

Perioperative Complications of Spinal Metastases Surgery

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Abstract: The incidence of symptomatic spinal metastasis has increased due to treatment improvements and longer patient survival. More patients with spinal tumors are choosing operative treatment with an associated increased rate of perioperative complications. Operative metastatic disease treatment complication rates have also increased with overall rates ranging from 5.3% to 76.20%. The common surgical-related complications are iatrogenic dural injury and wound complications. The most common postoperative medical complications are delirium, pneumonia, and deep vein thrombosis. Risk factors for perioperative complications after spinal metastatic surgery include older age, multilevel of spinal metastases, preoperative irradiation, low preoperative Karnofsky Performance Score (10–40) and multiple comorbidities. Charlson Comorbidity Index and New England Spinal Metastasis Score were significant predictor of 30-day complications. The reoperation rate is 10.7%, and the reoperation is most commonly performed in the same admission. In addition, the 30-day mortality rate in this patient population is ~7% (0.9%–13%) and is influenced by the type of cancer, disease burden, and patient comorbidities. We reviewed the prevalence and risk factors of common perioperative complications that occur with surgical treatment of

metastatic spine disease, in an effort to guide the spine surgeon in anticipating and potentially avoiding these complications.

Key Words: prevalence, perioperative complications, spinal metastases, mortality, risk factors

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The incidence of symptomatic spinal metastasis has increased due to treatment improvements and longer patient survival. Treatment for spinal metastatic disease is multidisciplinary and involves pain management, radiotherapy, chemotherapy, percutaneous procedures (eg, vertebroplasty and kyphoplasty) and operative treatment. Surgical indications have expanded over the past few years to address symptoms including neurological deficit due to epidural tumor compression or severe back pain from spinal instability through neural decompression or mechanical stabilization. Yoshihara and Yoneoka¹ reported increasing trend in the population growth-adjusted rate of surgical treatment for spinal metastasis (1.15–1.77 per 100,000) with a concomitant increase in the overall in-hospital complication rate from 14.8% to 27.7% between 2000 and 2009. The purpose of this article was to review the prevalence and risk factors of common perioperative complications of metastatic spine surgery that may guide the spine surgeon in anticipating and potentially avoiding these complications with preemptive treatment.

EPIDEMIOLOGY

Perioperative complication rate in surgery to treat spinal metastases is relatively high. In a review of the literature, the average perioperative complication rates is 26.87% and ranges from 5.3% to 76.20% depending on the study.^{2–18} In addition, multiple complications occurred in ~20% of patients who had at least 1 complication (range, 12.5%–26.73%).^{3,17} These complications may be classified as surgical-related complications and medical complications. The most common surgical-related complications were incidental dural tear, wound dehiscence or surgical site infection, neurological deterioration and nerve root injury. Postoperative medical complications usually relate to the compromised medical state of cancer patients included cerebrovascular disease, deep vein thrombosis, pneumonia, gastrointestinal bleeding, bowel

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TABLE 1. Summary of Perioperative Complications of Metastatic Spinal Surgery

Type of Complications	Average	Range
Total complication rate ^{2-9,12-18}	26.87	5.30–76.20
Intraoperative complications		
Dural tear ^{2-4,12,15-17}	8.37	0–16.00
Nerve root injury ^{2,12,13,17}	2.89	0.71–7.55
Neurologic deterioration ^{2,3,6-8,11,12,16,17}	4.32	0–10.00
Wrong level ¹⁵	0.71	
Surgical postoperative complication		
Wound infection/dehiscence ^{2,3,5,6,9-13,15-18,34}	10.22	3.51–20.00
Hardware problem ^{2-4,8,12,15-17}	1.52	0–2.83
Hematoma ^{2,4,5,8,12,13,15}	2.29	0.71–5.90
Medical postoperative complication		
Stroke ¹⁵	0.71	
Deep vein thrombosis ^{2,4,7,15,17}	2.36	0.94–4.00
Pneumonia ^{2-5,7,8,12-14,17}	3.98	0.71–11.90
Gastrointestinal bleeding ^{12,13,15}	0.67	0.35–0.94
Bowel ileus ^{3,12}	1.62	0.94–2.30
Liver failure ⁵	1	
Acute renal failure ^{5,12}	1.72	0.94–2.5
Cardiovascular problem ^{3,12,15-17}	2.29	1.10–5.00
Delirium ^{2,12,17}	11.21	2.83–20.80
Multiple complication ^{3,17}	19.62	12.50–26.73
30-days mortality rate ^{2-5,9,10,12-15,17,18}	6.7	0.9–13.00

ileus, liver failure, acute renal failure, cardiovascular problem and delirium. Delirium (11.21%) and pneumonia (3.98%) were the most common medical complications. The perioperative complications are summarized in Table 1.

RISK FACTORS

Previous studies have reported on multiple risk factors for increased morbidity after metastatic spine disease surgery including age,^{4,7} multilevel spinal metastases,⁴ preoperative irradiation,^{3,6} patients operated on by a surgeon who performed fewer procedures, presented with myelopathy,¹⁷ preoperative Karnofsky Performance Score (KPS), 10–40,¹⁹ and number of comorbidities.⁷ The KPS is one of the tools that assess the patients' general well-being and ability to doing daily-living activity. This score ranges between 100 (normal) to 0 (dead). For example, KPS, 10–40 means patients are unable to care themselves and need hospital care. However, there was no study that reported the effect of primary tumor type and location to rate of perioperative complications.

Postoperative complications were more common in elderly group. Lau and colleagues reported age above 40 years is an independent predictor of complication rate. When compared with patients below 40 years of age, patients between 40 and 65 years were at an increased risk of a complication [odds ratio (OR), 1.91; 95% confidence interval (CI), 1.02–16.78] and patients above 65 years were also at an increased risk of a complication (OR, 5.17; 95% CI, 1.54–29.81).⁴ Amelot et al²⁰ also demonstrated that the rate of postoperative complications significantly increased with age (33.3% in the age above 80 years group, 23.9% in the 70–80 years group, and 17.9% for patients below 70 years group, $P = 0.004$). Patil et al

reported that compared with patients aged 18–45 years, patients ages 65 to 84 years had a 2.5-fold risk of adverse outcome (death or discharge to an institution other than home) and age above 84 years group were 7 times more likely to have an adverse outcome.⁷ Murakami and colleagues reviewed perioperative complications for 32 elderly (> 70 y) patients with spinal metastases who underwent surgical treatment based on Tomita's surgical strategy. Tomita and colleagues reported the surgical strategy for spinal metastases that depend on prognostic score [range, 2 (best) to 10 (worst)] which calculated from 6 preoperative parameters. The strategy included prognostic score of 2–3 indicated a wide or marginal excision, 4–5 indicated marginal or intralesional excision, 6–7 indicated palliative surgery and 8–10 indicated non-operative supportive care.²¹ Perioperative complications encountered were respiratory in 6 patients (18.8%), cardiovascular in 3 (9.4%), and delirium in 4 (12.5%). In 161 nonelderly patients, lung complications arose in 4 patients (2.5%), cardiovascular in 1 (0.6%), and delirium in 2 (1.2%). Respiratory complications and delirium occurred at a significantly higher frequency in the elderly group.²²

The number of involved metastatic vertebral levels is also associated with increased risk of complications. Lau et al⁴ demonstrated that patients with metastatic lesions involving 3 or more contiguous vertebral levels had about 3 times the rate of complications (OR, 2.76; 95% CI, 1.09–9.61). The adverse outcome rate increased 1.8 fold in patients who had ≥ 3 comorbidities.⁷ Yokogawa et al⁶ reported that patients who underwent preoperative irradiation before total en bloc spondylectomy (TES) had perioperative complication 3-fold higher than patients without preoperative radiation (77.8% vs. 18.8%). Preoperative KPS between 10 and 40 (OR, 9.13; 95% CI, 1.42–58.63; $P = 0.020$) was associated with higher odds of complications.¹⁹

SCORING SYSTEM FOR PREDICTING PERIOPERATIVE COMPLICATIONS

There have been many scoring systems developed to attempt to predict risk of postoperative complications. Arrigo and colleagues retrospectively reviewed 200 metastatic spinal disease surgeries between 1999 and 2009. Multivariate analysis revealed that Charlson Comorbidity Index score ≥ 2 was a significant predictor of 30-day complication rate following spinal metastasis surgery.²³ Schoenfeld and colleagues demonstrated the accuracy of the New England Spinal Metastasis Score for predicting 30-day major systemic complications and mortality following metastatic spinal surgery. The New England Spinal Metastasis Score (ranged, 0–3) is based on functional status (ambulatory vs. impaired or non-ambulatory including neurologic impairment or pain), modified Bauer Score (≤ 2 vs. ≥ 3), and preoperative serum albumin (< 3.5 vs. ≥ 3.5 g/dL). When comparing with score of 0, patients who had score of 3 had 74% reduction in major systemic complications (95% CI,

0.11–0.62) and 89% reduction in mortality (95% CI, 0.04–0.31).²⁴ The modified Brauer Score is the prognostic score that use to predict the survival in spinal metastasis patients. The total score range between 0 (worst) to 4 (best) depend on 4 favorable prognostic criteria including (1) no visceral metastases, (2) primary tumor is not lung cancer, (3) primary tumor is breast, renal, lymphoma, or myeloma and (4) single skeletal metastasis.²⁵

Surgical Apgar Score (SAS) is a scoring system for predicting risk of postoperative morbidity and mortality based on three intraoperative measures including lowest mean arterial pressure (score range, 0–3), estimated blood loss (score range, 0–3) and lowest heart rate (score range, 0–4) resulting in a total score ranging from 0 to 10. This scoring system was a significant predictor for perioperative morbidity in patients with traumatic hip fracture²⁶ and esophagectomy.²⁷ However, Lau and colleagues reported that no significant correlation between SAS and complication rate ($P = 0.413$) in spinal metastases patients. Complication rates were 25.0% for SASs 0–2, 33.3% for 3–4, 18.4% for 5–6, 10.0% for 7–8, and 33.3% for 9–10 points.¹⁹

PERIOPERATIVE COMPLICATIONS OF EN BLOC VERTEBRECTOMY FOR SPINAL METASTASES

TES in spinal metastases is typically only performed in patients with a good prognosis who have solitary metastases. Lee and colleagues reported that patients who underwent TES had statistically significant lower postoperative complication rate when compared with patients who underwent debulking surgery. Postoperative complications were 12.9% in the en bloc group, 20.7% in the debulking group, and 14.3% in the palliative group ($P = 0.016$). Wound dehiscence rates were not significantly different.⁵ Preoperative radiotherapy in TES was the critical risk factor for complications. Yokokawa reported the overall rate of perioperative complications was 40%. Patients who underwent preoperative radiotherapy (RT-TES) had 77.8% complication rate that was significant higher than the nonradiotherapy group (18.8%). In addition, RT-TES group had significantly increased incidence of complications including intraoperative dural injuries, postoperative cerebrospinal fluid leakage, wound dehiscence, and pleural effusions.⁶

INTRAOPERATIVE COMPLICATIONS

Iatrogenic Dural Injury

The average incidence of dural tear in spinal metastatic surgery is 8.37% (0%–16%).^{2,3,6,12,15–17} Interestingly, incidence of intraoperative dural injuries (ID) in other case series that patients underwent palliative surgery (anterior or posterior decompressive surgery with instrumentation) were 0%–9.90% which is higher when compared with the incidence of unintended durotomy of 1.6% in spine surgery and 2.2% in revision surgery.²⁸ Yokogawa and colleagues reviewed 77 patients who underwent TES (22 patients were excluded because of primary spinal tumor surgery) and

reported the incidence of ID was 16% (8/50). The most of ID occurred in patients who had undergone preoperative radiotherapy especially in radiation interval > 12 months before surgery ($P = 0.046$) and total radiation dose was > 40 Gy ($P = 0.097$). This result is not unexpected as preoperative radiotherapy may create epidural fibrosis, adhesions and dural thinning which can predispose to durotomy. Epidural fibrosis results in tissue adhesion around the dura mater and may cause intraoperative dural injuries although this has not been verified as the cause of increased dural injury rates. Regardless, dural injuries must be considered as iatrogenic complications.⁶

Neurological Deterioration

The average overall incidence of postoperative neurological deterioration in spinal metastatic surgery was 4.32% (0%–10%), whereas average incidence of major neurological deficit was 2.36% (0%–5.94%) and minor deficit (nerve, nerve root injury, or reduced sensibility) was 4.39% (0%–7.55%).^{2,3,6–8,11,12,16,17} The etiology was varied including direct intraoperative spinal cord trauma, and extensive segmental arteries ligation during en bloc surgery. However, there was no study that reported the effect of primary tumor type, approach, preoperative neurological status, and location to rate of neurological deterioration. The details of neurological complications were shown in Table 2. Intraoperative neuromonitoring with somatosensory and motor evoked potential is often utilized to help monitor spinal cord function during the operation. In cases with unstable pathological fractures, neuromonitoring data can be obtained before positioning the patient in the prone position. In addition, the use of a rigid brace like a thoracolumbosacral orthosis or rigid cervical brace (in cases of cervical surgery) may be used to help safely position the patient prone on the operative table, and removed after all positioning manipulation is done. An alternative would be to position the patient supine and turn prone using a rotisserie maneuver on a capable table. Intraoperative neuromonitoring data loss can occur from numerous causes. Spinal deformity literature has reported protocols a surgeon can take if signal loss occurs which are helpful to review.²⁹

Intravenous corticosteroid use is controversial and varies by surgeon. No standard protocol has been proven to be most effective. Pahys et al²⁹ recommended giving steroids to patients who have a continued negative wake-up test (ie, absence of motor function) after release of tension from corrective and distractive maneuvers. If an intraoperative neurological deficit occurs, postoperative care will require patient monitoring in a surgical intensive care unit to maintain mean arterial pressure > 80 mm Hg, continuation of steroids, maintaining adequate oxygenation and administration of medications to minimize complications of steroid use such as gastrointestinal prophylaxis and glucose control with insulin. Assessment of patient comorbidities that may increase patient morbidity with use of high dose steroids needs to be considered on a case-by-case basis, as not all metastatic disease patients can tolerate high levels of steroids.

TABLE 2. Details of Neurological Complications

References	Total Patients	Collect Year	Sex	Mean Age (y)	Type of Primary Tumor	Procedure	Adjunctive therapy				No of Minor Deficit	No of Major Deficit	Details
							Steroid	Preop RT	Postop RT	Chemo			
Bauer ¹¹	67	1990–1994	M, 43 F, 24	64	18 prostate 12 breast 37 other	Posterior wide decompression and fixation	NA	13	35	NA	0	2	Frankel D to C
Pascal-Mousellard et al ²	145	1982–1991	NA	NA	39 breast, 13 lung, 8 colon 6 RCC 6 prostate 73 other	32 anterior, 97 posterior, 16 combined decompressive surgery and instrumentation	NA	NA	NA	NA	2	3	
Wise et al ³	80	1993–1996	M, 38 F, 42	55.6	18 breast 13 myeloma, 11 lung 6 renal 6 prostate 9 lymphoma 8 sarcoma 5 unknown 4 other	42 anterior, 36 posterior, 12 combined decompressive surgery and instrumentation	NA	41	NA	NA	0	0	
Patil et al ⁷	26233	1993–2002	M, 15512 F, 10721	NA	NA	NA	NA	NA	NA	NA	NA	158	Database review
Yang et al ⁸	17	2001–2009	M, 128 F, 89	NA	45 lung 27 colorectal 24 breast 20 HCC 17 RCC 13 prostate 12 thyroid 59 other	48 Decompressive laminectomy 40 decompressive laminectomy + postfixation 74 corpectomy + anterior fusion 55 corpectomy + posterior fixation	NA	53	104	NA	0	1	Paraplegia
Bollen et al ¹²	106	2001–2010	M, 53 F, 53	59	25 breast 20 lung 19 RCC 11 prostate	7 vertebroplasty 46 postdecompression 52 corpectomy 1 en bloc resection	NA	30	56	9	8	2	
Dea et al ¹⁷	101	2009–2012	M, 50 F, 51	62	22 breast 20 lung 17 kidney 11 colorectal 7 prostate 5 lymphoma 17 other	24 posterolateral vertebrectomy 50 decompression and fusion 6 decompression only 3 fusion only	NA	20	NA	NA	2	6	Transient neurological deterioration occurred in 6 patients
de Ruitter et al ¹⁶	60	2005–2011	M, 30 F, 30	62	14 breast 8 lung 10 kidney 2 prostate 8 multiple myeloma 2 thyroid 2 melanoma 5 gastrointestinal 2 urothelial cell 9 other	60 corpectomy with expandable cage reconstruction	NA	NA	NA	NA	4	2	1 weakness of the iliopsoas muscle 1 spinal cord injury during surgery 2 temporary hoarseness (recurrent laryngeal nerve traction) 2 transient Horner sign
Yokogawa et al ⁶	50	2010–2013	M, 27 F, 23	57.8	10 RCC 11 breast 7 thyroid 2 bladder 3 stomach 14 other 3 unknown	Total en bloc spondylectomy	4	18	NA	16	0	2	

Chemo indicates chemotherapy; HCC, hepatocellular carcinoma; Post, posterior; Postop, postoperative; Preop, preoperative; RCC, renal cell carcinoma.

Postoperative Complications

Wound Complication

Surgical site infection (SSI) after spinal surgery is a common complication that may lead to increased costs of treatment, morbidity, and mortality. The SSI rates in spine surgery vary from 2% to 15% based on the surgical procedure, use of instrumentation, patient factors, surgical time, and whether the surgery is primary or revision.^{30–33} By pooling multiple studies of patients undergoing spinal metastatic surgery. The average incidence of wound infection is 10.22% (3.51%–20%).^{2,3,5,6,9–13,15–18,34} Olsen and et al³¹ reported that tumor surgery itself is an independent risk factor for SSI (OR, 6.2; 95% CI, 1.7–22.3) and spinal metastases operations have a higher wound infection rate when compared with other type of spinal surgery. The deep wound infection rate was increased by presence of an iatrogenic dural tear, patient required another surgery during the same admission,¹⁷ diabetes mellitus,³⁵ duration of surgery >4 h and high blood loss >3000 mL.¹⁵ However, there was no study that reported the effect of primary tumor type and location and surgical approach to rate of wound infection.

McPhee et al³⁴ studied 53 patients who underwent 75 operations for spine metastases and reported a wound dehiscence/infection rate of 20% (15/75 surgical sites). In this study, associated risk factors for SSI included preoperative protein deficiency and perioperative corticosteroid administration. There were higher rates of wound infection in patients who had lymphocyte count below $<1000/\text{mm}^3$ (marker of malnutrition) and perioperative radiotherapy. Sugita and colleagues reported that some blood test parameters may predict postoperative infection following posterior surgery with intraoperative radiotherapy for spinal metastasis. The patients who had following abnormal parameters may be at increased risk of postoperative infection: white blood cell count $>9.6 \times 10^3/\mu\text{L}$ on postoperative day 1 (sensitivity: 54%, specificity: 68%), white blood cell count $>6.5 \times 10^3/\mu\text{L}$ on postoperative day 7 (sensitivity: 63%, specificity: 64%) or C-reactive protein level $>5.0 \text{ mg/dL}$ on postoperative day 7.³⁶ Kumar and colleagues also reported significant risk factors for spinal metastasis SSI to include low albumin level, surgery >7 levels, nonabsorbable suture for skin closure, and presence of neurological deficit. However, absorbable skin closure material, age, low lymphocyte count, and perioperative administration of corticosteroids did not influence the risk of SSI.³⁷

Preoperative radiotherapy is generally considered to be a risk factor for SSI.^{6,35} Yokogawa et al⁶ showed that postoperative wound dehiscence occurred only in patients who underwent preoperative irradiation before TES with a total radiation dose $>40 \text{ Gy}$. In addition, the type of radiotherapy may influence the risk of SSI. Keam and colleagues compared wound infection rates between patients who underwent spine surgery for metastasis with preoperative radiotherapy. One hundred thirty patients

received external beam radiotherapy (XRT) ($\leq 3 \text{ Gy}$ /fraction) and 35 patients received image-guided radiotherapy (IGRT) ($> 3 \text{ Gy}$ /fraction). The 6-month cumulative incidence of wound complications for XRT was higher when compared with IGRT group (17% vs. 6%, retrospectively). However, there was no significant difference in wound complications between IGRT and XRT group (hazard ratio, 0.31, 95% CI, 0.08–1.3; $P = 0.11$).³⁸ Demura et al reported the effectiveness of intravenous prostaglandin E1 (PGE1) administration that significant lowering the SSI rate in patients who previously treated with preoperative irradiation. The patients in PGE1 group were prescribed intravenous prostaglandin E1 administration after surgery at $60 \mu\text{g}$ twice daily for 7 days. The rate of SSI in the PGE1 group was 4.5% comparing with 31.8% in the control group ($P = 0.04$).^{35,39} Table 3 outlines risk factors for SSI in metastatic spine surgery. The details of wound complications were shown in Table 4.

Reoperation

The average incidence of reoperation was 12.64% (2.83%–20.90%).^{10,12,13,15,18,25,40} The common causes of reoperation after spinal metastases surgery were local recurrence in same or new level,^{10,13,15,25} implant failure^{12,15,25} and wound infection.^{13,18} Jansson and colleagues reported median time to reoperation in the patients who were reoperated from local recurrence at the same decompressed site and/or implant failure was 3 (0.4–9) years and median survival after reoperation was 0.6 years. Although median time to reoperation in the patients who had epidural compression at a new spinal level were only 0.7 (0.3–10) years and median survival was 0.3 years.¹⁵ Quraishi and colleagues reported reoperation rates in the surgical treatment of spinal metastases was 10.7%. Most reoperations (65%) were performed in the same admission. The median time between the first and second operation in patients who underwent second procedure in a subsequent hospitalization was 162 days (range, 60–335 d). The reasons for their revision surgery included surgical site infection (42%), failure of instrumentation (29%), local recurrence (16%), hematoma evacuation (6%), and refracture (6%). The median survival days was similar between single surgery group [250 d

TABLE 3. Risk Factors for Wound Infection in Surgery for Spinal Metastasis^{2,34,35,37}

Risk Factors

Low albumin level
≥ 7 levels of surgery
Preoperative protein deficiency
Perioperative corticosteroid administration
Use of delayed/nonabsorbable skin closure material
Operated for $>4 \text{ h}$
Blood loss of $>3000 \text{ mL}$
Preoperative neurological deficit
Surgery under emergency conditions
Preoperative radiation therapy
Diabetes

TABLE 4. Details of Wound Infections

References	Total Patients	Collect year	Sex	Mean Age (y)	Type of Primary Tumor	Adjunctive therapy				No. of Wound Dehiscence/ Infection	Details
						Steroid	Preop RT	Postop RT	Chemo		
Pascal-Moussellard et al ²	145	1982–1991	NA	NA	39 breast 13 lung 8 colon 6 RCC 6 prostate 73 other	NA	NA	NA	NA	20	6 wound infection, 8 wound dehiscence, and 6 delay or difficulties in healing
Wise et al ³	80	1993–1996	M, 38 F, 42	55.6	18 breast 13 myeloma 11 lung 6 renal 6 prostate 9 lymphoma 8 sarcoma 5 unknown 4 other	NA	41	NA	NA	8	6 deep wound infection and 2 superficial wound infection
Yokokawa (2014)	50	2010–2013	M, 27 F, 23	57.8	10 RCC 11 breast 7 thyroid 2 bladder 3 stomach 14 other 3 unknown	4	18	NA	16	4	All infection occurred in patients who underwent preoperative radiotherapy
Bauer ¹¹	67	1990–1994	M, 43 F, 24	64	18 prostate 12 breast 37 other	NA	13	35	NA	11	3 required debridement and 8 required local wound care and antibiotic treatment
Bollen et al ¹²	106	2001–2010	M, 53 F, 53	59	25 breast 20 lung 19 RCC 11 prostate 22 breast 20 lung 17 kidney 11 colorectal 7 prostate 5 lymphoma 17 other	NA	30	56	9	8	
Dea et al ¹⁷	101	2009–2012	M, 50 F, 51	62	22 breast 20 lung 17 kidney 11 colorectal 7 prostate 5 lymphoma 17 other	NA	20	NA	NA	6	4 deep wound infection and 2 superficial wound infection
Lee et al ⁵	200	2005–2011	M, 118 F, 82	59.7	42 lung 27 liver 27 colorectal 22 RCC 15 breast 11 thyroid 7 stomach 6 prostate 6 multiple myeloma	NA	163		NA	9	9 patients with wound dehiscence had both chemotherapy and radiotherapy with surgery
Walter et al ⁹	57	2000–2010	M, 31 F, 26	58.6	2 bladder 8 breast 3 cervix 1 chordoma 3 colon 4 carcinoma with unknown primary tumor syndrome 7 lung 2 lymphoma 1 ovary 1 pancreas 10 plasmacytoma 5 prostate 6 renal 1 sarcoma	NA	NA	42	48	2	

(Continued)

TABLE 4. Details of Wound Infections (*continued*)

References	Total Patients	Collect year	Sex	Mean Age (y)	Type of Primary Tumor	Adjunctive therapy				No. of Wound Dehiscence/ Infection	Details
						Steroid	Preop RT	Postop RT	Chemo		
Cho and Sung ¹⁰	21	2001–2006	M, 14 F, 7	56.6	1 stomach 1 testis 2 thyroid 4 prostate 1 breast 3 colon 4 lung 2 liver 2 cervix 1 stomach 1 renal 1 unknown	NA	NA	11	NA	2	
Wang et al ¹³	140	NA	M, 38 F, 42	60.3	29 RCC 25 lung 15 colon 14 sarcoma 12 breast 9 prostate 7 multiple myeloma 3 HCC 3 lymphoma 3 melanoma 3 thyroid 3 undifferentiated	NA	64	24	NA	16	9 required reoperation
Jansson and Bauer ¹⁵	282	1990–2001	M, 195 F, 87	66	114 prostate 41 breast 23 kidney 19 lung 15 myeloma 14 colon 12 genito-urinary 11 unknown primary 8 melanoma 6 sarcoma 3 lymphoma 2 thyroid 13 others	NA	NA	NA	NA	35	9 required reoperation
Park et al ¹⁸	29	2006–2011	M, 17 F, 6	54.7	6 lung 4 HCC 3 colorectal	NA	9	13	NA	3	2 required reoperation
de Ruiter et al ¹⁶	60	2005–2011	M, 30 F, 30	62	3 prostate 14 breast 8 lung 10 kidney 2 prostate 8 multiple myeloma 2 thyroid 2 melanoma 5 gastrointestinal 2 urothelial cell 9 other	NA	NA	NA	NA	6	
McPhee et al ³⁴	53	1984–1998	M, 30 F, 23	NA	7 breast 3 prostate 8 lung 6 colon 6 renal 7 adenocarcinoma 3 melanoma	33	42	NA	NA	15/75 wound	12 Methicillin-resistant Staphylococcus aureus 1 Methicillin-sensitive Staphylococcus aureus 1 <i>E. coli</i> /Methicillin-sensitive Staphylococcus aureus

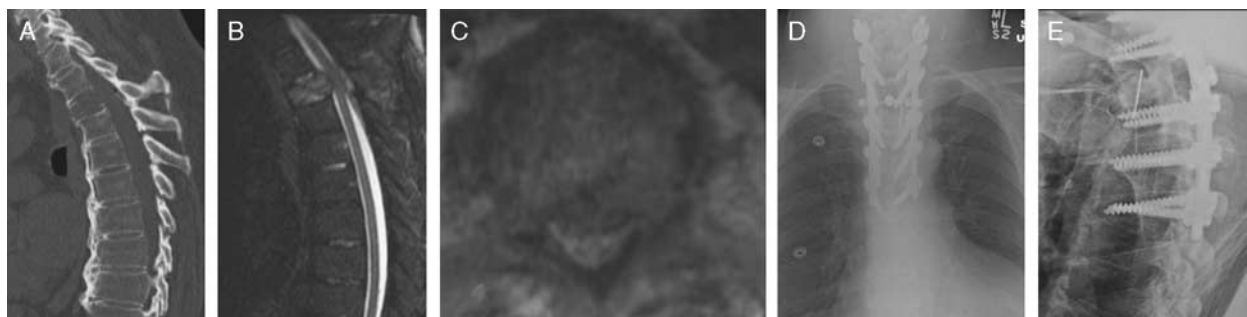


FIGURE 1. A 69-year-old man with history of renal cell carcinoma presented with several months of progressive thoracic back pain and a few days of urinary incontinence and inability to walk due to loss of balance. Computerized scan (A) demonstrates osteolytic lesion at third thoracic vertebra (T3). Sagittal T2 sequences (B) of the thoracic spine reveal a heterogeneous hyper intense signal at T3. Axial T2 sequences (C) show pathologic fracture with epidural extension. Patient underwent preoperative embolization. Postoperative thoracic anteroposterior films (D) and lateral films (E) demonstrate posterior segmental instrumentation with anterior reconstruction with bone cement and K-wire. In the postoperative period, patient regained ability to ambulate without complication and received postoperative radiotherapy and chemotherapy.

(range, 5–2597 d)] and revision group [215 d (range, 9–1352 d); $P = 0.719$].⁴⁰

Perioperative Mortality

Thirty-day mortality rate in this patient population is ~7% (0.9%–13%) and influenced by type of cancer, disease burden, and patient comorbidities.^{2–5,9,10,12–15,17} Patil and colleagues reported that postoperative mortality rate was higher in men, patients with comorbidity and perioperative complications. Compared with patients without any comorbidities, 1 comorbidity increased risk of in-hospital death 3.7-fold and patients who sustained 1 complication had a 4.6-fold increased mortality risk. In addition, patients who underwent surgery in the 1993–1997 period had 1.6 times higher risk of in-hospital death compared with patients operated in the 1998–2002 period.⁷ Patil and colleagues demonstrated that each postoperative complication increased mortality rate by 11%. Mortality rate in patients who had 0, 1, 2, complications was 3.4, 14.0, and 20.9%, respectively.⁷ Lee et al⁵ reported 21 deaths in patients who underwent en bloc vertebrectomy for spinal metastases; 57.1% of deaths were caused directly by complications including pneumonia (5 cases), acute renal failure (3 cases), liver failure (2 cases), meningitis, and cerebral infarction (1 case each).

Author's Preferred Treatment

To minimize perioperative complications, surgeons must complete a comprehensive preoperative evaluation and optimize modifiable risk factors. Unfortunately, the modifiable risk factors in patients requiring surgery to treat spinal metastasis are limited but include preoperative nutritional optimization (assessed by serum prealbumin levels) and functional status. In patients with progressive neurological deficits, there is limited ability to modify any risk factors as surgery is urgent or emergent (Fig. 1). All patients with spinal metastases who presented with only back pain or neck pain should be evaluated for

spinal stability by using Spinal Instability Neoplastic (SIN) score.⁴¹ The SIN score is used to evaluate the spinal stability in patients who present with spinal metastases by using 6 factors. The total score range between 0 (best) and 18 (worst) that classify spinal stability to 3 groups including stable (0–6), impending stability (7–12), and instability (13–18). The details of SIN score are showed in Table 5.

If impending instability or instability were found, operative treatment should be offered before patients develop spinal cord compression, but this patient population may be more amenable to preoperative optimization as surgery does not have the same sense of

TABLE 5. The Spinal Instability Neoplastic Score (SIN) Score

SINS Component	Score
Pain	
Yes	3
Occasional pain but not mechanical	1
Pain-free lesion	0
Location	
Junctional (occiput-C2, C7-T2, T11-L1, L5-S1)	3
Mobile spine (C3-C6, L2-L4)	2
Semirigid (T3-T10)	1
Rigid (S2-S5)	0
Bone lesion	
Lytic	2
Mixed (lytic/blastic)	1
Blastic	0
Vertebral body collapse	
> 50% collapse	3
< 50% collapse	2
No collapse with > 50% body involved	1
None of the above	0
Radiographic spinal alignment	
Subluxation/translation present	4
De novo deformity (kyphosis/scoliosis)	2
Normal alignment	0
Posterolateral involvement of spinal elements†	
Bilateral	3
Unilateral	1
None of the above	0

urgency in the absence of neural element compression. When surgery is not urgent or emergent, preoperative nutritional assessment and nutritional support may be of benefit. To minimize postoperative medical complications, the authors recommend that all patients undergoing surgery should be evaluated preoperatively by a medical team for optimization. To prevent postoperative neurological deterioration, intraoperative neuromonitoring is recommended in all cases. In high-risk cases (eg, in the setting of unstable pathologic fractures), prepositioning neuromonitoring data can be obtained before positioning the patient in the prone position. In addition, spinal instability may be mitigated by utilizing a rigid brace, cervical collar or halo vest and turning the patient prone using a rotatory operative table. Intravenous corticosteroid might be given in patients who have a continued negative wake-up test after release of tension from corrective and distractive maneuver. Wound complications are one of the major complication seen in this population (especially after preoperative radiotherapy), and paying close attention to careful tissue handling and wound closure are paramount in lowering the risk of wound breakdown.

CONCLUSIONS

The incidence of symptomatic spinal metastasis is increasing due to improvement in the prognosis of cancer patients. Complications can be categorized into intraoperative, postoperative surgical and postoperative medical complications. Preoperative correction of modifiable risk factors and well plan operative treatment may minimize risk of postoperative complications.

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