for the comparison of 2 cohorts of patients, 1 treated solely in a high volume specialized center for surgical spine oncology, the other cohort began treatment or invasive evaluation in less specialized centers and then referred for the completion of the treatment.

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All surgical procedures were performed in the same institution by the same team. These were done following full staging and oncological planning. This series of patients can be considered to represent a homogenous series of cases.

Local Recurrence

The main aim of en bloc resection is local and systemic control of the disease, and the achievement of this goal justifies the high level of morbidity reported to be related to this procedure. The risk of local recurrence is directly related to the margin of resection.[2,26] Epidural extension of the tumor increases the risk of local recurrence.[5,9,11,19] Therefore, even major neurological sacrifices must be considered in the decision-making process, given that a local recurrence jeopardizes neurological function and worsens the prognosis. The survival and quality of life of patients with recurrences are very poor. In the series considered, 33 patients suffered from local recurrence.

A higher rate of local recurrence was observed in the CC group compared with the NCC (29.1% vs. 11.3%, respectively). This higher rate was maintained and was shown to be statistically significant independent risk factor when performing a multivariate analysis, where the OR for local recurrence was 3.97 ($P = 0.006$). In this model, adjustment for other possible contributing factor as described in the methods was performed for the assessment of the independent risk of contamination to the local recurrence of the tumor. This statistically significant risk has a direct affect on the following oncological management of the patient, as the treatment of a locally controlled disease differs from a recurrent disease.

As is well reported in the literature, clear margins have a direct relation to the local recurrence of tumors.[16,26] In this study when applying the multivariate model, independent risk factors for local recurrence of the tumor were contamination, inadequate resection of the tumor—such as intralesional or marginal, and malignant type tumors. To that extent, the complete resection of the tumor with clear margins is of paramount importance in terms of local recurrence and disease control. The high OR for intralesional resection compared with wide margins (OR, 7.28) suggests that extreme care and measures should be taken to prevent tumor violation. As it is almost impossible for the surgeon to differentiate between wide and marginal margins during surgery, a more clinically relevant distinction between intralesional and either marginal or wide resection was performed in this study. This distinction, of either clear or violated margins, represents better the surgical parameters upon which the surgeon should base his intraoperative decisions and planes of resection. Still when analyzing the data based on this distinction, the increased risk for local recurrence remained when an intralesional (violated margins) resection was performed compared with clear (wide or marginal) margins (OR, 4.54).

Indeed, it reveals that the prognosis is mainly related to the first treatment (more specifically the expertise of the team performing the initial assessment and treatment), and that the infringement of oncological principles may be followed by very serious consequences, as local control is increasingly difficult to achieve through the treatment of further recurrences. Intentionally violating oncological principles to improve the functional outcome means performing intralesional surgery, which reduces the possibility of local control.[3–9,11,16–21,23,27]

Morbidity

It is commonly accepted that the morbidity of surgical procedures for spine tumors is related to both the altered anatomy secondary to the tumor growth, and the fibrosis caused by preoperative RT or previous surgery. To that extent, a revision surgery and procedures conducted following oncological contamination of the surgical field mandates a more aggressive approach and at times, the necessity of sacrifice of adjacent structures.

The peculiar and at times aggressive, surgical techniques required to achieve en bloc resection are expected to increase the rate of complications, as extratumoral resection requires the violation of anatomic barriers and the manipulation or sacrifice of vascular and nervous structures.

Accurate analysis of all the incidences is very difficult as most are multifactorial and may lead to other complications (eg, hematoma after en bloc resection in the thoracic spine creates hemopneumothorax due to resection of the barrier for oncological purposes, and can cause paraplegia). The definition of a complication used in this study was an unplanned medical problem or damage that occurred during or following the surgical procedure. Therefore, in this review, the sacrifice of important structures performed for oncological purposes, were not considered to be complications.

A higher rate of complications was observed in the group of patients who underwent en bloc resection after open biopsy or previous treatment followed by recurrence. Indeed, 28 of 48 (58.33%) patients in this latter group had at least 1 complication, compared with 72 of 168 (42.8%) treated from the beginning in the same center. In particular, a higher rate of major complications was observed: 39 major complications of 48 events (81.2%) in the CC group, compared with 66 major complications of 105 events (62%) in the NCC group. Nevertheless, in the multivariate model, contamination was not shown to be a statistically independent risk factor for complications to occur. To that extent, the relatively small number of events combined with the established contributing factors that are known as risk factors for complications such as previous chemotherapy and RT, combined surgical approach,[27] might have caused this difference to be statistically insignificant as an independent factor.

Patient's Death from the Disease

En bloc surgical resection of spine tumors is an extremely aggressive surgical procedure performed for the ultimate purpose of lengthening the patient's life. This

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treatment involves a relatively high intraoperative and postoperative morbidity and requires both the patient's and the treating physician's appreciation of the risks involved and pitfalls that are expected. All these are justified if the ultimate goal, the extension of the patient's life, and at times the cure from the disease.

When reviewing the outcome of the 216 patients submitted to en bloc resections, a total of 60 patients died from the disease, 21 from the CC group (43.75%) and 39 from the NCC group (23.21%). The previous invasive attempt at treating the tumor in an institution that was not specialized in this procedure was shown to be an independent risk factor for patient's increase mortality, as the OR for patient's death from the disease was 2.55 ($P = 0.022$). Indeed, when assessing for risk factors for death from the disease, independent risk factors were shown to be patients that began their treatment in a less specialized institute, local recurrence, and previous RT. This suggests that the initial management of the patient, both diagnostic (invasive) and therapeutic (neoadjuvant RT) has a direct affect on the patient's mortality. To that extent, the surgical and oncological limitations subjected by an inappropriate open biopsy or an inadequate initial surgical treatment mandates a more aggressive surgical resection and at times even prevents a complete oncological removal of the tumor, affecting both the patient's quality of life as well as mortality. It is therefore reasonable to perform the entire management, from the initial invasive diagnostic procedures through the preoperative assessment and surgical attempt at complete tumor removal in a high volume specialized center.

Limitations

Referral for further treatment to a higher more experienced center holds a potential bias, as it is assumed that the more difficult or recurrent cases are referred to a more experienced center, having a worse prognosis and a higher likelihood of recurrence morbidity and mortality. In this report, both groups of CC and NCC where similar in terms of patient demographics, disease diagnosis and staging. Still, as differences exist in both the number of patients in these 2 groups as well as the lack of presentation of some of the less frequent pathologies in the CC group, it is reasonable to assume that a bias still exist. Despite this possible bias, the potential of limiting the option of local control of the disease, when an inadequate biopsy or first attempt of resection occurs, warrants an experienced and multidisciplinary approach when performing such procedures.

CONCLUSIONS

The surgical techniques of en bloc resections are clearly described in the literature. Although there are few reports on large series, these surgical procedures seem to dramatically improve local control in aggressive benign and low-grade malignant bone tumors, also in the spine. Oncological criteria should guide the decision-making process regarding bone tumors of the spine.[2–9,11,16–21,23,24,27–29]

The ultimate goal of locally controlling the disease for both improving the patient's quality of life as well as improving mortality by allowing the optimal oncological treatment, is the basis of performing such an extensile and major surgical procedure. Thus these outcome measures should always be evaluated when assessing en bloc resection of spine tumors.

This study describes the outcomes recorded in a large single-center series of en bloc resections, and compares these outcomes between patients who were initially treated in that high volume specialized center, and patients who initially underwent either invasive diagnostic procedure or an initial surgical attempt to treat the disease in a different center.

The data support the conclusion that local recurrence is the worst complication, as this negatively affects quality of life and prognosis. The results in terms of better prognosis and better local control[3–9,11,16–21,23,27,30] justify performing such highly demanding and risky procedures in aggressive benign and in low-grade malignant bone tumors.

It is apparent that there is a substantial added risk in performing either invasive diagnostic procedures or attempting a surgical resection of the tumor in a nonspecialized center. This risk includes both higher recurrence of the tumor as well as increased mortality. It is therefore reasonable to conclude that the whole treatment, from biopsy to resection, should be performed in the same center, and this center should be a high volume, specialized in treating these type of spine pathologies. The specifically dedicated teams should include trained oncological surgeons and anesthesiologists for increased safety of this complicated procedure.

The surgeon who treats the patient first has a great responsibility, as it is the first treatment that most affects prognosis. To reduce the chance of local recurrence, morbidity and mortality, this should be performed by an experienced team as the consequences are dramatic.

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