ORIGINAL ARTICLE
TUMOR AND MEDICAL ONCOLOGY

COMPLICATIONS OF SURGICAL TREATMENT OF SPINAL METASTASES

COMPLICAÇÕES DO TRATAMENTO CIRÚRGICO DAS METÁSTASES VERTEBRAIS

COMPLICACIONES DEL TRATAMIENTO QUIRÚRGICO DE LAS METÁSTASIS VERTEBRALES

PRISCILA BARILE MARCHI CANDIDO[1], FERNANDA MARIS PERIA[2], VINICIUS NOGUEIRA TOLEDO[3], HERTON RODRIGO TAVARES COSTA[3], HELTON LUIZ APARECIDO DEFINO[3]

1. Universidade de São Paulo. Ribeirão Preto School of Medicine. Department of Clinical Medicine, Ribeirão Preto, SP, Brazil.
2. Universidade de São Paulo. Ribeirão Preto School of Medicine. Clinical Oncology Division. Medical Imaging Department, Hematology and Clinical Oncology. Ribeirão Preto, SP, Brazil.
3. Universidade de São Paulo. Ribeirão Preto School of Medicine. Department of Orthopedics and Anesthesiology, Ribeirão Preto, SP, Brazil.

ABSTRACT

Objectives: To evaluate the complications of surgical treatment in a group of patients with spinal metastasis with epidural compression, undergoing surgical treatment. Methods: This is a comparative retrospective study (level of evidence III), which evaluated 96 patients with spinal metastases undergoing surgical treatment. Intra- and postoperative complications were obtained from the patients' medical records and correlated with the following clinical characteristics: tumor type, tumor location, neurological deficit, age, number of affected vertebrae, Tokuhashi scale, Tomita scale, Karnofsky performance scale, and type of approach. Results: Complications of surgical treatment were observed in 29 (30.20%) patients. Surgical wound infection was the most frequent complication, observed in 15% of patients. Conclusions: Surgical treatment of spinal metastases presents complications in about 30% of patients and their occurrence should be considered in the treatment planning, weighing the risks and benefits for achieving the treatment goals. ***Level III evidence; Retrospective Study.***

Keywords: Spinal Neoplasms; Life Expectancy; Evaluation of Results.

RESUMO

Objetivo: Avaliar as complicações do tratamento cirúrgico em grupo de pacientes com metástase da coluna vertebral, compressão epidural e submetidos ao tratamento cirúrgico. Métodos: Trata-se de estudo retrospectivo comparativo (nível de evidência III), que avaliou 96 pacientes com metástase da coluna vertebral, submetidos ao tratamento cirúrgico. As complicações intra e pós-operatórias foram obtidas dos prontuários dos pacientes e correlacionadas com características clínicas: tipo de tumor, localização do tumor, déficit neurológico, idade, número de vértebras acometidas, escala de Tokuhashi, escala de Tomita, escala de performance de Karnofsky e tipo de acesso. Resultados: As complicações do tratamento cirúrgico foram observadas em 29 (30,20%) pacientes. A infecção da ferida operatória foi a complicação mais frequente e observada em 15% dos pacientes. Conclusões: O tratamento cirúrgico das metástases da coluna vertebral apresenta complicações em cerca de 30% dos pacientes, e a sua ocorrência deve ser considerada na elaboração do tratamento frente aos riscos e benefícios para a obtenção dos objetivos do tratamento. ***Evidência nível III; Estudo Retrospectivo.***

Descritores: *Neoplasias da Coluna Vertebral; Expectativa de Vida; Avaliação de Resultado.*

RESUMEN

Objetivos: Evaluar las complicaciones del tratamiento quirúrgico en un grupo de pacientes con metástasis vertebrales, compresión epidural y sometidos a tratamiento quirúrgico. Métodos: Se trata de un estudio comparativo retrospectivo (nivel de evidencia III), que evaluó a 96 pacientes con metástasis en la columna vertebral sometidos a tratamiento quirúrgico. Las complicaciones intra y postoperatorias se obtuvieron de la historia clínica de los pacientes y se correlacionaron con las características clínicas: tipo de tumor, localización del tumor, déficit neurológico, edad, número de vértebras afectadas, escala de Tokuhashi, escala de Tomita, escala de rendimiento de Karnofsky y tipo de acceso. Resultados: Se observaron complicaciones del tratamiento quirúrgico en 29 (30,20%) pacientes. La infección de la herida quirúrgica fue la complicación más frecuente y se observó en el 15% de los pacientes. Conclusiones: El tratamiento quirúrgico de las metástasis de columna vertebral presenta complicaciones en aproximadamente el 30% de los pacientes, y su ocurrencia debe ser considerada en la elaboración del tratamiento, considerando los riesgos y beneficios para lograr los objetivos del mismo. ***Evidencia de nivel III; Estudio retrospectivo.***

Descriptores: *Neoplasias de la Columna Vertebral; Esperanza de Vida; Evaluación de Resultado.*

INTRODUCTION

The advances in oncological treatment have increased patient survival and the occurrence of metastases.[1-3] Tumor metastases located in the spine are the most frequent form of metastases affecting bone tissue. Approximately 30-40% of cancer patients present metastasis in the spine.[4-6]

Clinical manifestations of spinal metastases include pain, instability or neurological deficit, and epidural compression by metastasis occurs in 5% to 10% of cancer patients.[7] Surgical treatment of spinal metastases is palliative, with the main goal of improving the patient's quality of life by reducing pain, maintaining or reducing the neurological deficit, and enabling activities of daily living.[8,9]

Study conducted at Hospital das Clínicas de Ribeirão Preto, Ribeirão Preto, SP, Brazil.
Correspondence: Vinicius Nogueira Toledo. Rua: Magda Perona Frossard, 155. Ap. 13, Nova Aliança, Ribeirão Preto, SP, Brazil. CEP: 14026596. Email: viniciusntoledo@gmail.com

http://dx.doi.org/10.1590/S1808-185120212004255227

Received on 09/27/2021 accepted on 10/08/2021

Reviewed by: Dr. Helton Delfino

The treatment of spinal metastasis is related to its clinical manifestation. Surgical treatment is indicated in cases where there is pain, instability of the vertebral segment, or epidural compression.[3,4,8] Isolated metastases, without epidural compression or instability and with maintenance of the posterior wall of the vertebral body can be treated by methods with lower morbidity.[3,4,8] However, spinal metastases with epidural compression or instability of the vertebral segment require surgical treatment.[3,5,8,9]

Surgical treatment became more widespread after it became apparent that when associated with adjuvant therapies, it gives better results than radiotherapy alone.[10] Improvements in spine fixation methods, enabling greater stability associated with decompression of nervous structures, have also contributed to its dissemination and improvement of the results.[10]

Although surgical treatment of spinal metastases is palliative, improvement of pain and neurological deficit and of patients' quality of life have been observed. It is also more cost-effective, and plays an important role in the oncological treatment of patients with spinal metastasis.[11-14]

Surgical treatment of patients with spinal metastasis presents considerable risk due to the patients' clinical condition, and morbidity of 47.9% and mortality of 28.6% have been estimated in this group of patients.[11,13,15]

The authors of this study work at an Oncology Reference Center, where the number of patients with spinal metastasis requiring surgical treatment has increased considerably. The motivation for this study was the retrospective evaluation of the surgical complications in this patient population, with the purpose of reevaluating the treatment carried out and modifying or developing new therapeutic approaches. Thus, the objective of the study was to conduct a retrospective evaluation of the intra- and postoperative complications in patients with spinal metastasis and epidural compression submitted to surgical treatment.

METHODS

This is a retrospective descriptive study of 96 patients with spinal metastasis and epidural compression. The study included patients aged over 18 years old with epidural metastasis of a solid malignant tumor, submitted to surgical treatment. Medical records of patients with hematological tumors, previous surgery, or incomplete data were excluded from the study. The study was approved by the Local Ethics Committee under number 6513/2015.

Of the total, 59 patients (61.45%) were male and 37 (38.54%) were female, with ages ranging from 24 to 91 years (mean 54.85 years ±16.93). Spinal metastasis was located in the cervical spine in seven patients, in the thoracocervical transition in 12 patients, in the thoracic spine in 44 patients, in the thoracolumbar spine in transition in 10 patients, in the lumbar spine in 13 patients, in the lumbo-sacral transition in three patients, and in more than two vertebral spine segments in seven patients. The spinal metastasis affected only one vertebra in 22 patients, and multiple vertebrae in 74 patients. Visceral metastasis was observed in 48 (50%) patients. The etiology of the primary tumor is shown in Table 1. Breast and prostate tumors were the most frequent, affecting 23 patients (23.95%). Thirty-two patients (33.33%) did not present neurological deficit. According to the Frankel scale,[16] 15 patients (15.62%) were Frankel A, 12 (12.5%) Frankel B, 20 (20.83%) Frankel C and 17 (16.50%) Frankel D.

The indication for surgical treatment was related to pain, instability of the vertebral segment, or neurological deficit associated with spinal metastasis and epidural compression. Fixation and decompression were performed in 96 (100%) patients. Reconstruction of the vertebral body, using a spacer and/or methacrylate, was performed through the posterior approach in 36 patients (37.50%), and the associated anterior approach was performed in seven patients (7.29%).

Intra- and postoperative complications were verified through patients' records and correlated with some of the patients' clinical characteristics, such as tumor type, tumor location, neurological deficit, age, number of affected vertebrae, Tokuhashi score, Tomita score, Karnofsky performance status and type of approach.[17-19]

Descriptive statistics was performed to analyze the parameters evaluated and the relative risk for observation of the association of the selected parameters.

RESULTS

Complications of surgical treatment were observed in 29 patients (30.20%). Intraoperative complications only were observed in four patients (4.16%), postoperative complications only in 21 patients (21.87%) and both in four patients (4.16%). The intraoperative complications observed were: Dura mater injury (six patients) and cardiorespiratory arrest, which was reverted (two patients). The postoperative complications are shown in Table 2, with infection of the surgical wound being the most frequent one, observed in 15 patients (15.62%).

Complications were observed in 20 male patients (20.83%) and nine female patients (9.37%). The relative risk of complications in males was 1.37 times higher than in females.

The ages of patients with complications ranged from 24 to 91 years (mean 59.58 years ± 16.93). Four patients (13.79%) were aged 40 years or less, and 25 patients (86.20%) were older than 40 years. The relative risk of postoperative complications over 40 years of age was 1.34 times higher than that of patients under 40 years of age.

Table 1. Distribution of the etiology of spinal metastases and observed complications.

Tumor etiology	Total patients	Complications
Sarcoma	8	3 (3.12%)
Vesicle	1	0
Thyroid	4	2 (2.08%)
Testicle	2	1 (1.04%)
Unknown primary site	7	2 (2.08%)
Maxillary sinus	1	0
Kidney	3	1 (1.04%)
Rectum	5	3 (3.12%)
Lung	4	0
Prostate	22	6 (6.25%)
Nasopharynx	1	0
Choroid plexus melanoma	1	0
Breast	23	6 (6.25%)
Small intestine	1	1 (1.04%)
Esophagus	1	0
Colon	3	2 (2.08%)
Uterine cervix	2	0
Oral cavity	4	1 (1.04%)
Bladder	2	1 (1.04%)
Adrenal	1	0
Total	96 (100%)	29 (30.20%)

Table 2. Postoperative complications.

Postoperative complications	No. of patients
Respiratory failure	1
Pneumonia	1
Surgical wound infection	15
Steven Johnson	1
Worsening of deficit	3
Renal failure	1
Hematemesis	1
Deep vein thrombosis	1
Pleural effusion	1
Surgical wound hematoma	4
Meningitis	1
ICVA	1
Liquoric fistula	2

Table 1 illustrates the complications related to the type of tumor and its frequency. The highest number of complications was observed in primary prostate (six patients) and breast (six patients) tumors, corresponding to (6.25%), which were the most frequent tumors in the group of patients studied.

The frequency of complications by tumor location, is shown in Figure 1. The highest percentage of complications was observed in the thoracic spine.

The distribution of complications according to the presence of visceral metastases is shown in Figure 2. Complications were observed in 17 patients with metastasis in other organs (58.62%). The relative risk of complications in patients with metastasis in other organs was 1.4 times higher than that of patients without visceral metastasis.

Complications were observed in 13 patients (13.54%) without neurological deficit and in 16 (16.66%) which presented preoperative neurological deficit, distributed according to the Frankel classification as: A 04; B 02; C 04; D 06; E 13. The relative risk of complications in patients with neurological deficit was 1.20 higher than that of patients without neurological deficit.

In the patients with metastasis in only one vertebra (23 patients), complications were observed in eight patients, and in patients with metastasis in more than one vertebra (73 patients), 21 complications were observed. The relative risk of complications in patients with only one affected vertebra was 0.42 in relation to patients with more than one metastasis.

The posterior approach alone was performed in 89 patients, 27 of whom presented complications. The combined approach: posterior and anterior, was performed in seven patients, two of whom presented surgical complications.

Postoperative complications did not present any association with the Karnofsky performance scale. The complications in relation to the Karnofsky performance scores are shown in Figure 3.

No association was observed between postoperative complications and the Tomita and Tokuhashi scores. The distribution of postoperative complications in the different Tomita and Tokuhashi scores is shown in Figures 4 and 5.

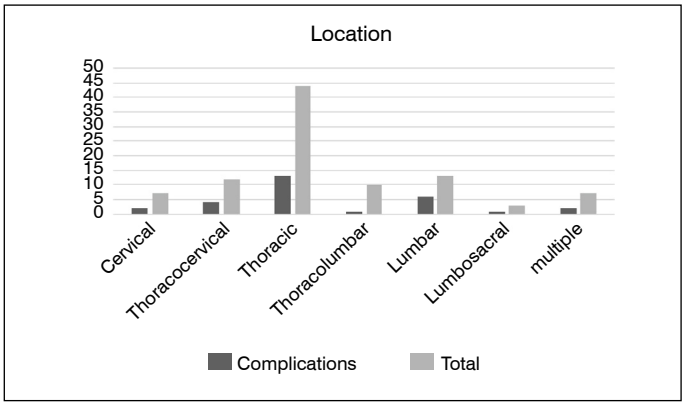

Figure 1. Distribution of postoperative complications by location of metastasis.

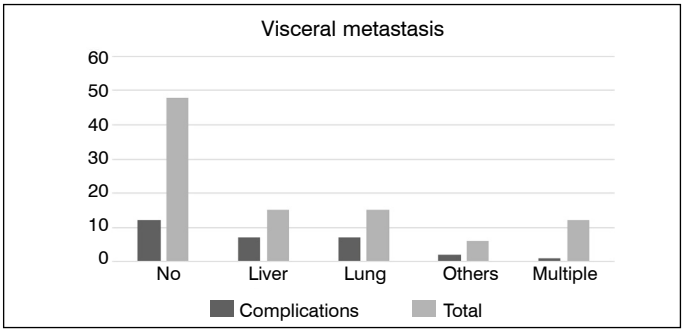

Figure 2. Distribution of complications according to the presence of visceral metastases.

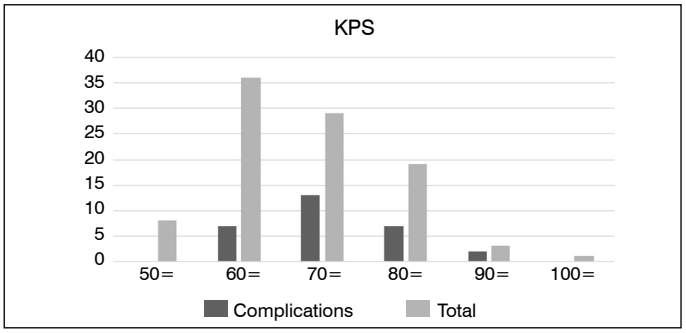

Figure 3. Distribution of postsurgical complications according to the Karnofsky scores.

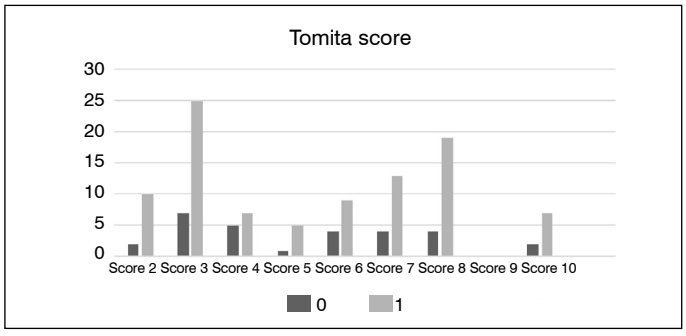

Figure 4. Distribution of postoperative complications according to the Tomita score.

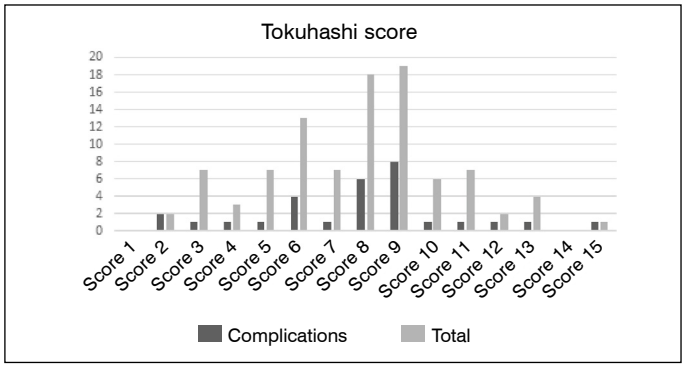

Figure 5. Distribution of postoperative complications according to the Tokuhashi score.

DISCUSSION

Complications of surgical treatment were observed in 29 patients (30.15%) with spinal metastasis and epidural compression submitted to surgical treatment.

The percentage of complications observed in the group of patients in this study is in accordance with the reported rates of 10% to 66.7%.[13,19,20] More recent reports have presented lower rates of infection, which may be associated with less invasive techniques.[15,21,22] Due to complications three months after hospital discharge, readmission and reoperation rates ranged from 9.7% to 16.8%, evidencing the impact of the disease and its treatment on the health system.[23-26]

Surgical treatment of spinal metastases carries the same risks as non-oncological surgeries, plus the risk of complicating factors associated with oncological disease and its metastases. Complications can reduce patients' quality of life, and one of the goals of surgical treatment is to improve this, reinforcing the need for careful evaluation of the indication for surgical treatment.[22]

Low albumin levels, additional comorbidities, pathological fractures, involvement of more than three vertebral levels, combined approach, age, type of tumor, blood transfusion and Charlson

comorbidity index have all been reported as factors associated with complications of surgical treatment.[21,22]

The most frequently reported complication is infection or dehiscence of the surgical wound, which varies from 1.5% to 30% of patients.[15,22] A 15% rate of infection was observed in the group of patients studied, which is in line with the highest rates reported in the literature, though more recent reports have presented lower rates of infection, which may be related to the use of less invasive techniques.[21-23]

Complications with the surgical wound can result in longer hospitalization, reoperations, and significant morbidity.[24] The predictive risk factors for surgical wound complications in patients with spinal metastasis have been: female gender, smoking, adjuvant therapies (chemotherapy, radiotherapy, corticoids), anemia, poor nutritional status, alcoholism, prolonged surgical time and previous surgery.[24] In contrast to the occurrence of surgical wound infection of less than 2.5% for spinal surgeries, this type of complication has high rates in patients with spinal metastasis.[20,21]

The complications observed in the group of patients in this study are in accordance with the spectrum of clinical complications found in the literature, which is very broad.[21,25]

Despite the possibility of improvement of the neurological status with decompression of the nervous structures, worsening of this picture may occur due to injury to the spinal cord or nerve roots in 0.6% to 14% of patients.[20,21] In the patients of this study, neurological complications were relatively low (three patients/0.03%) and are related to the performance of a surgical procedure that is relatively conservative when compared to more radical oncological resections. Neurological injury may occur due to patient positioning with instability of the vertebral segment, or to iatrogenic manipulation during the surgical procedure.[21,22] Neurological complications present a broad spectrum of severity and may still occur in the postoperative period due to the formation of hematomas.[20,21]

Complications related to instrumentation of the spine have been acutely reported: failure of the implant anchorage due to poor bone tissue quality, later breakage or loosening of the implants, or junctional kyphosis.[23,24] This type of complication was observed in 1.9% of the patients and was associated with previous radiotherapy.[27] This type of complication was not observed in the patients of this study, and may be related to the non-performance of previous radiotherapy in this group and to the type of fixation used, in which reconstruction of the anterior spine was associated with posterior pedicle fixation, which provides great mechanical stability to the fixation system. The overall survival of patients was less than two years, and this is another factor that would explain the absence of complications related to the spinal fixation.

Age over 40 years and involvement of three or more vertebrae have been shown as predictive factors for complications of surgical treatment of spinal metastases[27] and the results observed in the group of patients studied are in accordance with these reports. Although the relative risk of complications in the patients with visceral metastases in this study was higher, this parameter has not been considered a predictive factor for complications in other studies.[27] The presence of visceral metastasis has been related to lower patient survival, [27,28] although some reports have shown that the presence of visceral metastases has no impact on patient survival.[29,30]

The distribution of complications in the different Tomita and Tokuhashi scores did not present any association with complications in the patients in this study. The association of these scores with complications of surgical treatment has not been emphasized in the relevant literature.

No statistical differences in complications have been observed in relation to the type of primary tumor, except in the report by Wang *et al.* [13,21] The highest rate of complications was observed in the most frequent tumors of the group of patients studied (breast and prostate) but the interpretation of the results is limited by the distribution of tumor types in our sample of patients.

The distribution of complications according to the Karnofsky performance scale did not enable us to identify any association of this variable with complications. The association of this variable with postoperative complications has been contradictory.[25, 28, 29]

The reported intraoperative and immediate postoperative mortality varied from 0% to 10%,[12] and the mortality observed in the group of patients studied was relatively low, considering the risk presented. Deaths occurring during the first postoperative month may be due to the surgical procedure or to the evolution of the primary tumor. Patients whose primary tumor cannot be identified presented a higher rate of early death in the postoperative period. Spinal metastases with primary tumor of unknown origin present poor prognosis, low survival, and aggressive clinical evolution.[31,32]

This study presents some limitations: it is a retrospective study, conducted at a single center, and it includes a heterogeneous patient population, in which the treatment used was not uniform. The general conditions of the patients, the different types of primary tumor, location of the tumor, and neurological status all added to the heterogeneity of the sample. Therefore, the results should be interpreted with caution and due criticism. However, the analysis of the results enabled a critical review of the treatment of spinal metastases and reorganization of the surgical treatment, especially the performance of less invasive procedures.

Complications of surgical treatment occur in 25% to 34% of patients[11,29] and should be considered in the evaluation of possible benefits of surgical treatment and elaboration of the therapeutic plan for spinal metastases.[12,29,30,32] Less invasive surgeries, with lower morbidity, associated with stereotactic radiotherapy, were not available during the period in which the group of patients studied received surgical treatment, and it is hoped that the complications associated with surgical treatment of spinal metastases can be reduced by the use of less invasive contemporary treatments.

CONCLUSION

Surgical treatment of spinal metastases presents complications that should be considered in the preparation of surgical treatment, and confronted with the risk and benefit of the procedure to reach the treatment objectives.

All authors declare no potential conflict of interest related to this article.

CONTRIBUTIONS OF THE AUTHORS: Each author made significant individual contributions to the development of this manuscript. PBMC: Data collection and participation in the discussion of results; FMP: Data collection, participation in the discussion of results; VNT: Data collection, tables and graphs, writing and review; HRTC: Performance of surgeries; HLAD: performance of surgeries, writing, data collection of results, participation in the discussion of results, preparation of tables and figures and review.

REFERENCES

1. Barzilai O, McLaughlin L, Amato MK, Reiner AS, Ogilvie SQ, Lis E, et al. Predictors of Quality of life improvement after surgery for metastatic tumors of the spine: prospective cohort study. Spine J. 2018;18(7):1109-15.
2. Andrade Neto J, Fontes BPC, Macedo RD, Simões CE. Patients with spinal metastasis submitted to neuological decompression and stabilization. Coluna/Columna. 2016;15(3):230-34.
3. Nater A, Martin AR, Sahgal A, Choi D, Fehlings MG. Symptomatic spinal metastasis: a systematic literature review of the preoperative prognostic factors for survival, neurological, functional and quality of life in surgically treated patients and methodological recommendations for prognostic studies. Plos One. 2017;12(2):e0171507.
4. Stutcliff P, Connock M, Shyangdan D, Court R, Kandala NB, Clarke A. A systematic review of evidence on malignant spinal metastases: natural history and technologies for identifying patients at high risk of vertebral fracture and spinal cord compression. Health Technol Assess. 2013;17(42):1-274.

5. Wong DA, Fornasier VL, MacNab I. Spinal metastases: the obvious, the occult, and the impostors. Spine (Phila Pa 1976). 1990;15(1):1-4.
6. Gómez JAO. The incidence of vertebral body metastases. Int Orthop. 1995;19(5):309-11.
7. Sciubba DM, Petteys RJ, Dekutoski MB, Fisher CG. Fehlings MG, Ondra SL, et al. Diagnosis and management of metastatic spine disease. A review. J Neurosurg Spine. 2010;13(1):94-108.
8. Mattana JL, Freitas RR, Mello GJP, Armani Neto M, Freitas Filho G, Ferreira CB, et al. Estudo da aplicabilidade do escore de Tokuhashi modificado nos pacientes tratados cirurgicamente de metástases vertebrais. Rev Bras Ortop. 2011;46(4):424-30.
9. Oliveira MF, Barros BA, Rotta JM, Botelho RV. Tokuhashi Scoring System has limited applicability in the majority of patients with spinal cord compression secondary to vertebral metastasis. Arq Neuropsiquiatr. 2013;71(10):798-801.
10. Patchell RT, Tibbis PA, Regine WF, Payne RP, Saris S, Kryscio RJ, et al. Direct decompressive surgical resection in the treatment of spinal cord compression caused by metastatic cancer: A randomised trial. Lancet. 2005;366(9486):643-8.
11. Aoude A, Amiot LP. A comparison of the modified Tokuhashi and Tomita scores in determining prognosis for patients afflicted with spinal metastasis. Can J Surg. 2014; 57(3):188-93.
12. Pascal-Moussellard H, Broc G, Pointillart V, Siméon F, Vital JM, Sénégas J. Complications of vertebral metastasis surgery. Eur Spine J. 1998:7(6):438–44.
13. Dea N, Versteeg AL, Sahgal A, Verlaan JJ, Charest-Morin R, Rhines LD, et al. Metastatic spine disease: should patients with short life expectancy be denied surgical care? An international retrospective cohort study. Neurosurgery. 2020;87(2):303-11.
14. Lee BH, Park J-O, Kim H-S, Park Y-C, Lee H-M, Moon S-H. Perioperative complication and surgical outcome in patients with spine metastases: retrospective 200-case series in a single institute. Clin Neurol Neurosurg. 2014;122:80-6.
15. Bakar D, Tanenbaum JE, Phan K, Alentado VJ, Steinmetz MP, Benzel EC, et al. Decompression surgery for spinal metastases: a systematic review. Neurosurg. Focus. 2016;41(2):E2.
16. Frankel HL, Hancock DO, Hyslop G, Melzak J, Michaelis LS, Ungar GH, et al. The value of postural reduction in the initial management of closed injuries of the spine with paraplegia and tetraplegia. I. Paraplegia. 1969;7(3):179-92.
17. Tomita K, Kawahara N, Kobayashi T, Yoshida A, Murakami H, Akamaru T. Surgical strategy for spinal metastases. Spine. 2001;26(3):298-306.
18. Tokuhashi Y, Kawano H, Ohsaka S, Matsuzaki H, Toriyama S, A scoring system for preoperative evaluation of the prognosis of metastatic spine tumor (a preliminary report). Nihon Seikeigeka Gakkai Zasshi.1989;63(5):482-9.
19. Karnofsky DA, Young CW. Comparative aspects of the pharmacology of the antimetabolites. Fed Proc.1967;26(4);1139-45.
20. Igoumenou VG, Mavrogenis AF, Angelini A, Baracco R, Benzakour A, Benzakour T, et al. Complications of spine surgery for metastasis. Eur. J Orthop. Surg. Traumatol. 2020;30(1):37-56.
21. Wang M, Jensen AB, Morgen SS, Wu CS, Sun M, Li H, et al. Survival analysis of breast cancer subtypes in patients with spinal metastases. Spine. 2014;39(19):1620-7.
22. Yahanda AT, Buchowski JM, Wegner AM. Treatment, complications, and outcomes of metastatic disease of the spine: from Patchell to PROMIS. Ann Transl Med. 2019;7(10):216.
23. Zuckerman SL, Laufer I, Sahgal A, Yamada YJ, Schmidt MH, Chou D, et al. When less is more: the indications for MIS techniques and separation surgery in metastatic spine disease. Spine (Phila Pa 1976). 2016;41(20 suppl):S246-S53.
24. Schilling AT, Ehresman J, Huq S, Ahmed AK, Lubelski D, Cottrill E, et al. Risk factors for wound-related complications after surgery for primary and metastatic spine tumors: a systematic review and meta-analysis. World Neurosurg. 2020;141:467-78.
25. Clarke MJ, Vrionis FD. Spinal tumor surgery: management and the avoidance of complications. Cancer Control. 2014;21(2):124-32.
26. Pedreira R, Abu-Bonsrah N, Ahmed AK, Garza-Ramos RL, Goodwin R, Gokaslan ZL, et al. Hardware failure in patients with metastatic cancer to the spine. J Clin Neurosci. 2017;45:166-71.
27. Lau D, Leach MR, Than KD, Ziewacz J, La Marca F, Park P. Independent predictors of complication following surgery for spinal metastasis. Eur Spine J.2013;22(6):1402-7.
28. Pereira NRP, Ogink PT, Groot OQ, Ferrone ML, Hornicek FJ, Van Dijk CN, et al. Complications and reoperations after surgery for 647 patients with spine metastatic disease. Spine J. 2019;19 (1):144-56.
29. Gábor C, Mezei T, Pollner P, Horváth A, Banczerowski P. Prognostic factors of surgical complications and overall survival of patients with metastatic spinal tumor. World Neurosurg. 2018;113:e20-e28.
30. Lun D-X, Wang X-D, Ji Y-D, Hu Y-C, Yang X-G, Yu X-C, et al. Relationship beetween visceral metastases and survival in patients with metastasis-related spinal cord compression. Orthop Surg. 2019;11(3):414-21.
31. Wang JC, Boland P, Mitra N, Yamada Y, Lis E, Stubblefield M, et al. Single-stage posterolateral transpedicular approach for resection of epidural metastatic spine tumors involving the vertebral body with circumferential reconstruction: results in 140 patients. J Neurosurg Spine. 2004;1(3):287-98.
32. Anzuatégui PR, Cunha LAM, Mello GJP, Stieven Filho E, Graells XS. Spinal Metastasis Surgery: A Proposal for a Predictive Model of Morbidity and Mortality. Rev Bras Ortop. 2019;54(6):665-72.