

Racial Disparities in Perioperative Morbidity Following Oncological Spine Surgery

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Abstract

Study Design: Retrospective cohort study.

Objective: To assess the impact of race on complications following spinal tumor surgery.

Methods: Adults with cancer who underwent spine tumor surgery were identified in the American College of Surgeons National Surgical Quality Improvement Program datasets from 2012 to 2016. Clavien-Dindo Grade I-II (minor complications) and Clavien-Dindo Grade III-V (major complications including 30-day mortality) complications were compared between non-Hispanic Whites (NHW) and Black patients. A multivariable analysis was also conducted.

Results: Of 1,226 identified patients, 85.9% were NHW (n = 1,053) and 14.1% were Black (n = 173). The overall rate of Grade I-II complications was 16.2%; 15.1% for NHW patients and 23.1% for Black patients (P = .008). On multivariable analysis, Black patients had significantly higher odds of having a minor complication (OR 1.87; 95% CI, 1.16-3.01; P = .010). On the other hand, the overall rate of Grade III-V complications was 13.3%; 12.5% for NHW patients and 16.2% for Black patients (P = .187). On multivariable analysis, Black race was not independently associated with major complications (OR 1.26; 95% CI, 0.71-2.23; P = .430). Median length of stay was 8 days (IQR 5-13) for NHW patients and 10 days (IQR 6-15) for Black patients (P = .011).

Conclusion: Black patients who underwent metastatic spinal tumor surgery were at a significantly increased risk of perioperative morbidity compared to NHW patients independent of baseline and operative characteristics. Major complications did not differ between groups. Race should be further studied in the context of metastatic spine disease to improve our understanding of these disparities.

Keywords

metastasis, spine, spine tumor, race, disparities, complications

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Introduction

Surgery plays a fundamental role in the care of patients with solid tumors. However, variation exists in who gets surgery, what type of surgery is performed, and the outcomes of these surgical procedures.¹ These disparities are multifactorial but usually the result of factors such as age, sex, race or ethnicity, socioeconomic status, education, culture, and geographic region, among others.^{1,2} Previous studies have shown that rates of surgical resection for breast, colorectal, and non-small-cell lung cancer differ based on the patient's race.³⁻⁵ Furthermore, race has also been shown to be a risk factor for increased perioperative morbidity after major oncologic surgery.⁶

The skeleton is the third most common site of metastases after the lung and liver, and the spine is the most common site for skeletal metastases. Symptomatic spinal metastases are estimated to affect 10-20% of all cancer patients and can cause bone pain, instability, and/or neurological deficits. Recent evidence also shown that Black patients with metastatic spine disease are significantly more likely to present with metastatic spinal cord compression (MSCC) and paralysis compared to White patients.⁷ They are also less likely to receive surgical intervention for MSCC and have a higher rate of adverse in-hospital events.⁷

For patients with metastatic spine disease, surgery can provide pain relief, preserve neurological function, and restore spinal stability. Nonetheless, metastatic spinal tumor surgery can be a morbid intervention given that patients are usually older and in vulnerable conditions.^{8,9} While multiple studies have focused on factors affecting complication rates in oncological spine surgery, race has been mostly overlooked in these investigations.⁸⁻¹² Thus, the purpose of this study was to examine the impact of race on short-term morbidity after spinal tumor surgery using the American College of Surgeons National Surgical Quality Improvement Program (NSQIP), a large prospective multicenter surgical database and provides a unique opportunity to assess racial disparities in major cancer surgery.

Materials and Methods

Data Source

This is a retrospective cohort study that used the NSQIP database for the years 2012 through 2016. Adult patients over 18 years of age with a diagnosis of "disseminated cancer" (preoperative variable collected by NSQIP) who underwent metastatic spinal tumor surgery were identified via appropriate CPT codes [Supplementary Table 1]. NSQIP data is collected by trained research personnel at participating institutions and each surgical case contains over 240 variables including demographics, baseline comorbidities, intraoperative variables, and 30-day morbidity and mortality (<https://www.facs.org/quality-programs/acs-nsqip>). This study was deemed exempt from review by our local institutional review board (IRB 2016-6862).

Collected Data

Patients' race was classified as Non-Hispanic White (NHW) or Black as defined by NSQIP. Other races and patients with missing data were excluded given the small number of occurrences ($n = 375$). Collected data included age at surgery, sex, obesity, current smoking status (smoking within 1 year of surgery), insulin-dependent diabetes mellitus, congestive heart failure, chronic obstructive pulmonary disease (COPD), hypertension, dialysis, steroid use for a chronic condition, functional status (independent versus partially/fully dependent for activities of daily living), ASA class (1-2 versus 3-4), hypoalbuminemia (<3.5 g/dL), previous transfusion (transfusion of at least 4 units of red blood cells (RBC) within 72 h prior to surgery), anemia, and $\text{INR} \geq 1.4$. Operative data included case designation as "emergency," surgical technique, use of instrumentation, intra- or peri-operative RBC transfusion, and operative time in hours.

Outcome Measures

The primary outcome measure was occurrence of minor or major complications. These were defined based on the classification by Dindo et al which stratifies complications based on the type of intervention needed to treat/correct the adverse event.¹³ Clavien-Dindo Grade I-II complications (i.e. *minor* complications) included superficial wound infection, deep wound infection, organ space infection, wound dehiscence, renal insufficiency, pneumonia, urinary tract infection, deep vein thrombosis, pulmonary embolism, or sepsis.¹⁴ Grade III-V complications (i.e. *major* complications) included unplanned return to the operating room, reintubation, prolonged ventilation (>48 hours), septic shock, intraoperative cardiac arrest, perioperative myocardial infarction, stroke, new renal failure requiring hemodialysis, or 30-day mortality.¹⁴ These complications are prospectively collected at each participating institution by a trained surgical clinical reviewer.

Statistical Analysis

Statistical analyzes were performed in Stata SE 12 (StataCorp, College Station, Texas). Descriptive statistics were performed for the examined population. Comparisons between groups were made via t-tests or chi-squared tests as appropriate. A multivariable analysis controlling for variables that were significantly different between groups or with a P -value less than 0.200 on univariable analysis, as well as other parameters known to impact 30-day morbidity and mortality in tumor surgery was performed. These parameters included age, sex, obesity, smoking, insulin-dependent diabetes mellitus, COPD, hypertension, dialysis dependence, dependent functional status, ASA class, hypoalbuminemia, previous transfusion, anemia, $\text{INR} \geq 1.4$, emergency case, use of instrumentation, red blood cell transfusion, and operative time. Results are reported as odds ratios (OR) with 95% confidence intervals (CI). Variance inflation factors (VIFs) were also calculated and

Table 1. General Patient Characteristics Stratified by Race.

Parameter	Non-Hispanic white (n = 1,053)	Black (n = 173)	P-value
Age (mean years, SD)	62 (12)	60 (11)	.010*
Male sex (%)	62.0	68.2	.118
Obesity (%)	30.4	25.3	.173
Comorbidities			
Current smoking (%)	20.2	27.2	.039*
Insulin-dependent diabetes mellitus (%)	4.1	8.7	.008*
Congestive heart failure (%)	1.1	0.6	.504
COPD (%)	6.7	3.5	.100
Hypertension (%)	48.8	54.3	.178
Dialysis (%)	0.4	1.7	.028*
Steroid use for chronic condition (%)	18.2	16.2	.515
Dependent functional status	9.8	11.6	.478
ASA class 3-4	88.5	90.8	.386
Hypoalbuminemia (%)	42.8	45.9	.504
Previous transfusion (%)	3.8	1.7	.171
Anemia (%)	62.4	75.0	.001*
INR \geq 1.4 (%)	1.3	1.3	.991

*Statistically significant difference.

reported. Statistical significance was defined as a probability value less than 0.05.

Results

There were 1,226 NHW or Black patients who were identified as undergoing metastatic spinal tumor surgery and included in this study. From this cohort, 85.9% were NHW (n = 1,053) and 14.1% were Black (n = 173). General patient characteristics are summarized and compared in Table 1. Overall, there were significant differences in average age ($P = .010$), prevalence of smoking ($P = .039$), prevalence of IDDM ($P = .008$), dialysis-dependent patients ($P = .028$), and patients with anemia ($P = .001$) based on race. No significant differences in operative data were found except that instrumentation was less likely to be used in Black patients ($P = .016$) [Table 2]. Median length of stay was 8 days (IQR 5-13) for NHW patients and 10 days (IQR 6-15) for Black patients ($P = .011$). The overall rate of complications (proportion of patients who developed at least 1 Grade I-IV complication) was 24.8%; 23.6% for NHW and 32.4% for Black patients ($P = .013$).

Multivariable Analysis for Grade I-II Complications

The rate of Grade I-II complications was 16.2%; 15.1% for NHW patients and 23.1% for Black patients ($P = .008$). On multivariable analysis [Table 3], Black patients had significantly higher odds of having a complication compared to NHW patients (OR 1.87; 95% CI, 1.16-3.01; $P = .010$). Other predictors of minor complication occurrence included increasing age (OR 1.02; 95% CI, 1.01-1.03; $P = .026$),

Table 2. Operative Data Stratified by Race.

Parameter	Non-Hispanic white (n = 1,053)	Black (n = 173)	P-value
Emergency case (%)	14.8	17.9	.293
Type of surgical approach			
Excision procedure (%)	2.4	1.7	.601
Fracture/dislocation reduction (%)	7.8	5.2	.229
Transpedicular or costovertebral approach for corpectomy (%)	5.4	6.9	.420
Anterior or anterolateral approach for corpectomy (%)	9.7	7.5	.364
Lateral extra cavitory approach for corpectomy (%)	20.0	19.1	.769
Excision by laminectomy (%)	64.6	67.1	.527
Instrumentation (%)	61.7	52.0	.016*
Red blood cell transfusion	38.9	41.6	.503
Operative time (mean hours, SD)	3.9 (2.2)	3.8 (2.0)	.702

*Statistically significant difference.

Table 3. Multivariable Associations of Black Race and Other Explanatory Variables With Clavien-Dindo Grade I-II Complications.

Parameter	Odds-ratio	95% CI	P-value
Black race	1.87	1.16-3.01	.010*
Increasing age	1.02	1.01-1.03	.026*
Male sex	1.01	0.69-1.49	.977
Obesity	1.03	0.69-1.53	.894
Smoking	1.44	0.94-2.22	.095
IDDM	0.84	0.38-1.84	.663
COPD	1.20	0.61-2.30	.609
Hypertension	0.91	0.61-1.34	.632
Dialysis	1.63	0.16-16.3	.678
Dependent functional status	1.84	1.07-3.16	.027*
ASA class 3-4	2.03	0.90-4.59	.087
Hypoalbuminemia	1.41	0.97-2.07	.072
Previous transfusion	0.68	0.26-1.78	.429
Anemia	0.75	0.50-1.12	.162
INR \geq 1.4	0.31	0.04-2.50	.274
Emergency case	1.70	1.03-2.78	.036*
Instrumentation	1.07	0.71-1.62	.749
Red blood cell transfusion	1.35	0.90-2.03	.148
Increasing operative time	1.02	0.93-1.13	.609

*Statistically significant difference.

dependent functional status (OR 1.84; 95% CI, 1.07-3.16; $P = .027$), and emergency procedures (OR 1.70; 95% CI, 1.03-2.78; $P = .036$). The VIF for race was 1.05. The area under the receiver operating characteristic curve for the multivariate model was 0.66.

Multivariable Analysis for Grade III-V Complications

The rate of Grade III-V complications was 13.1%; 12.5% for NHW patients and 16.2% for Black patients ($P = .187$). On multivariable analysis [Table 4], Black race was not associated

Table 4. Multivariable Associations of Black Race and Other Explanatory Variables With Clavien-Dindo Grade Iii-V Complications.

Parameter	Odds-ratio	95% CI	P-value
Black race	1.26	0.71-2.24	.430
Increasing age	1.01	0.99-1.03	.163
Male sex	0.88	0.56-1.38	.575
Obesity	0.91	0.57-1.46	.711
Smoking	2.56	1.60-4.10	< .001*
IDDM	1.31	0.57-2.97	.525
COPD	1.29	0.62-2.68	.492
Hypertension	0.97	0.61-1.53	.895
Dialysis	2.56	0.24-27.3	.435
Dependent functional status	2.93	1.68-5.08	< .001*
ASA class 3-4	2.12	0.73-6.13	.163
Hypoalbuminemia	1.67	1.07-2.58	.023*
Previous transfusion	1.46	0.63-3.41	.381
Anemia	1.54	0.92-2.58	.098
INR \geq 1.4	0.82	0.15-4.43	.817
Emergency case	2.69	1.60-4.53	< .001*
Instrumentation	1.12	0.69-1.81	.646
Red blood cell transfusion	1.28	0.80-2.04	.300
Increasing operative time	1.00	0.89-1.13	.942

*Statistically significant difference.

with higher odds of developing a major complication (OR 1.26; 95% CI, 0.71-2.23; $P = .430$). Predictors of major complication occurrence were smoking (OR 2.56; 95% CI, 1.60-4.10; $P < .001$), dependent functional status (OR 2.93; 95% CI, 1.68-5.08; $P < .001$), hypoalbuminemia (OR 1.67; 95% CI, 1.07-2.58; $P = .023$), and emergency procedures (OR 2.69; 95% CI, 1.60-4.53; $P < .001$).

Discussion

Cancer disparities are a major public health concern in the United States. Variations in patient characteristics, healthcare utilization, and quality of care delivered have led to important differences in surgical outcomes and also survival for patients with metastatic disease.^{6,15} In this study, we investigated the impact of patient's race on short-term morbidity and mortality after metastatic spinal tumor surgery, finding that Black patients were significantly more likely to develop a complication compared to NHW patients after extensive adjustment for baseline and operative characteristics. Hospital length of stay was also longer for Black patients. Major complication rates including mortality were not found to be different between groups.

To the best of our knowledge, this is the first study to examine the impact of race on morbidity and mortality after oncological spine surgery. In the U.S., Black patients are known to have higher rates of new cancer diagnoses and also the highest cancer death rates among all races.¹⁵ In a major investigation of over 3 million patients undergoing major surgical oncological procedures (including colectomy, cystectomy, esophagectomy, gastrectomy, hysterectomy, pneumonectomy, pancreatectomy, and prostatectomy) Sukumar et al found that Black patients

were 24% more likely to experience postoperative complications, 24% more likely to experience in-hospital mortality, and 52% more likely to receive a RBC transfusion compared to Whites.⁶ Specific complications that were more common in this patient population included vascular complications, wound complications, and gastrointestinal complications.⁶ In our study, Black patients were 87% more likely to experience a Grade I-II complication compared to Whites after multivariable analysis. Other predictors of complications included older age, smoking, dependent functional status, hypoalbuminemia, and emergency procedures, all of which have also been previously associated with worse short-term outcome after MSTs.^{8,12,16}

While major complication rates including mortality were not different between races, even minor complications such as wound infection, deep vein thrombosis, or pulmonary embolism can result in longer lengths of stay, need for medical/interventional treatment, and increased healthcare costs. While the exact cause cannot be fully elucidated, Black patients did have significantly longer lengths of stay compared to NHW patients in our present study. Similar to our findings, Sanford et al studied the impact of race on outcome after cervical fusion, lumbar fusion, and laminectomy.¹⁷ They found that Black patients were significantly more likely to experience prolonged length of stay, higher risk of deep vein thrombosis in lumbar fusion, and higher risk of superficial wound infection and pulmonary embolism in lumbar laminectomy procedures.¹⁷ Likewise, they had a much higher comorbidity burden compared to NHW patients.¹⁷

The reason as to why Black patients have worse surgical oncology outcomes is multifactorial. Black patients have been shown to present with more advanced stages of cancer.¹⁸ Advanced cancer results in increased patient frailty, malnutrition, pain, weakness, anxiety/depression, lack of energy, dyspnea, fatigue, and many other symptoms.¹⁹ Patients with multilevel or diffuse metastatic disease are at also a higher risk of complications compared to patients with solitary metastases.²⁰ All these parameters are known to contribute to higher morbidity and could certainly account for the findings of this investigation.

Black patients also usually also have a higher comorbidity burden than NHWs.²¹ In our study Black patients had higher prevalence of smoking, IDDM, dialysis dependence, and pre-operative anemia. Commensurate with our findings, a recent investigation using the United States National Inpatient Sample database found that among patients with metastatic spine disease, Black patients had the highest incidence of MSCC and paralysis.⁷ Compared to White patients, their absolute risk increase was 14.6% for MSCC and 5.3% for paralysis.⁷ Additionally, among patients who presented with MSCC, Black patients were significantly less likely to receive surgical intervention compared to White patients (OR 0.71; 95% CI, 0.62-0.82).⁷ In-hospital complication rates, prolonged length of stay, and non-routine discharges were also more frequent for Black patients.⁷

While differences in socioeconomic, life style, and other factors have long been considered to be a major cause for these disparities, there is also evidence that genetic and epigenetic factors may also play a role. For example, Black women have high frequencies of triple-negative breast cancer and intra-tumor genetic heterogeneity, both associated with more aggressive disease.²² Another study found that differences in CD44 gene methylation patterns is associated with prostate cancer pathogenesis in Black patients.²³ Choudhury and Singh also suggested that high rates of mitochondrial gene alterations found in African lineage are also associated with a higher predisposition of cancer.²⁴ Nonetheless, these differences have not yet been studied in the context of metastatic disease to the spine.

To address these major disparities, the National Cancer Institute established the Center to Reduce Cancer Health Disparities.¹ This center supports research on the matter, including expanding minority participation in clinical trials, and supporting evidence-based screening, prevention, and treatment interventions.¹ While our study is among the first to evidence racial disparities after oncological spine surgery, results must be interpreted within the limitations of the NSQIP database. Although it is a prospective and validated multicenter database, data such as the patient's ambulatory status at presentation or extent of disease is unknown, both of which can impact perioperative morbidity. Furthermore, examined outcomes only include up to 30-days after surgery, and other long-term outcomes remain unknown. While the NSQIP database collects data from over 500 hospitals in the U.S., there are numerous hospitals not captured in the data set, and thus the findings presented herein are not necessarily nationally-representative. Our statistical finding that race is an "independent" risk factor for complication occurrence must also be interpreted within the limitations of using only the captured variables for analysis. The association of race with worse outcomes in oncological surgery is complex and the result of many interactions including genetic, environmental, socioeconomic, and others. As mentioned earlier, Black patients represent a more vulnerable cancer population and the cancer disparities observed in this group are well documented. Rather than visualizing race as an "independent" risk factor for worse outcomes in spine tumor surgery, future research into the specific causes in the form of large multicenter prospective studies is needed.

Conclusion

Race has an important impact in outcomes of cancer patients. In this study, Black patients undergoing metastatic spinal tumor surgery were found to have significantly higher rates of overall perioperative complications compared to NWH patients. While multiple studies have previously examined risk factors for complication occurrence in oncological spine surgery, race has been mostly neglected as a potential contributing factor. Future research into the impact of race on outcomes for patients with metastatic spine disease is warranted.

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Supplemental Material

Supplemental material for this article is available online.

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