

Survival Predictions in Spinal Metastasis: A Comparative Analysis of Modified Bauer and Van der Classification

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ABSTRACT

Objective: The development of targeted therapies for primary tumors and early diagnosis enabled by advanced imaging methods have extended survival in cancer patients. This study aims to evaluate the effectiveness of the Modified Bauer and Van der Linden classifications in determining survival in the Turkish population.

Methods: Retrospective analysis was conducted on 83 patients who presented with spinal metastases at neurosurgery clinic from 2012 to 2020. Demographic characteristics, malignancy origin, metastasis region, and scores Modified Bauer, Vander Linden systems were detailed. Survival was calculated from the date of diagnosis and analyzed using statistical software.

Results: The average age of the 83 patients was 59.6 years; 67 (80.72%) were male, and 16 (19.27%) were female. Primary tumor types included lung cancer (43.37%), urogenital tumors (32.53%), gastrointestinal tumors (14.45%), breast tumors (7.22%), and nasopharyngeal tumors (2.4%). Thoracic involvement was present in 46.98%, lumbar in 39.75%, cervical in 8.43%, and sacral in 4.81%. In 45.78% of the patients, the diagnosis of a spinal mass led to further investigation to identify the primary tumor. The Modified Bauer score predicted survival accurately in 48.19% of patients, and the Van der Linden score in 46.99%. No significant difference was found between the tumor growth rate and the survival prediction accuracy of the classifications.

Conclusion: While prognostic scoring systems provide useful guidance in managing spinal metastases, their predictive accuracy varies. These systems often underestimate survival predictions. Further improvements, including the development of new AI-assisted classifications, could enhance the accuracy of survival predictions and improve treatment strategies.

INTRODUCTION

The development of targeted therapies for primary tumors and the early diagnosis enabled by advanced imaging methods have extended survival in cancer patients. Autopsy studies reveal that the rate of vertebral metastasis ranges from 36% to 70%.^[1] The extension of survival has led to an increase in surgical interventions for spinal metastases.

Nowadays, various classifications are used to determine survival in spinal metastases. Some of these classifications include the Revised Tokuhashi, Tomita, Modified Bauer, and Van der Linden classifications. These classifications have been revised over time to become more functional.

Most vertebral metastases do not require surgery. Treatment options for patients with vertebral metastases range from simple analgesic therapy to percutaneous sta-

bilization techniques. The primary goal of treatment in metastatic patients is to improve quality of life. Despite the wide range of treatment options, metastasis remains a chronic, progressive condition.^[2-4]

This study aims to demonstrate how effective the Modified Bauer and Van der Linden classifications are in determining survival in the Turkish population.

MATERIALS AND METHODS

Between 2012 and 2020, 83 patients who presented with spinal metastasis to the neurosurgery clinic were retrospectively reviewed, following the approval of the ethics committee (No: B.10.I.TKH.4.34.H.GP0.01/53, Date: 11/02/2021). The study is in compliance with the Declaration of Helsinki.

The patients were thoroughly examined for demographic characteristics, origin of malignancy, metastasis location, Modified Bauer and Van der Linden scores, and pre- and postoperative neurological motor examinations. Survival was calculated from the time of diagnosis. The results were analyzed using statistical software.

Statistical Analysis

Statistical analyses were conducted using SPSS version 25.0. The normality of the distribution of variables was examined using histogram graphs and the Kolmogorov-Smirnov test. Descriptive analyses included the use of mean, standard deviation, median, and min-max values. Categorical variables were compared using the Chi-Square Test. For parametric variables with normal distribution, ANOVA Test was used for comparison among more than two groups, and the Tukey post hoc method was employed to identify the source of significance. A p-value of less than 0.05 was considered statistically significant.

RESULTS

The average age of the 83 patients included in our study was 59.6 years. Of these patients, 67 (80.72%) were male, and 16 (19.27%) were female.

When examining the primary tumor types, 36 (43.37%) patients had lung cancer, 27 (32.53%) had tumors originating from the urogenital region, 12 (14.45%) had gastrointestinal tumors, 6 (7.22%) had breast tumors, and 2 (2.4%) had nasopharyngeal tumors.

Regarding the affected spinal levels, 39 (46.98%) patients had thoracic involvement, 33 (39.75%) had lumbar involvement, 7 (8.43%) had cervical involvement, and 4 (4.81%) had sacral involvement.

In 38 (45.78%) of the patients, the diagnosis of a spinal mass led to further investigation to identify the primary tumor.

For diagnosis, MRI imaging was used in 48 patients, CT scans in 30 patients, and PET-CT in 5 patients. The low rate of PET-CT use is due to most patients being diag-

Table 1. Accuracy rates of the Bauer and Van der Linden classifications in predicting survival

	n	%
Bauer	40	(48.19)
Van der Linden	39	(46.99)

nosed with a spinal mass after presenting to the neurosurgery outpatient clinic.

When analyzing the presenting symptoms, 42 (50.6%) patients had motor strength loss, 36 (43.37%) had local tenderness, and 5 (6.02%) had sciatica due to nerve compression.

Decompression alone was performed in 27 patients, both decompression and instrumentation were performed in 25 patients, biopsy and vertebral augmentation were performed in the same session in 27 patients, corpectomy and anterior stabilization surgery were performed via an anterior approach in 4 cervical patients.

The effectiveness of the Bauer and Van der Linden scores in predicting survival was assessed. The Bauer score was found to be successful in 40 (48.19%) patients, and the Van der Linden score was successful in 39 (46.99%) patients (Table 1).

Primary tumors were classified into three groups based on the Tomita classification: slow, intermediate, and rapid growth. Thyroid and breast cancers were categorized as slow-growing, kidney and urogenital cancers as intermediate, and lung and gastrointestinal tumors as fast-growing. The relationship between these tumor groups and survival predictions by the classifications was examined using the Chi-Square test. No significant difference was found between the growth rate of the primary tumor and the survival prediction accuracy of the classifications (Table 2).

The relationship between these tumor groups and the survival predictions by the classifications was examined using the Chi-Square test. No significant results were found in survival predictions based on the tumor growth rate among the classifications.

Table 2. Primary tumors were classified into three groups based on their growth rate: Slow, intermediate, and fast-growing

	Tumor Growth Rate						p
	1		2		3		
	n	%	n	%	n	%	
Bauer							
Prediction Negative	1	(16.67)	18	(62.07)	24	(50.00)	0.119
Prediction Positive	5	(83.33)	11	(37.93)	24	(50.00)	
Vander							
Prediction Negative	4	(66.67)	15	(51.72)	25	(52.08)	0.785
Prediction Positive	2	(33.33)	14	(48.28)	23	(47.92)	

Table 3. The relationship between survival time and the Bauer and Van der Linden classifications using the ANOVA test

	Postoperative Survival		p
	Ort±s.s.	Medyan (Min-Max)	
Bauer			
0-1 score	206.59±187.47	183 (8-824)	0.011
2 score	361.054±248.28	343 (28-653)	
3-4 score	275.88±327.01	131(0-1158)	
Van der Linden			
0-3 score	215.01±217.01	139 (0-965)	0.009
4-5 score	383.96±267.78	348 (28-1158)	
6 score	470±475.18	470 (134-806)	

According to the Bauer classification, the survival for patients with a score of 0-1 was found to be 206.59 days; for those with a score of 2, survival was 361.054 days; and for those with a score of 3-4, survival was 275.88 days.

Based on the Van der Linden classification, patients were divided into three groups according to their scores, consistent with the literature. Group A (0-3 points) had a survival of 215 days, Group B (4-5 points) had a survival of 383 days, and Group C (6 points) had a survival of 470 days (Table 3).

DISCUSSION

Survival times in metastatic patients vary from months to years. Advances in oncological treatments over the past decade, along with the early diagnosis of oncology patients, have extended survival times and necessitated revisions in scoring systems.

The Tokuhashi classification, widely used for vertebral metastases today, was first published in 1990 and revised in 2005 to address identified deficiencies. The revision added new tumors to the primary tumor section and made changes to the scoring system to increase the reliability of prognosis prediction.^[3,4] The Tokuhashi classification has been shown to be 51%-88% successful in predicting prognosis.^[5-7]

In 2001, Tomita et al.^[8] built upon the work of Tokuhashi and colleagues and developed the Tomita score. The Tomita classification particularly emphasizes the pathology of the primary tumor.^[9] By specifically highlighting primary tumor pathology, the classification maintains its predictive value even when examining subtypes of primary tumors.^[10] A study by Morgen et al.^[11] found the Tomita classification to be 52.9% successful in predicting prognosis.

Studies comparing the effectiveness of the Revised Tokuhashi and Tomita classifications in predicting prognosis have found the Revised Tokuhashi classification to be more accurate.^[11,12] For spinal metastasis patients who do not require surgery but need radiotherapy, the Van der Linden scoring system was developed by Van der Linden et al.^[13] to select candidates for radiotherapy. In their study,

patients were divided into three groups based on their scores. Group A had a survival of 3 months, Group B 9 months, and Group C an average survival of 18.7 months. According to Van der Linden, the accuracy rate in predicting prognosis was calculated to be 46.99%. In our study, Group A had a survival of 215 days, Group B 383 days, and Group C 470 days. The higher survival rates compared to the literature are attributed to advancements in oncological treatments.

A study by Leithner et al.^[14] found the modified Bauer classification to have the best correlation with survival among seven classifications for spinal metastasis patients. In our study, the accuracy rate of the modified Bauer classification in predicting prognosis was 48.19%. When divided into three groups based on their scores in the modified Bauer classification, the average survival was 4.8 months for a score of 0-1, 18.2 months for a score of 2, and 28.4 months for a score of 3-4.^[15]

In our study, the survival times for the Bauer classification were 206.59 days for a score of 0-1, 361.054 days for a score of 2, and 275.88 days for a score of 3-4. While the first and second groups had longer survival times compared to the literature, the third group had lower survival times. The lower survival rate in the third group is due to the small number of patients.

The use of prognostic scores often underestimates survival prediction, which can lead to some patients not receiving treatment.^[16,17] The goal of surgical treatment should be to preserve existing neurological functions and improve the patient's quality of life. Preoperative assessments of tumor-related instability, Karnofsky score, and multidisciplinary oncological evaluation will be beneficial.^[18]

Conclusion

Patients with metastatic tumors should be evaluated in a multisystemic manner. With advancements in oncological treatments, survival has increased. Classification scores often underestimate survival predictions. New classifications supported by artificial intelligence could be developed for more accurate survival determination.

Ethics Committee Approval

The patients were retrospectively reviewed, following the approval of the ethics committee (Date: 11.02.2021, Decision No: B.10.1.TKH.4.34.H.GP.0.01/53).

Informed Consent

Retrospective study.

Peer-review

Externally peer-reviewed.

Authorship Contributions

Concept: C.S.; Design: C.S.; Supervision: C.S.; Fundings: C.S.; Materials: S.N.; Data: S.N.; Analysis: S.N.; Literature search: C.S.; Writing: C.S.; Critical revision: S.N.

Conflict of Interest

None declared.

REFERENCES

1. Fornasier VL, Horne JG. Metastases to the vertebral column. *Cancer* 1975;36:590–4. [CrossRef]
2. Coleman RE. Clinical features of metastatic bone disease and risk of skeletal morbidity. *Clin Cancer Res* 2006;12:6243s–9. [CrossRef]
3. Tokuhashi Y, Matsuzaki H, Toriyama S, Kawano H, Ohsaka S. Scoring system for the preoperative evaluation of metastatic spine tumor prognosis. *Spine (Phila Pa 1976)*. 1990;15:1110–3. [CrossRef]
4. Tokuhashi Y, Matsuzaki H, Oda H, Oshima M, Ryu J. A revised scoring system for preoperative evaluation of metastatic spine tumor prognosis. *Spine (Phila Pa 1976)* 2005;30:2186–91. [CrossRef]
5. Gakhar H, Swamy GN, Bommireddy R, Calthorpe D, Klezl Z. A study investigating the validity of modified Tokuhashi score to decide surgical intervention in patients with metastatic spinal cancer. *Eur Spine J* 2013;22:565–8. [CrossRef]
6. Tabouret E, Cauvin C, Fuentes S, Esterni B, Adetchessi T, Salem N, et al. Reassessment of scoring systems and prognostic factors for metastatic spinal cord compression. *Spine J* 2015;15:944–50. [CrossRef]
7. Park S, Lee C, Chung S, Lee K. How accurately can tokuhashi score system predict survival in the current practice for spinal metastases?: Prospective analysis of 145 consecutive patients between 2007 and 2013. *J Spinal Disord Tech* 2015;28:E219–24. [CrossRef]
8. Tomita K, Kawahara N, Kobayashi T, Yoshida A, Murakami H, Akamaru T. Surgical strategy for spinal metastases. *Spine (Phila Pa 1976)* 2001;26:298–306. [CrossRef]
9. Papastefanou S, Alpantaki K, Akra G, Katonis P. Predictive value of Tokuhashi and Tomita scores in patients with metastatic spine disease. *Acta Orthop Traumatol Turc* 2012;46:50–6. [CrossRef]
10. Tang V, Harvey D, Park Dorsay J, Jiang S, Rathbone MP. Prognostic indicators in metastatic spinal cord compression: Using functional independence measure and Tokuhashi scale to optimize rehabilitation planning. *Spinal Cord* 2007;45:671–7. [CrossRef]
11. Morgen SS, Nielsen DH, Larsen CF, Sogaard R, Engelholm SA, Dahl B. Moderate precision of prognostic scoring systems in a consecutive, prospective cohort of 544 patients with metastatic spinal cord compression. *J Cancer Res Clin Oncol* 2014;140:2059–64. [CrossRef]
12. 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;57:188–93. [CrossRef]
13. Van der Linden YM, Dijkstra SP, Vonk EJ, Marijnen CA, Leer JW; Dutch Bone Metastasis Study Group. Prediction of survival in patients with metastases in the spinal column: Results based on a randomized trial of radiotherapy. *Cancer* 2005;103:320–8. [CrossRef]
14. Leithner A, Radl R, Gruber G, Hochegger M, Leithner K, Welkerling H, et al. Predictive value of seven preoperative prognostic scoring systems for spinal metastases. *Eur Spine J* 2008;17:1488–95. [CrossRef]
15. Bauer HC, Wedin R. Survival after surgery for spinal and extremity metastases. Prognostication in 241 patients. *Acta Orthop Scand* 1995;66:143–6. [CrossRef]
16. Tabouret E, Cauvin C, Fuentes S, Esterni B, Adetchessi T, Salem N, et al. Reassessment of scoring systems and prognostic factors for metastatic spinal cord compression. *Spine J* 2015;15:944–50. [CrossRef]
17. Pollner P, Horváth A, Mezei T, Banczerowski P, Czegléczki G. Analysis of four scoring systems for the prognosis of patients with metastasis of the vertebral column. *World Neurosurg* 2018;112:e675–82. [CrossRef]
18. Yao A, Sarkiss CA, Ladner TR, Jenkins AL 3rd. Contemporary spinal oncology treatment paradigms and outcomes for metastatic tumors to the spine: A systematic review of breast, prostate, renal, and lung metastases. *J Clin Neurosci* 2017;41:11–23. [CrossRef]

Spinal Metastazda Survive Tahmininde: Modifiye Bauer ve Van der Sınıflandırmasının Karşılaştırmalı Analizi

Amaç: Birincil tümörler için hedeflenmiş tedavilerin geliştirilmesi ve ileri görüntüleme yöntemleriyle erken tanı konulması, kanser hastalarının yaşam sürelerini uzatmıştır. Bu çalışma, Modifiye Bauer ve Van der Linden sınıflamalarının Türk popülasyonunda hayatta kalmayı belirlemedeki etkinliğini değerlendirmeyi amaçlamaktadır.

Gereç ve Yöntem: 2012-2020 yılları arasında beyin cerrahisi kliniğine omurga metastazı ile başvuran 83 hasta üzerinde retrospektif bir analiz yapıldı. Demografik özellikler, malignite kaynağı, metastaz bölgesi ve Modifiye Bauer, Van der Linden sistemlerinin skorları detaylandırıldı. Hayatta kalma süresi tanı tarihinden itibaren hesaplandı ve istatistiksel yazılımlar kullanılarak analiz edildi.

Bulgular: Seksen üç hastanın ortalama yaşı 59.6 yıl olup, 67'si (%80.72) erkek, 16'sı (%19.27) kadındı. Birincil tümör tipleri arasında akciğer kanseri (%43.37), ürogenital tümörler (%32.53), gastrointestinal tümörler (%14.45), meme tümörleri (%7.22) ve nazofarenks tümörleri (%2.4) bulunuyordu. Torasik tutulum %46.98, lomber %39.75, servikal %8.43 ve sakral %4.81 oranında gözlemlendi. Hastaların %45.78'inde omurga kitlesi tanısı, birincil tümörü belirlemek için ek araştırmalara yol açtı. Modifiye Bauer skoru hastaların %48.19'unda hayatta kalma süresini doğru tahmin ederken, Van der Linden skoru %46.99 oranında doğru tahminde bulundu. Tümör büyüme hızı ile sınıflamaların hayatta kalma tahmin doğruluğu arasında anlamlı bir fark bulunmadı.

Sonuç: Prognostik skorlama sistemleri, omurga metastazlarının yönetiminde yararlı rehberlik sağlarken, tahmin doğruluğu değişkenlik göstermektedir. Bu sistemler genellikle hayatta kalma tahminlerini düşük tahmin eder. Yapay zeka destekli yeni sınıflamaların geliştirilmesi, hayatta kalma tahminlerinin doğruluğunu artırabilir ve tedavi stratejilerini iyileştirebilir.

Anahtar Sözcükler: Modifiye Bauer Sınıflaması; spinal metastazlar; Vander Linden sınıflaması.