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Epidemiology and national trends in prevalence and surgical management of metastatic spinal disease

Samantha R. Horn [a], Ekamjeet S. Dhillon [b], Gregory W. Poorman [a], Jared C. Tishelman [a], Frank A. Segreto [a], Cole A. Bortz [a], John Y. Moon [a], Omar Behery [a], Nicholas Shepard [a], Bassel G. Diebo [c], Shaleen Vira [a], Peter G. Passias [a,*]

[a] Department of Orthopaedic Surgery, New York University Langone Orthopedic Hospital, New York, NY 10003, United States
[b] Feinberg School of Medicine, Northwestern University, Chicago, IL 60611, United States
[c] SUNY Downstate Medical Center, Brooklyn, NY 11203, United States

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ABSTRACT

Surgical treatment for spinal metastasis has benefited from improvements in surgical techniques. However, the trends in treatment and outcomes for spinal metastasis surgery have not been well-established in a pediatric population. Patients <20 years old with metastatic spinal tumors undergoing spinal surgery were identified in the KID database. Trends for spinal metastases treatment and patient outcomes were analyzed using weight-adjusted ANOVAs. 333 patients were identified in the KID database. The top five primary diagnoses were metastatic brain/spinal cord tumor (19.8%), metastatic nervous system tumor (15.9%), metastatic bone cancer (13.2%), spinal cord tumor (4.2%), and tumor of ventricles (3.0%). There was an increased incidence of spinal metastasis diagnoses from 2003 to 2012 (88.5–117.9 per 100,000; $p < 0.001$) and an increased trend in the incidence of surgical treatment for spinal metastasis from 2003 to 2012 ($p = 0.014$). The average age was 10.19 ± 6.33 years old and 38.4% were female. The average length of stay was 17.34 ± 24.36 days. Average CCI increased over time (2003: 7.87 ± 1.40, 2012: 8.44 ± 1.39; $p = 0.006$). The most common surgeries were excision of spinal cord/meninges lesions (69.1%) and decompression of spinal canal (38.1%). Length of hospital stay and in-hospital mortality did not change over time (17.34–18.04 days, $p = 0.337$; 1.6%–2.9%, $p = 0.801$). 10.5% of patients underwent a posterior fusion and 22.2% had at least one complication (nervous system, respiratory, dysphagia, infection). The overall complication rate remained stable over time (23.4%–21.8%, $p = 0.952$). Surgical treatment for spinal metastasis in the last decade has increased, though the complication rates, in-hospital mortality, and length of stay have remained stable.

1. Introduction

Cancer is a leading cause of death in the pediatric population. It is estimated that 1 in 285 children will be diagnosed with cancer before the age of 20 [29]. A subset of these patients will present with metastatic spine lesions [19]. Although uncommon, metastatic spine tumors are associated with significant morbidity due to the presence of critical structures in the spine. Up to 50% of these patients present with spinal cord compression (SCC) as the first sign of a metastatic lesion in the osseous spine or epidural space [1,24]. SCC is thought to occur in 3%–25% of pediatric oncology patients and is often a medical emergency that can lead to irreversible paraplegia [2,6,12,17]. Other causes of morbidity secondary to metastatic spine tumors include nerve root compression, local bone destruction, and vascular compromise [12,25]. Due to the significance of these complications in a pediatric population, metastatic spine tumors present a clinical challenge that requires a multidisciplinary approach for optimal patient outcomes.

Treatment for metastatic spine tumors is controversial and debated in the literature [25]. The type of tumor, age of child, and involvement of spinal cord is critical in determining the treatment algorithm [16,25]. Surgery is indicated if either radiotherapy or chemotherapy fail, in older children, for the resection of paraspinal tumors or chemoresistant tumors, and with progressive symptomatic deformity due to destruction of bone [25]. The decision to intervene surgically for metastatic SCC is especially con-

* Corresponding author at: New York Spine Institute, NYU Langone Orthopedic Hospital/NYU School of Medicine, Departments of Orthopaedic and Neurological Surgery, 301 East 17th Street, New York, NY 10003, United States.
E-mail address: peter.passias@nyumc.org (P.G. Passias).

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tested. Some studies recommend surgical resection to decompress the spinal cord only if irradiation fails to provide adequate relief [3,4,11,18]. Others recommend emergent surgery on presentation of spinal cord compression with the immediate goal of restoring neurologic function [12,16,23,26,28]. A recent randomized clinical trial demonstrated that surgical decompression for SCC improved patient outcomes compared to radiotherapy suggesting the benefits for surgical intervention in these patients [21]. Similarly, Pollono et al. found that 70% (19/27) of patients with paraplegia secondary to metastatic SCC improved after laminectomy while those without paraplegia also reported symptom relief from the surgical intervention [22]. These findings suggest that surgical intervention may be playing a bigger role in the management of metastatic spinal tumors than in the past.

In addition, there have been significant advances in the diagnosis and management of pediatric spine malignancies in the past two decades resulting in children with metastatic spine tumors living longer and with a better quality of life [25]. Introduction of patient registries, improvements in diagnostic imaging, and creation of oncological and surgical staging systems has allowed for more accurate diagnosis and better surgical planning [5,9,10,13,15,20,27]. In particular, advancements in spine instrumentation, improvements in surgical approaches, and understanding of the natural history of spine deformity has improved patient outcomes following spine tumor surgery resulting in a greater acceptance for surgical intervention for metastatic spine tumors [7,13,15,20]. As a result, more recent studies have explored and found positive outcomes for surgical interventions for metastatic spine tumors that previously had no established treatment regimens or were treated non-operatively, including metastatic intraspinal tumors [8], metastatic intracranial primary glioblastoma multiforme [14], and metastatic spine tumors with poor prognosis [25]. These studies conclude that despite the overall poor prognosis of some of these young patients, the improvement in quality of life from symptom resolution or regaining mobility justifies these more invasive interventions [8].

Despite literature hinting towards a trend in increased surgical intervention for metastatic spine tumors, no study has investigated the incidence of and surgical management of metastatic spine metastasis on a national scale in the pediatric population. Existing literature on the topic Is limited and largely consists of small, retrospective clinical studies spanning several decades and utilizing inconsistent treatment modalities [15]. As a result, it is difficult to even begin drawing conclusions regarding surgical treatment of metastatic spine tumors [25]. Before any attempts at standardizing the surgical management of metastatic spine lesions, it is important to first study the epidemiology of this condition in the pediatric population and understand the trends in both the incidence and surgical management over time.

Therefore, the aim of this study was to analyze national trends in the diagnosis and surgical treatment of metastatic spine tumors in the pediatric age group using the pediatric-specific Kid Inpatient Database and to compare the surgical approach chosen for the surgery.

2. Methods

2.1. Data source

The Kid Inpatient Database (KID) is the largest publicly-available all-payer pediatric all-payer pediatric (age < 21 at admission) inpatient health care database in the United States. The Agency for Healthcare Research and Quality's Healthcare Cost and Utilization Project (HCUP) created this KID database. KID sampling includes complicated and uncomplicated births, as well as other pediatric inpatient procedures from community, non-rehabilitation hospitals. The KID database contains 107 data elements, using *International Classification of Disease*, *Ninth Revision*, *Clinical Modification* (ICD-9-CM) format to code all of the diagnoses and procedures. With over 3 million hospital stays per 3-year database, it is designed to allow accurate calculation of medical condition incidences using HCUP-provided trend weights. (Taylor et al., 2015, Intro to HCUP, 2013.) A detailed overview of the KID design is available at (https://www.hcup-us.ahrq.gov/kidoverview.jsp).

2.2. Patient sample

Patients in the KID database with a diagnosis of metastatic spinal tumors identified using the ICD-9 codes 198.3, 198.4, 198.5. Patients included in the study if they underwent spine surgery associated with this diagnosis (ICD9 codes: 03.0, 03.4, 03.09, 81.00–81.08).

2.3. Statistical analysis

IBM SPSS Statistics version 23.0 (IBM Corp., Armonk, NY) was used to perform all descriptive and comparative statistics. We estimated the prevalence of metastatic spinal tumor cases in the United States using HCUP sampling weights. KID year- and hospital-weights define sampling weights by the ratio of discharges in the American Hospital Association contributing hospitals to discharges in the sample. Trends in the demographic variables, hospital charges, surgical details, and outcomes were assessed using ANOVA. Trends in demographic variables, surgical details, and outcomes were assessed using ANOVA.

3. Results

3.1. Patient demographics

333 pediatric patients undergoing spine surgery for spine metastasis were identified in the KID database from 2003 to 2012. The population weighted incidence of spinal metastasis in the pediatric population has increased from 2003 to 2012, from 88.5 to 117.9 per 100,000 ($p < 0.001$). The average age of this cohort was 10.19 ± 6.33 years and 38% of patients were female (Table 1). The age of these patients has remained stable over time (2003: 10.61, 2012: 9.75, $p = 0.388$). The average Charlson Comorbidity Index (CCI) score was 8.11 ± 1.37, with an increasing trend in CCI over the decade (2003: 7.87, 2012: 8.44, $p = 0.006$). The most common insurance types of these patients was private insurance (55.9%), followed by Medicaid (31.5%), and other insurance types (10.8%, Table 1). Insurance type has remained constant over the period from 2003 to 2012 ($p > 0.05$). Most frequently, these metastatic spine patients presented to hospitals in central counties of areas with a population of at least one million (36.2%), followed by fringe counties of metro areas with a population of at least one million individuals (27.9%). The hospital location for these patients has not changed over the decade ($p > 0.05$).

The most common primary diagnosis of these patients are in Table 2: 66 (19.8%) patients with metastatic brain/spinal cord tumor, 53 (15.9%) patients with metastatic nervous system tumor, and 44 (13.2%) patients with metastatic bone cancer. The top secondary diagnosis of these patients are also in Table 2: 41 (12.3%) patients with metastatic bone cancer, 39 (11.7%) patients with metastatic brain/spinal cord tumor, and 22 (6.6%) with metastatic nervous system tumor.

As a reference, the entire KID database contains 12,718,381 patients with an average age of 6.88 years (range 0–20) and is 53.8% female. The most common diagnoses overall in the KID data-

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