

Predictors of Prolonged Survival in Tokuhashi Group 1 Patients After Surgery for Metastatic Spinal Cord Compression

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Abstract

Study Design: Retrospective Cohort Study

Background: To identify clinical and oncological factors independently associated with postoperative survival ≥ 6 months among surgically treated metastatic epidural spinal cord compression (MESCC) patients classified as Tokuhashi Group 1 (score ≤ 8).

Methods: We retrospectively reviewed 367 patients who underwent separation surgery for MESCC at a single tertiary center (2015–2022). Demographic, oncologic, radiologic (Bilsky grade), and treatment variables were extracted. Extended survival was defined as ≥ 6 months. Variables with $p < 0.10$ entered multivariable logistic regression. A landmark analysis excluding patients dying within 12 weeks of surgery was performed to address immortal time bias.

Results: Despite a Tokuhashi prediction of < 6 months, median postoperative survival was 5.00 months (IQR 2.00–12.00) and 180/367 (49.05%) survived ≥ 6 months. Kidney (OR 2.31, 95% CI 1.03–5.33), prostate (OR 3.77, 95% CI 1.56–9.59), and breast (OR 2.99, 95% CI 1.23–7.75) primaries were independent predictors of extended survival, remaining significant in the landmark cohort. An association with age 45–54 years (OR 2.58, 95% CI 1.17–5.87) was identified but did not persist on landmark analysis and is considered exploratory. Postoperative radiotherapy showed no independent association after landmark analysis ($p = 0.47$), consistent with immortal time bias.

Conclusions: Kidney, prostate, and breast primary tumors were robust independent predictors of survival ≥ 6 months in Tokuhashi Group 1 MESCC patients undergoing surgery, likely reflecting responsiveness to modern systemic therapy. These findings should inform rather than dictate surgical candidacy within multidisciplinary decision-making.

Background

Metastatic epidural spinal cord compression (MESCC) is a severe complication of systemic malignancy, occurring in up to 10% of patients with advanced-stage cancer [1, 2]. MESCC can present insidiously or as an acute neurological emergency, resulting in motor weakness, sensory loss, sphincter dysfunction, and in severe cases, complete paralysis [3]. Prompt recognition and management are essential to preserving function and improving patient quality of life [2].

Historically, treatment strategies for MESCC were limited to invasive surgical approaches, high-dose corticosteroids, and conventional external beam radiotherapy (EBRT) [4]. The landmark randomized controlled trial by Patchell et al. in 2005 demonstrated the superiority of surgical decompression followed by radiotherapy over radiotherapy alone in preserving ambulatory function and achieving better neurological outcomes [5]. This pivotal study, along with the advent of more selective radiotherapy modalities such as spine stereotactic radiosurgery (SSRS) marked a paradigm shift in the approach to

MESCC, firmly establishing surgery as a cornerstone of treatment in appropriately selected patients [6, 7].

Accurate survival prediction is essential for selecting surgical candidates, as spine surgery for metastases is palliative in nature and involves significant perioperative risk [8–11]. The revised Tokuhashi score remains one of the most widely used tools to guide surgical decision-making [11, 12]. It incorporates six clinical parameters: performance status, number of extraspinal bone metastases, number of vertebral metastases, metastases to major internal organs, primary tumor type, and neurologic status [12, 13]. Patients with scores ≤ 8 are traditionally considered poor surgical candidates due to a predicted survival of less than 6 months. Several studies have demonstrated that the revised Tokuhashi score systematically underestimates survival in the modern treatment era [11, 21, 22]. It is now increasingly recognized that a substantial proportion of Tokuhashi Group 1 patients survive beyond 6 months after surgery. However, while the inaccuracy of this threshold is established, the clinical and oncological factors that distinguish longer survivors within this poor-prognosis group have not been systematically investigated.

In this retrospective cohort study, we evaluated the survival outcomes of 367 MESCC patients treated surgically, all of whom were classified as Tokuhashi Group 1 (score ≤ 8). Patients in this category are traditionally considered inoperable due to their predicted survival of less than 6 months. However, this threshold has increasingly been challenged by modern clinical experience and emerging literature [4, 7, 11, 14, 15]. Therefore, the purpose of this study was to identify preoperative and perioperative predictors of prolonged survival (≥ 6 months) among surgically treated MESCC patients classified as Tokuhashi Group 1, with the aim of informing surgical decision-making in this challenging population.

Several modern survival algorithms have emerged since the Tokuhashi revision, most notably the machine-learning-derived SORG nomogram, which achieves c-indices of 0.76–0.87 for 30- and 90-day survival, and the NESMS, prospectively validated to predict 1-year survival more accurately than legacy tools [16, 17]. These models, however, were developed in heterogeneous populations spanning a wide prognostic spectrum and include laboratory or functional variables not always captured in routine practice. Whether they outperform the revised Tokuhashi score in the sickest patients (score ≤ 8) undergoing contemporary separation surgery remains untested. Our study therefore focuses on this ‘worst-case’ subgroup and now contextualizes our findings within the published performance metrics of SORG and NESMS.

Methods

Study design

After approval by the Institutional Review Board of Severance Hospital, Yonsei University College of Medicine, Seoul, Korea (IRB No. 4-2022-0760), which waived the requirement for informed consent because personal identifying information was excluded from the dataset, we conducted a retrospective review of patients who underwent surgery for metastatic spinal tumors at a single tertiary academic

hospital between January 2015 and December 2022. This article is reported following the STROBE guideline. All studies were performed according to relevant guidelines and regulations.

Inclusion and Exclusion Criteria

Eligible patients were: (1) aged 18 years or older, (2) diagnosed with metastatic spine lesions involving the cervical, thoracic, or lumbar vertebrae, (3) treated surgically for MESCC, and (4) classified as Tokuhashi group 1. Patients with incomplete preoperative imaging or documentation were excluded. Cases with surgery-related infection or revision for the same lesion were excluded to ensure consistent oncologic follow-up.

Prognostic Classification

All patients included in the analysis were classified as **Tokuhashi Group 1**, with a revised Tokuhashi score of **8 or less**, indicating a predicted survival of less than 6 months. The revised Tokuhashi score was determined based on general condition, number of extraspinal bone metastases, number of vertebral metastases, presence of visceral metastases, primary tumor site, and neurologic status [12, 13].

Radiologic Evaluation

The degree of epidural spinal cord compression was graded based on preoperative magnetic resonance imaging (MRI) using the **Bilsky scale** [6, 18, 19]. Grades 0 and 1 were classified as “low grade.” The presence of extraspinal disease was assessed via bone scan, CT, or PET imaging.

Postoperative Radiotherapy

Receipt and timing of adjuvant radiotherapy were extracted from institutional oncology records. “Within 12 weeks” was chosen to encompass the standard postoperative window used in our center, allowing sufficient wound healing while capturing early adjuvant treatment. This interval corresponds to the time frame reported in prior studies where delayed radiotherapy (> 40 days) was associated with inferior local control [20].

Conventional external-beam radiotherapy (EBRT) was used in the majority of cases; stereotactic body radiotherapy (SBRT) was introduced in the later study years and applied selectively for radio-resistant histologies such as renal or melanoma metastases.

Surgical Technique

The decision to proceed with surgery was guided by thorough multidisciplinary cancer team discussions. In principle, all patients underwent “separation surgery” as described by Wang et al [18], which allowed for circumferential decompression and stabilization of the affected spinal segment. Decompressive laminectomy with a unilateral or bilateral facetectomy was done along with placement of pedicle screws.

Circumferential decompression of the thecal sac and nerve roots was performed, with partial resection of the posterior longitudinal ligament and vertebral body/pedicle when necessary [7].

Outcome and Statistical analysis

The primary outcome was prolonged survival, defined as postoperative survival ≥ 6 months. The proportion of patients achieving this threshold was additionally reported to contextualize the performance of the Tokuhashi classification. Patients were dichotomized into two groups accordingly (< 6 months vs. ≥ 6 months). Independent variables included age (continuous), Bilsky grade (ordinal), receipt of postoperative radiotherapy within 12 weeks (binary), and primary tumor histology (categorical). Univariate analyses were first conducted using chi-square tests for categorical variables and independent t-tests for continuous variables. Variables with $p < 0.10$ in univariate analysis were included in a multivariable logistic regression model to identify independent predictors of extended survival. Odds ratios (ORs), 95% confidence intervals (CIs), and p-values were calculated. Overall survival was estimated using the Kaplan–Meier method and compared across primary tumor types with the log-rank test; patients alive at last contact were censored at the date of last follow-up, and median follow-up was estimated by the reverse Kaplan–Meier method. All statistical analyses were performed using IBM SPSS Statistics version 30.0 (IBM Corp., Armonk, NY), with $p < 0.05$ considered statistically significant. Because serum albumin and pre-operative ambulation—the two additional NESMS variables—were incompletely recorded, a head-to-head calculation was not feasible. Instead, we compared our observed survival distributions with the published discriminative statistics (AUC, c-index) for both the SORG and NESMS models, acknowledging this as an indirect comparison.

We minimized selection bias by consistently applying predefined inclusion and exclusion criteria to all Tokuhashi Group 1 patients during the study period. Radiologic variables, including Bilsky grade, were independently reviewed by two spine surgeons to reduce observer bias, with discrepancies resolved by consensus. To control for confounding, we included key clinical variables (age, tumor type, and radiotherapy status) in our multivariable logistic regression model. Data collection was standardized using a uniform retrospective chart review process to reduce information bias. Cases with missing data were excluded from each respective analysis. No data imputation was performed.

To address potential immortal time bias in the association between postoperative radiotherapy and survival, a landmark analysis was performed. Patients who died within 12 weeks (84 days) of surgery were excluded, and multivariable logistic regression was repeated in the remaining cohort.

Results

Patient characteristics

A total of 367 patients met the inclusion criteria after applying exclusions (Figure 1). Table 1 summarizes baseline demographic and clinical characteristics of the cohort. The median age was 61.00 years (IQR, 51.50–70.00) in patients who survived less than 6 months and 60.00 years (IQR, 51.00–68.25) in those

who survived 6 months or longer, with no statistically significant difference between the groups ($p = 0.55$). Male patients constituted 67.91% (127/187) of the group surviving <6 months and 65.56% (118/180) of those surviving ≥ 6 months, also showing no significant difference ($p = 0.71$). Bilsky grade 3 was observed in 79.14% (148/187) of patients who survived less than 6 months and 78.33% (141/180) of patients who survived 6 months or more ($p = 0.95$). Bilsky grade 2 was found in 20.86% (39/187) of the <6-month group and 21.67% (39/180) of the ≥ 6 -month group, with no significant difference ($p = 1.00$). No patient had low-grade epidural compression (Bilsky grade 0 or 1); all patients presented with Grade 2 or Grade 3 compression.

Primary Tumor Types

Table 2 illustrates the distribution of primary tumor types and postoperative survival outcomes, highlighting significant variations across different tumor origins. The most frequent primary tumor was lung cancer ($n=92$, 25.07%) with a median survival of 4.00 months. Notably, breast cancer ($n=29$, 7.90%) and prostate cancer ($n=31$, 8.45%) showed longer median survival times of 12.00 and 7.00 months, respectively. Tumors of kidney origin ($n=35$, 9.54%) also had favorable median survival of 9.00 months. In contrast, liver ($n=40$, 10.90%) and cervical cancers ($n=11$, 3.00%) exhibited poorer median survival of 4.00 and 3.00 months, respectively. Survival differed significantly across primary tumor types (log-rank $p < 0.001$; Figure 2).

Actual vs. Predicted Survival

Despite all patients being classified as Tokuhashi Group 1 (predicted survival <6 months), the actual median postoperative survival was **5.00 months** (IQR 2.00–12.00; mean **10.90 $\pm$ 15.22 months**), reflecting considerable variability in patient outcomes. Of the 367 patients scored ≤ 8 , 180 (49.05%) survived beyond 6 months, constituting the prolonged survival group for subsequent analysis.

Prognostic Factors Associated with Extended Survival

Factors significantly associated with extended survival beyond 6 months are detailed in Tables 3 and 4. In univariable analysis, receipt of postoperative radiotherapy within 12 weeks was associated with prolonged survival (OR 1.53, 95% CI 1.01–2.34, $p=0.05$). However, in landmark analysis excluding patients who died within 12 weeks of surgery ($n=255$ remaining), this association was no longer statistically significant (OR 1.27, 95% CI 0.66–2.40, $p=0.47$), suggesting that the initial association may have been influenced by immortal time bias. Accordingly, radiotherapy was not retained in the primary multivariable model. Age between 45–54 years also emerged as a significant predictor of prolonged survival (OR = 2.58, 95% CI: 1.17–5.87, $p = 0.02$), with 57.83% (48/83) of patients in this age group surviving more than 6 months. Furthermore, kidney (OR = 2.31, 95% CI: 1.03–5.33, $p = 0.04$), prostate (OR = 3.77, 95% CI: 1.56–9.59, $p < 0.01$) and breast cancers (OR = 2.99, 95% CI: 1.23–7.75, $p = 0.02$) were significantly associated with better survival outcomes, with survival rates of 60.00% (21/35), 67.74% (21/31) and 68.97% (20/29) respectively. In the landmark cohort (Table 4), the kidney, prostate, and breast associations persisted (OR 3.56, 95% CI 1.14–13.74, $p=0.04$; OR 5.50, 95% CI 1.56–26.22, $p=0.01$;

and OR 5.05, 95% CI 1.26–34.13, $p=0.04$, respectively), whereas the association with age 45–54 years was no longer significant (OR 1.75, 95% CI 0.51–5.71, $p=0.36$). The tumor-specific predictors were therefore robust to the landmark sensitivity analysis, while the age association was not.

Discussion

In this cohort of 367 surgically treated MESCC patients predicted to survive less than 6 months, nearly half survived beyond this threshold. Kidney, prostate, and breast primary tumors were independently associated with prolonged survival and remained significant after landmark sensitivity analysis. Age 45–54 years was associated with prolonged survival in the full cohort, but this association was not robust to landmark analysis and should therefore be regarded as hypothesis-generating. Although postoperative radiotherapy within 12 weeks was associated with prolonged survival in univariable analysis, landmark analysis revealed that this association was attributable to immortal time bias: patients who died within the early postoperative period were, by definition, unable to receive adjuvant radiotherapy. After excluding these early deaths, radiotherapy was no longer an independent predictor. This finding does not negate the established oncological rationale for adjuvant radiotherapy in MESCC — namely, local tumor control, and neurological preservation — but highlights the methodological importance of accounting for immortal time when analyzing time-dependent exposures in this population.

Contemporary prognostic models such as SORG and NESMS have demonstrated superior discriminative ability (AUC 0.87 and c-index 0.73, respectively) compared to the revised Tokuhashi score across heterogeneous populations [16, 17]. However, these models address overall survival prediction across the full prognostic spectrum, whereas our study specifically characterizes the clinically challenging subgroup with the poorest Tokuhashi classification. The tumor-specific factors identified in our cohort — particularly kidney, prostate, and breast primaries — may complement these models when applied within high-risk strata.

These findings are consistent with emerging literature calling into question the continued accuracy of legacy prognostic tools [11, 21–23]. The Tokuhashi score was developed based on patient outcomes in the late 1990s and early 2000s, prior to the widespread adoption of targeted therapy, immunotherapy, and advanced radiation techniques [11]. It does not account for tumor molecular markers, systemic therapy responsiveness, or real-time disease burden, all of which are now critical factors in oncology prognostication [4, 14]. Several newer models, including the SORG Classic and Nomogram, have incorporated these variables and shown improved discrimination, especially for short- and intermediate-term survival prediction [15, 24].

The most crucial clinical implication of our findings is that Tokuhashi Group 1 patients should not be excluded from surgery based solely on their prognostic score. Doing so risks withholding meaningful treatment from patients who may benefit significantly. Our results align with those of Park et al. [22], who reported that the Tokuhashi score was suboptimal in reliably predicting survival in patients receiving contemporary systemic treatments. Similarly, Tabourel et al. [11] highlighted the growing risk of

undertreatment if scoring systems developed in earlier eras are used as rigid criteria for surgery. Our study adds real-world, institutional data from a large MESCC cohort to this ongoing conversation, offering quantitative evidence of survival extension beyond predicted values.

We also found that patients with kidney, prostate, and breast cancer had significantly better survival outcomes than patients with other primary tumors. This is congruent with the literature showing that these tumors are not only biologically more indolent but also respond well to systemic treatment options, and radiotherapy [2, 4, 6, 10, 14]. These tumor types are indeed given higher scores in the Tokuhashi system, but our data suggest that even within the same prognostic group, survival can vary widely due to advances in disease-specific treatments.

A major paradigm shift in spine oncology has been the movement from aggressive cytoreductive surgery to separation surgery, which prioritizes safe, limited decompression to facilitate high-dose stereotactic body radiotherapy (SBRT) [8, 10]. This approach balances surgical morbidity with oncologic efficacy and is especially beneficial in patients with metastatic tumors in anatomically complex or high-risk regions. The Spine Instability Neoplastic Score (SINS), developed and validated by the Spine Oncology Study Group, further aids in surgical decision-making by classifying neoplastic instability based on radiographic and clinical criteria [25, 26]. Our institutional use of standardized posterior circumferential decompression and instrumentation across the cohort reflects current surgical best practices and supports reproducibility of outcomes [9].

Importantly, both SORG and NESMS require variables (e.g., serum albumin, detailed systemic therapy response) that were missing in our retrospective dataset. Centers that cannot routinely capture these data may still rely on Tokuhashi while adopting dynamic tools as electronic data capture becomes standard.

Our study draws from a relatively large and homogenous cohort of patients treated with a consistent surgical technique at a high-volume spine center. This enhances internal validity and minimizes confounding from variation in surgical indications or methods. However, the study's retrospective design imposes limitations such as potential selection bias and lack of prospective neurological or quality-of-life assessments. Furthermore, systemic treatment data (e.g., type and timing of chemotherapy, immunotherapy, endocrine therapy) were not uniformly available for analysis. These factors could influence survival outcomes but were not controlled in our model. Additionally, the extent and timing of surgical intervention likely could have varied for each patient though not accounted for in the analysis. Importantly, only patients who actually underwent surgery were included; without a non-operated Tokuhashi Group 1 comparison group, our data cannot establish whether surgery itself confers benefit, and the conclusions apply to the selection of operated patients rather than to the decision to operate. The favorable kidney, prostate, and breast associations should likewise be interpreted as markers of systemic-therapy-responsive disease rather than as independent surgical indications, because disease-specific systemic treatment—the principal driver of survival in these histologies—could not be adjusted for. Finally, the age 45–54 years association was not retained in the landmark sensitivity analysis and

should be regarded as exploratory. Direct head-to-head validation of SORG and NESMS was not feasible due to incomplete recording of serum albumin and preoperative ambulatory status. Additionally, while landmark analysis was employed to address immortal time bias for the radiotherapy variable, residual confounding from unmeasured covariates cannot be excluded. Dichotomization of survival at 6 months may have resulted in loss of prognostic information; future studies employing time-to-event analyses are warranted.

Given the limitations of the revised Tokuhashi and other static scoring systems, there is an urgent need for updated, dynamic prognostic tools. Future efforts should focus on developing updated prognostic tools that integrate modern oncologic variables, including molecular markers and systemic therapy response, to provide a more complete prognostic framework.

Conclusion

This study demonstrates that among surgically treated MESCC patients classified as Tokuhashi Group 1, kidney, prostate, and breast primary tumors were independent predictors of survival ≥ 6 months that remained significant in a landmark sensitivity analysis; an association with age 45–54 years was observed in the full cohort but was not robust and should be regarded as hypothesis-generating. The apparent benefit of postoperative radiotherapy was attributable to immortal time bias and disappeared after landmark analysis. Because these favorable tumor types largely reflect responsiveness to contemporary systemic therapy, and because only operated patients were studied, these predictors should inform multidisciplinary decision-making rather than serve as stand-alone surgical criteria, and warrant confirmation in time-to-event analyses.

Abbreviations

Metastatic epidural spinal cord compression (MESCC), External beam radiotherapy (ERBT), Spine stereotactic radiosurgery (SSRS), Skeletal oncology research group (SORG), New England spinal metastasis score (NESMS), Stereotactic body radiotherapy (SBRT), Spine instability neoplastic score (SINS).

Declarations

Ethics approval and consent to participate

This study was approved by the Institutional Review Board (IRB) of Severance Hospital, Yonsei University College of Medicine, Seoul, Korea (IRB No. 4-2022-0760). The IRB waived the requirement for informed consent as personal identifying information was excluded from the dataset.

Consent for publication

Not applicable.

Availability of data and materials

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Author's contributions

JWS and PSP conceptualized the study, designed the methodology, curated the data, performed the formal analysis, developed the software, created the visualizations, administered the project, and drafted the original manuscript. SYP conceptualized the study, designed the methodology, curated the data, administered the project, supplied the resources, validated the results, and provided supervision. DKK curated the data. CWK developed the software and created the visualizations. HSK, SHM, KSS, BHL, and JWK provided supervision. All authors reviewed and edited the manuscript, and read and approved the final manuscript. JWS and PSP contributed equally to this work.

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Tables

Table 1. Baseline Characteristics of Tokuhashi Group 1 Patients Undergoing Surgery for Metastatic Epidural Spinal Cord Compression (MESCC)

	Survived < 6 months (n=187)	Survived ≥ 6 months (n=180)	p-value
Age [median (IQR)]	61.00 (51.50–70.00)	60.00 (51.00–68.25)	0.55
Sex			0.71
Male	127 (67.91%)	118 (65.56%)	
Female	60 (32.09%)	62 (34.44%)	
Bilsky grading scale			
Grade 3	148 (79.14%)	141 (78.33%)	0.95
Grade 2	39 (20.86%)	39 (21.67%)	1.00

MESCC, metastatic epidural spinal cord compression

*No patient had Bilsky Grade 0 or 1 compression; these grades were therefore excluded from the table.

Table 2. Distribution of Primary Tumor Types Among Tokuhashi Group 1 Patients with MESCC

Primary tumor	N (%)	Median survival (IQR)
Lung	92 (25.07%)	4.00 (1.75–12.00)
Liver	40 (10.90%)	4.00 (1.00–7.25)
Kidney	35 (9.54%)	9.00 (2.00–24.00)
Prostate	31 (8.45%)	7.00 (3.50–18.00)
Breast	29 (7.90%)	12.00 (3.00–28.00)
Rectum	13 (3.54%)	4.00 (2.00–6.00)
Multiple myeloma	12 (3.27%)	9.50 (4.25–17.25)
Pancreas	11 (3.00%)	3.00 (2.00–10.50)
Cervix	11 (3.00%)	3.00 (2.00–5.50)
Melanoma	10 (2.72%)	4.50 (2.25–10.50)
Colon	10 (2.72%)	9.00 (4.50–14.25)
Stomach	10 (2.72%)	2.00 (1.00–5.75)
Esophagus	8 (2.18%)	4.50 (1.75–8.25)
Thyroid	7 (1.91%)	12.00 (6.50–30.00)
Bile duct	6 (1.63%)	3.00 (2.00–4.00)
Other specified*	37 (10.08%)	—
Unknown origin†	5 (1.36%)	—

*Tumors with fewer than 4 patients (n = 37) were grouped as “Other specified.” This includes, for example, ureter (n = 3), ovarian (n = 1), bladder (n = 1), and parathyroid (n = 1) cancers.

†“Unknown origin” refers to cases where no primary tumor site was identified based on available clinical, radiologic, or histopathologic data.

Table 3. Univariate and Multivariate Analysis of Factors Associated with Extended Survival in MESCC Patients

Variable	Category	Survived ≥6 mo, n/N (%)	Univariable OR (95% CI)	p-value	Multivariable OR (95% CI)	p-value
Radiotherapy	No (ref)	64/150 (42.67%)	1.00 (ref)	—	—	—
	Yes	117/217 (53.92%)	1.53 (1.01–2.34)	0.05	—	—
Age (years)	<44 (ref)	15/41 (36.59%)	1.00 (ref)	—	1.00 (ref)	—
	45–54	48/83 (57.83%)	2.38 (1.11–5.23)	0.03	2.58 (1.17–5.87)	0.02
	55–64	56/109 (51.38%)	1.83 (0.88–3.90)	0.11	2.01 (0.94–4.43)	0.08
	65–74	40/84 (47.62%)	1.58 (0.74–3.44)	0.24	1.58 (0.71–3.61)	0.27
	>75	21/50 (42.00%)	1.26 (0.54–2.96)	0.60	1.22 (0.49–3.07)	0.66
Primary tumor	Lung (ref)	37/92 (40.22%)	1.00 (ref)	—	1.00 (ref)	—
	Liver	17/40 (42.50%)	1.10 (0.51–2.33)	0.81	1.08 (0.50–2.32)	0.85
	Kidney	21/35 (60.00%)	2.23 (1.02–5.02)	0.05	2.31 (1.03–5.33)	0.04
	Prostate	21/31 (67.74%)	3.12 (1.35–7.64)	0.01	3.77 (1.56–9.59)	<0.01
	Breast	20/29 (68.97%)	3.30 (1.39–8.38)	0.01	2.99 (1.23–7.75)	0.02
	Other*	64/140 (45.71%)	1.25 (0.74–2.14)	0.41	1.34 (0.78–2.33)	0.29

*"Other" includes all primary tumor types except Lung, Liver, Kidney, Prostate, and Breast cancers.

OR, odds ratio; CI, confidence interval; ref, reference category. Bold denotes statistical significance ($p < 0.05$) in the multivariable model. Radiotherapy was significant in univariable analysis but was not entered into the multivariable model because the landmark sensitivity analysis (Table 4) indicated immortal time bias; univariable results are shown for reference only. Overall Pearson χ^2 for each variable (survival ≥ 6 vs. < 6 months): radiotherapy, 3.56; age, 6.41; primary tumor, 14.80.

Table 4. Landmark Multivariable Logistic Regression Analysis (n=255, excluding patients who died within 12 weeks of surgery)

		OR (95% CI)	p-value
Radiotherapy	No	1.00	
	Yes	1.27 (0.66–2.40)	0.47
Age	< 44	1.00	
	45-54	1.75 (0.51–5.71)	0.36
	55-64	1.29 (0.40–3.87)	0.66
	65-74	0.78 (0.23–2.44)	0.67
	> 75	1.15 (0.29–4.50)	0.84
Primary tumor	Lung	1.00	
	Liver	1.84 (0.60–6.39)	0.30
	Kidney	3.56 (1.14–13.74)	0.04
	Prostate	5.50 (1.56–26.22)	0.01
	Breast	5.05 (1.26–34.13)	0.04
	Other*	1.78 (0.86–3.72)	0.12

*"Other" includes all primary tumor types except Lung, Liver, Kidney, Prostate, and Breast cancers.

Figures

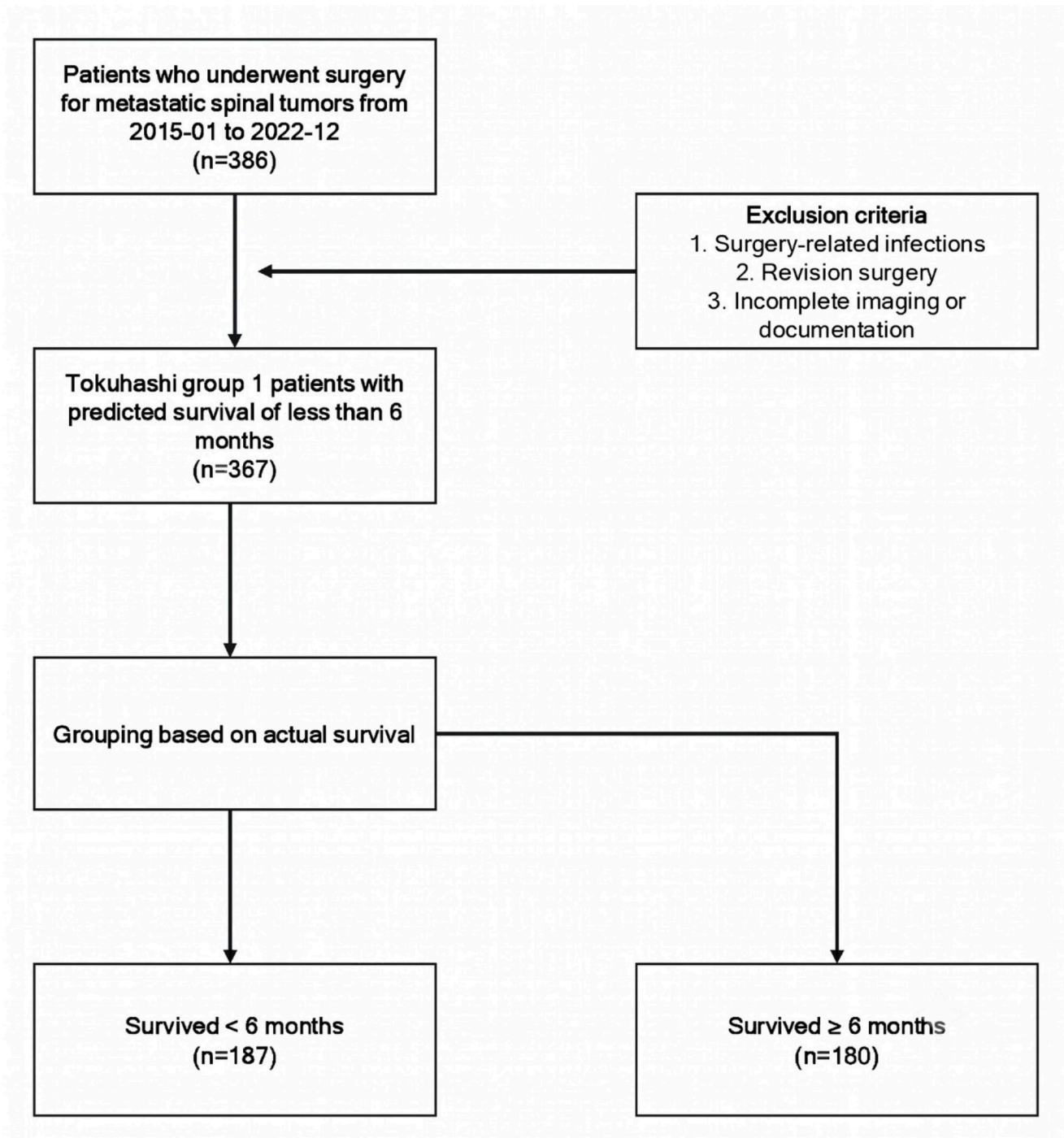
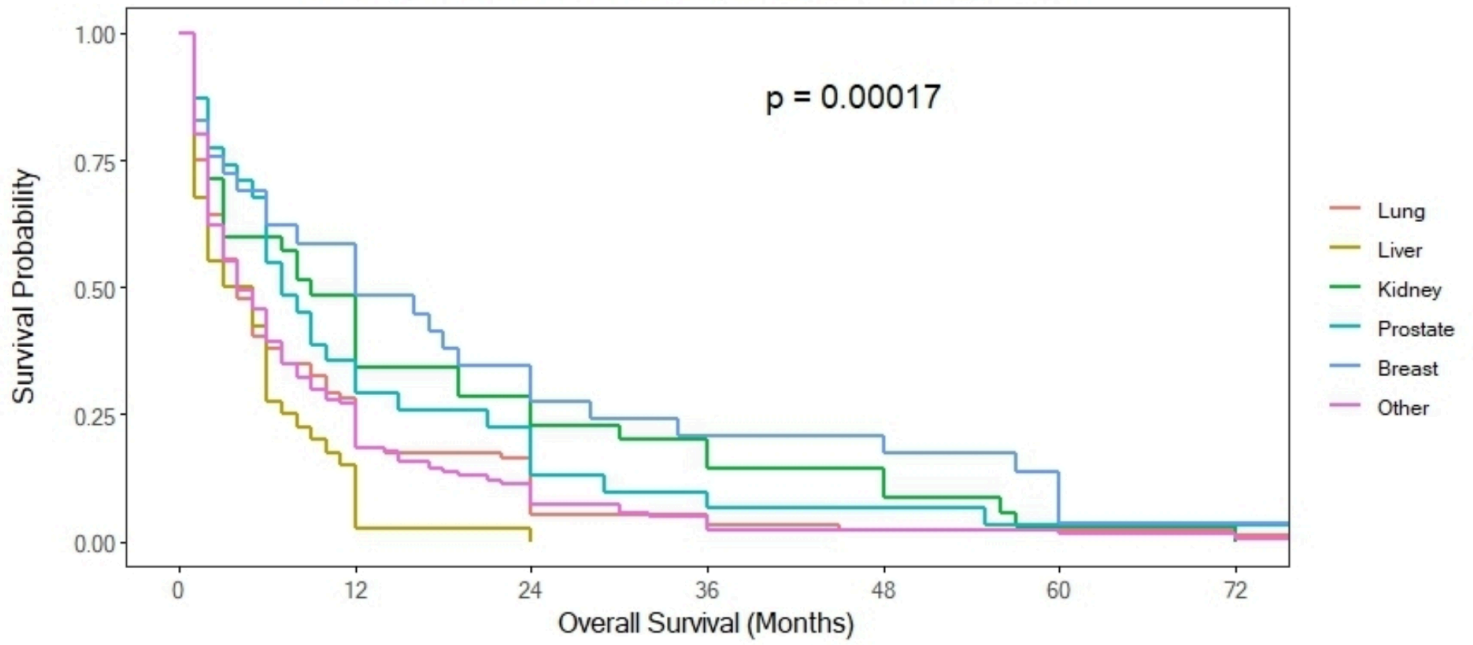


Figure 1

Flowchart of Patient Selection and Grouping Based on Postoperative Survival Duration.

Kaplan-Meier Curve According to Primary Tumor



Number at risk								
Lung	92	26	15	5	2	2	2	
Liver	40	6	1	0	0	0	0	
Kidney	35	17	10	7	5	1	1	
Prostate	31	11	7	3	2	1	1	
Breast	29	17	10	6	6	4	1	
Other	140	38	16	7	3	3	2	

Figure 2

Kaplan-Meier survival curves stratified by primary tumor type.