Long-term cure of high-grade spinal cord glioma in a pediatric patient who underwent corpectomy

*R. Webster Crowley, MD,¹ Rebecca M. Burke, MD, PhD,¹ M. Beatriz S. Lopes, MD, PhD,²
D. Kojo Hamilton, MD,³ and John A. Jane Sr., MD, PhD¹

Departments of ¹Neurological Surgery and ²Pathology, University of Virginia Health System, Charlottesville, Virginia; and
³Department of Neurosurgery, University of Pittsburgh, Pennsylvania

High-grade spinal cord gliomas are rare and carry a poor prognosis. A number of treatment modalities exist for spinal cord gliomas, but no consensus exists regarding their management. Corpectomy represents a possible option for treating these lesions; however, few cases have been reported in adults, and none have been reported in the pediatric population. The authors describe the use of corpectomy for the treatment of a high-grade spinal glioma in a 9-year-old boy who remains cancer free 14 years following his initial presentation.

<http://thejns.org/doi/abs/10.3171/2015.7.SPINE15656>

KEY WORDS corpectomy; spinal glioma; high-grade; tanycytic ependymoma; oncology

INTRAMEDULLARY spinal cord gliomas are relatively rare lesions, accounting for approximately 20%–25% of all primary spinal cord tumors.^{2,4} Of this small population of patients with intramedullary gliomas, only 7.5%–17% have high-grade lesions, a percentage that varies according to the type of glioma and the age of the patient.^{2,4,18} Unfortunately, much like high-grade gliomas of the brain, high-grade gliomas of the spinal cord are associated with a dismal prognosis, one that may also be worse for lesions in the thoracic spine.^{2,6,18} Moreover, there is no consensus regarding their treatment.

In general, treatment often consists of surgical debulking followed by radiation therapy and, occasionally, chemotherapy. Corpectomy is used infrequently, for, despite its potential utility, there are substantial associated risks with unproven benefits, since high-grade lesions are believed to be incurable. Thus, there has been only a handful of reported cases in which corpectomy has been employed for spinal neoplasms.^{1,7,9,14,15,21,25} Here, we present the case of a 9-year-old boy who underwent corpectomy for the treatment of a high-grade spinal glioma. The patient has been disease free in the 14 years since his diagnosis and in the 13 years since undergoing corpectomy.

Case Report

Presentation

This 9-year-old boy originally presented to medical attention in 2001 with a several-month history of a wide-based swinging gait and difficulty running. MRI of the spinal cord revealed an enhancing intramedullary T9–12 mass that appeared consistent with a diffusely infiltrative astrocytoma (Fig. 1).

Initial Operation and Histopathological Findings

After discussing the options with his family, the patient underwent T9–12 laminectomies and debulking of the tumor. Due to the infiltrative nature of the lesion, a gross-total resection was not attempted in an effort to spare normal spinal cord function. Electrophysiological neuromonitoring was performed using somatosensory and motor evoked potentials, and alteration of the former was observed at the time of the midline myelotomy. Pathology demonstrated a glioma composed of glial fibrillary acidic protein (GFAP)–immunoreactive cells with elongated processes and homogeneous oval nuclei. The tumor cells were arranged in a palisading-like fashion resembling a “polar

ABBREVIATIONS GBM = glioblastoma multiforme; GFAP = glial fibrillary acidic protein.

SUBMITTED June 4, 2015. **ACCEPTED** July 15, 2015.

INCLUDE WHEN CITING Published online August 7, 2015; DOI: 10.3171/2015.7.SPINE15656.

* Drs. Crowley and Burke contributed equally to this work.

FIG. 1. Sagittal contrast-enhanced T1-weighted MR image (A) and sagittal T2-weighted MR image (B) demonstrating an enhancing mass extending from T-9 to T-12.

spongioblastoma-like” arrangement. No Rosenthal fibers or hyaline droplets were observed. The tumor exhibited minimal cellular atypia and no necrosis or microvascular proliferation. Mitotic figures were rare, but the Ki 67 labeling index was mildly elevated. Though the tumor did not fit the typical appearance of a pilocytic astrocytoma, a diagnosis of low-grade astrocytoma was made (Fig. 2).

Postoperative Course

The patient was able to ambulate short distances with the aid of orthotics and crutches. One month later, MRI revealed a mildly enhancing residual mass that extended from T-9 to the conus medullaris (Fig. 3). Subsequently, the patient received a 1-month course of external-beam radiotherapy, with an overall dose of 3960 cGy in 22 treatment fractions utilizing a 3-field spinal technique.

Following radiotherapy, the patient returned to normal activity and regained the ability to participate in athletic activities. However, several months later he experienced acute-onset paraparesis, paresthesias, back pain, and spasms. MRI revealed progression of the lesion such that it was slightly increased in size from the original tumor. In addition, associated edema was noted to extend from the tumor caudally to the conus and rostrally to the level of C-5, leading to weakness in the upper extremities.

Second Operation and Histopathological Findings

After further discussion with the family, the patient underwent reoperation with internal debulking of the tumor while intraoperative electrophysiological neuromonitoring was performed. Pathology confirmed a fibrillary glioma

FIG. 2. First surgical biopsy specimen. **A and B:** The tumor was composed of slightly elongated, fibrillary cells arranged in delicate fascicles. **C:** The tumor cells were strongly immunopositive for GFAP. **D:** Mitotic figures were rare and the Ki 67 proliferative index was low. H & E, original magnification $\times 100$ (A) and $\times 200$ (B); GFAP immunohistochemistry (IHC), original magnification $\times 100$ (C); and Ki 67 IHC, original magnification $\times 100$ (D). Figure is available in color online only.

with histopathological features similar to those seen in the previous biopsy sample. However, in this larger specimen, the tumor exhibited infiltration of the spinal cord parenchyma without a definitive tumor–spine parenchyma in-

FIG. 3. Postoperative images demonstrating a mildly enhancing residual mass extending from T-9 to the conus medullaris. **A:** Sagittal contrast-enhanced T1-weighted MR image. The blue line denotes the T-10 level. **B:** Corresponding axial image at T-10. Figure is available in color online only.

FIG. 4. Second surgical specimen. Fibrillary cells arranged on fascicular arrangements similar to previous biopsy (A). The tumor cells diffusely infiltrated the spinal parenchyma most conspicuously by the perivascular spaces (B). Features of anaplastic transformation including increased mitotic activity and Ki 67 index (C), microvascular proliferation (D), and palisading necrosis (E) were present in this second biopsy. Several areas of radiation necrosis were also present (F). H & E, original magnification $\times 100$ (A, E, and F) and $\times 200$ (B and D); and Ki 67 IHC, original magnification $\times 100$ (C). Figure is available in color online only.

surface (Fig. 4). Although the glioma infiltrated the parenchyma within the perivascular spaces, perivascular pseudorosettes were not observed. Unlike the previous biopsy sample, in this surgical specimen the tumor showed, in addition to areas of radiation necrosis, multifocal areas of palisading necrosis and microvascular proliferation. Mitotic activity and the Ki 67 labeling index were elevated. Similar to the previous biopsy sample, obvious features of a pilocytic astrocytoma including Rosenthal fibers and hyaline droplets were not observed. Because of the increased anaplastic features, we established a diagnosis of a high-grade astrocytoma, at least WHO Grade III. Postoperatively, the patient had substantially decreased strength bilaterally, with Grade 0/5 strength in both legs, and loss of proprioception and light touch below the T-8 level.

Second Postoperative Course

Two weeks after his second surgery, follow-up MRI revealed residual enhancement from T-9 to T-12, with significantly improved edema and no abnormal enhancement rostral to the tumor. Abnormal enhancement was also absent throughout the remainder of the craniospinal axis (Fig. 5). In light of the increasingly aggressive nature

FIG. 5. Sagittal contrast-enhanced T1-weighted MR image demonstrating postoperative changes following the second surgical debulking. Residual enhancement is seen from T-9 to T-12 with no abnormal enhancement throughout the remainder of the craniospinal axis.

of the tumor, as well as the absence of return of function inferior to the tumor, a corpectomy was recommended. The patient and his family were counseled regarding the expected permanent neurological deficits, and the absence

FIG. 6. Third surgical specimen following corpectomy. **A:** The tumor exhibited similar features as the second surgical specimen. Prominent diffuse infiltration by tumor of the perivascular spaces and diffuse infiltration of the gray and white matter of the cord can be seen. **B:** Note posterior column neurons and myelinated fibers intermixed with tumor cell fascicles. H & E, original magnification $\times 100$ (A); and Luxol Fast Blue, original magnification $\times 100$ (B). Figure is available in color online only.

of a proven benefit to the surgery, before they decided to proceed with a corpectomy for potentially definitive treatment of his high-grade lesion.

Third Operation

The patient was brought back to the operating room where he underwent T6–L1 laminectomies. In an attempt to achieve a wide margin of resection, an intraoperative biopsy was performed at the T-6 level, 3 levels above the radiographic extent of the lesion. Although a more rostral resection would have widened the surgical margin to known tumor, it was felt that stopping at T-6 would minimize the potential risk of resultant autonomic dysreflexia. Once the intraoperative biopsy demonstrated normal spinal cord with no evidence of tumor, the T-6 vertebra was selected as the rostral margin of the resection and a complete removal of the spinal cord from T-6 to the conus was performed, with transection of the accompanying exiting nerve roots. Pathology again was consistent with a high-grade astrocytoma (Fig. 6).

Third Postoperative Course

By postoperative Day 2, the patient was out of bed without difficulty and did not have any unexpected deficits. Postoperative MRI revealed complete removal of all abnormal spinal cord, and the patient was discharged to a rehabilitation facility on postoperative Day 3. No further adjuvant therapy was initiated.

Beginning 2 months after the corpectomy, the patient underwent serial MRI every 6 months for 3 years, followed by annual examinations, all of which showed no recurrence of his tumor. Approximately 2 years after surgery, the patient presented with paralytic kyphoscoliosis, which was treated with posterior instrumentation and T5–L4 fusion to correct his substantial deformity. This required reoperation 2 years later for extension of the fusion. MRI and radiography performed 8 years following his initial surgery demonstrated expected postoperative changes and failed to show evidence of a syrinx or enhancing lesions (Fig. 7).

Ultimately, the patient was able to resume athletic activity. He eventually received an athletic scholarship to the University of Illinois for wheelchair basketball and later was a member of the Under-23 US Men's National Wheel-

chair Basketball Team (Fig. 8). He has been disease free for the last 13 years.

Reclassification of the Tumor

During the recent review of the pathological materials for preparation of this manuscript, a question of the precise diagnosis of the tumor was raised. The intense fibrillary nature and fascicular arrangements of this glioma, in conjunction with the lack of features suggesting a pilocytic astrocytoma, raised the possibility that the tumor might have been a tanyctic ependymoma, a rare variant of ependymoma that may exhibit histopathology features indistinguishable from pilocytic astrocytomas.^{8,12} This diagnosis was not entertained at the time of the initial resections (2001–2002). Additional immunohistochemical stains performed at this time demonstrated the tumor cells' lack of reactivity for the transcription factor Olig-2, a feature described in spinal cord ependymomas,¹⁹ and the presence of dot-like epithelial membrane antigen positivity in the tumor cells. Therefore, despite the infiltrative nature of this glioma, we now believe that the tumor would be classified as an anaplastic tanyctic ependymoma, WHO Grade III.

Discussion

We have presented the successful treatment option for a high-grade spinal cord glioma, describing a complete removal of the spinal cord, and its associated nerve roots, beginning approximately 2 levels above the level of the tumor. We feel that there are several aspects of this particular case that warrant further discussion; however, what is perhaps most remarkable is the infrequency with which this procedure is used.

While corpectomy has been advocated for a number of neurosurgical conditions, including intractable pain, spasticity, and syringomyelia,^{5,10,13,23,24} there is little mention of its being performed in the setting of spinal cord tumors. In fact, to our knowledge, the literature contains only 7 reported cases in which corpectomy was used to treat spinal cord tumors,^{1,7,9,14,15,21,25} none of which involved pediatric patients.

The first mention of using corpectomy to treat a spinal cord tumor was in 1949, when MacCarty and Kiefer¹⁴ described performing it to treat a thoracic glioblastoma multiforme (GBM) in a 25-year-old man. Approximately 40 years later, a corpectomy for a spinal cord tumor was again described by Tokoro et al.,²⁵ who performed the procedure for a recurrent neurinoma of the thoracic spine. While the lesion was not malignant, it had caused syringobulbia-myelia with resultant central sleep apnea, both of which resolved after surgery.

Later, in 2002, Kyoshima et al.⁹ described their use of corpectomy for an anaplastic astrocytoma of the thoracolumbar spinal cord in a 48-year-old man. Similar to our patient, theirs had undergone multiple subtotal resections of a low-grade astrocytoma, and the patient eventually developed paraplegia. However, the corpectomy was not performed until roughly 2 years after the tumor had progressed to a malignant glioma, and the patient died of tumor recurrence and dissemination 15 months after the corpectomy.

FIG. 7. Sagittal T2-weighted MR image (**A**) and radiographs (**B** [anteroposterior] and **C** [lateral]) demonstrating expected post-operative changes and continued absence of disease. The MR image demonstrates transection of the spinal cord at T-6 with no evidence of tumor recurrence. The radiographs show the final spinal fusion construct.

In 2005, Raza et al.²¹ reported performing corpectomy in a 65-year-old patient with a recurrent atypical meningioma of the thoracic spine, although they were unable to achieve a total resection due to persistent meningeal involvement. Marchan et al.¹⁵ performed corpectomy for a spinal GBM in a 50-year-old man. Approximately 3 months after establishing the diagnosis of spinal GBM and after the patient had become progressively paraplegic despite radiotherapy and chemotherapy, Marchan and colleagues opted to undertake a spinal corpectomy rather than debulk the lesion. The patient remained disease free for approximately 6 years before developing multiple cerebellar GBMs and dying shortly thereafter.

Most recently, Ewelt and associates reported on a 27-year-old woman with a recurrent T9–12 anaplastic astrocytoma treated by corpectomy.⁷ The patient had previously undergone surgical debulking, radiation treatment, and temozolomide-based chemotherapy without successful eradication of the lesion. Subsequently, the patient developed paraplegia as a result of tumor progression. A corpectomy was ultimately performed between the T-8 and T-9 levels and no disease recurrence was seen up to 15 months postoperatively.

Regarding ependymomas, a large epidemiological study found that approximately 36% of ependymomas are located in the spine, but only 13% of pediatric ependymo-

mas are spinal.¹⁶ In addition, 8.6% of ependymomas were found to be Grade III. Oh et al. recently reviewed the literature on pediatric spinal cord ependymomas and, after excluding myxopapillary ependymomas, found a total of 58 cases for their analysis.¹⁸ They indicated that 17% of the individuals in this group had Grade III lesions.

As previously stated, the prognosis for high-grade spinal gliomas is poor, and certainly the treatment options available for many of these infiltrative lesions are not ideal. While some advocate function-preserving subtotal resection followed by postoperative radiation therapy, or even radiation therapy alone,^{17,22} others feel that radiation therapy may be of limited value in children and therefore recommend radical resection despite the increased risk of neurological deficit.^{2,20} However, largely due to the relative infrequency of these lesions, no consensus exists regarding their management. Although our patient was initially diagnosed with a low-grade glioma, the infiltrative nature of the tumor and the elevated Ki 67 labeling index portended a more aggressive course. Therefore, after discussing further aggressive surgery, observation, or radiotherapy, the decision was made to proceed with adjuvant radiation following the patient's first surgery. Once the tumor worsened, radical surgery became a more reasonable option. While there have been few reports of corpectomy for high-grade gliomas of the spinal cord, we felt that our patient's

FIG. 8. The patient as a member of the Under-23 US Men's National Wheelchair Basketball Team. The picture was taken approximately 12 years after his corpectomy. Figure is available in color online only.

preexisting paraplegia below the level of the tumor, combined with the worsening tumor grade, ultimately made him a good candidate for complete excision of the spinal cord above the lesion. In hindsight, we do not believe that our recent reclassification of his tumor as a WHO Grade III anaplastic tanyocytic ependymoma would have changed our recommendations.

Another aspect of our patient's care that is worth mentioning is the development of kyphoscoliosis, a condition that is frequently seen as a consequence of extensive laminectomies, radiation therapy, or intramedullary tumor resection.^{3,11,20,22} Our patient underwent an 8-level decompression in addition to the spinal cord resection, which eventually required segmental instrumentation and fusion. Because of the increased risk for developing progressive spinal deformity in this patient population, patients should undergo long-term follow-up not just for the management of their tumor, but for observation for the development of deformity.

Conclusions

We have provided further evidence that corpectomy is a

viable option for patients with high-grade spinal cord gliomas, with the potential for cure of the disease. However, evidence demonstrating the success of the procedure is merely anecdotal. Therefore, given the lack of higher levels of evidence demonstrating its efficacy, we believe that complete resection of the spinal cord should likely only be considered for patients with poor neurological function and no evidence of tumor dissemination. It is in this select patient population that corpectomy may have a legitimate role for the management of high-grade spinal cord gliomas.

References

1. Amini A, Chin SS, Schmidt MH: Malignant transformation of conus medullaris ganglioglioma: case report. *J Neurooncol* **82**:313–315, 2007
2. Cohen AR, Wisoff JH, Allen JC, Epstein F: Malignant astrocytomas of the spinal cord. *J Neurosurg* **70**:50–54, 1989
3. Constantini S, Miller DC, Allen JC, Rorke LB, Freed D, Epstein FJ: Radical excision of intramedullary spinal cord tumors: surgical morbidity and long-term follow-up evaluation in 164 children and young adults. *J Neurosurg* **93** (2 Suppl):183–193, 2000
4. DeSousa AL, Kalsbeck JE, Mealey J Jr, Campbell RL, Hockey A: Intraspinal tumors in children. A review of 81 cases. *J Neurosurg* **51**:437–445, 1979
5. Durward QJ, Rice GP, Ball MJ, Gilbert JJ, Kaufmann JC: Selective spinal corpectomy: clinicopathological correlation. *J Neurosurg* **56**:359–367, 1982
6. Epstein FJ, Farmer JP: Pediatric spinal cord tumor surgery. *Neurosurg Clin N Am* **1**:569–590, 1990
7. Ewelt C, Stummer W, Klink B, Felsberg J, Steiger HJ, Sabel M: Corpectomy as final treatment option for diffuse intramedullary malignant glioma using 5-ALA fluorescence-guided resection. *Clin Neurol Neurosurg* **112**:357–361, 2010
8. Kawano N, Yagishita S, Oka H, Utsuki S, Kobayashi I, Suzuki S, et al: Spinal tanyocytic ependymomas. *Acta Neuropathol* **101**:43–48, 2001
9. Kyoshima K, Ito K, Tanabe A, Iwashita T, Goto T, Sato A, et al: Malignant astrocytoma of the conus medullaris treated by spinal corpectomy. *J Clin Neurosci* **9**:211–216, 2002
10. Laxton AW, Perrin RG: Corpectomy for the treatment of posttraumatic syringomyelia. Report of four cases and review of the literature. *J Neurosurg Spine* **4**:174–178, 2006
11. Lee HK, Chang EL, Fuller GN, Aldape KD, Atkinson GJ, Levy LB, et al: The prognostic value of neurologic function in astrocytic spinal cord glioma. *Neuro Oncol* **5**:208–213, 2003
12. Lehman NL: Central nervous system tumors with ependymal features: a broadened spectrum of primarily ependymal differentiation? *J Neuropathol Exp Neurol* **67**:177–188, 2008
13. MacCarty CS: The treatment of spastic paraplegia by selective spinal corpectomy. *J Neurosurg* **11**:539–545, 1954
14. MacCarty CS, Kiefer EJ: Thoracic lumbar and sacral spinal corpectomy; preliminary report. *Proc Staff Meet Mayo Clin* **24**:108–115, 1949
15. Marchan EM, Sekula RF Jr, Jannetta PJ, Quigley MR: Long-term survival enhanced by corpectomy in a patient with a spinal glioblastoma multiforme and paraplegia. Case report. *J Neurosurg Spine* **7**:656–659, 2007
16. McGuire CS, Sainani KL, Fisher PG: Incidence patterns for ependymoma: a surveillance, epidemiology, and end results study. *J Neurosurg* **110**:725–729, 2009
17. O'Sullivan C, Jenkin RD, Doherty MA, Hoffman HJ, Greenberg ML: Spinal cord tumors in children: long-term results of combined surgical and radiation treatment. *J Neurosurg* **81**:507–512, 1994

18. Oh MC, Sayegh ET, Safaee M, Sun MZ, Kaur G, Kim JM, et al: Prognosis by tumor location for pediatric spinal cord ependymomas. **J Neurosurg Pediatr** **11**:282–288, 2013
19. Otero JJ, Rowitch D, Vandenberg S: OLIG2 is differentially expressed in pediatric astrocytic and in ependymal neoplasms. **J Neurooncol** **104**:423–438, 2011
20. Przybylski GJ, Albright AL, Martinez AJ: Spinal cord astrocytomas: long-term results comparing treatments in children. **Childs Nerv Syst** **13**:375–382, 1997
21. Raza SM, Anderson WS, Eberhart CG, Wolinsky JP, Gokaslan ZL: The application of surgical corpectomy in the management of an intramedullary-extramedullary atypical meningioma: case report and literature review. **J Spinal Disord Tech** **18**:449–454, 2005
22. Reimer R, Onofrio BM: Astrocytomas of the spinal cord in children and adolescents. **J Neurosurg** **63**:669–675, 1985
23. Smyth MD, Peacock WJ: The surgical treatment of spasticity. **Muscle Nerve** **23**:153–163, 2000
24. Tasker RR, DeCarvalho GT, Dolan EJ: Intractable pain of spinal cord origin: clinical features and implications for surgery. **J Neurosurg** **77**:373–378, 1992
25. Tokoro K, Chiba Y, Yagishita S, Kunimi Y: Corpectomy for syringobulbo-myelia with sleep apnea secondary to a spinal

extramedullary tumor: case report. **Neurosurgery** **24**:118–124, 1989

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Crowley, Hamilton, Jane. Acquisition of data: Burke, Lopes, Hamilton. Drafting the article: Crowley, Burke, Lopes, Jane. Critically revising the article: all authors. Reviewed submitted version of manuscript: Crowley. Approved the final version of the manuscript on behalf of all authors: Crowley. Study supervision: Crowley.

Correspondence

R. Webster Crowley, Department of Neurological Surgery, University of Virginia Health System, Box 800212, Charlottesville, VA 22908. email: webster.crowley@virginia.edu.