JOURNAL OF NEUROSURGERY:
Case Lessons

J Neurosurg Case Lessons 3(11): CASE21363, 2022
DOI: 10.3171/CASE21363

Treatment of a symptomatic thalamic pilocytic astrocytoma with reservoir placement and laser interstitial thermal therapy: illustrative case

*Cordell Baker, MD,[1] Jordan Crevelt, BS,[2] Nicholas Whipple, MD, MPH,[3] Robert J. Bollo, MD,[1] and Samuel Cheshier, MD, PhD[1]

[1]Department of Neurosurgery, Intermountain Primary Children's Hospital, University of Utah, Salt Lake City, Utah; [2]School of Nursing, University of Utah, Salt Lake City, Utah; and [3]Division of Pediatric Hematology/Oncology, Department of Pediatrics, Primary Children's Hospital, Salt Lake City, Utah

BACKGROUND Treatment of pilocytic astrocytomas (PAs) in children can be challenging when they arise in deep midline structures because complete surgical resection may result in significant neurological injury. Laser interstitial thermal therapy (LITT) has provided an alternative treatment modality for lesions that may not be amenable to resection. However, many patients with PAs may be symptomatic from a compressive cyst associated with the PA, and LITT does not obviate the need for cystic decompression in these patients.

OBSERVATIONS A 12-year-old male presented with left-sided weakness. Magnetic resonance imaging (MRI) revealed an enhancing mass with a large cyst involving the right thalamus and basal ganglia. The patient underwent a reservoir placement for cyst drainage and biopsy of the mass, revealing a pilocytic astrocytoma. He then underwent LITT followed by adjuvant chemotherapy. Sixteen months after LITT, follow-up MRI of the brain revealed no tumor growth.

LESSONS This is the first case to describe reservoir placement to treat the cystic portion of a pilocytic astrocytoma followed by LITT and targeted chemotherapy. Reservoir placement reduced the cyst's mass effect and resolved the patient's symptoms, allowing for treatment options beyond resection.

https://thejns.org/doi/abs/10.3171/CASE21363

KEYWORDS pilocytic astrocytoma; laser interstitial thermal therapy; Ommaya reservoir; pediatric; thalamus

Pilocytic astrocytoma (PA) is the most common brain tumor in children.[1] A significant number of these tumors arise in deep midline structures, such as the basal ganglia and thalamus. Tumors in this location can be challenging to treat, because complete resection is not always feasible without causing devastating neurological injury.[2] Laser interstitial thermal therapy (LITT) is an alternative treatment modality with increasing popularity for lesions that are not amenable to resection.[3,4] First described more than 20 years ago to treat low-grade gliomas, LITT has been shown to be safe in treating pediatric low-grade gliomas and has favorable control rates.[4–6]

LITT is a stereotactic technique that uses thermal energy from a laser diode to target an area of interest and promote cell death. The underlying principle of thermoablation is based on the photothermal effect, in which light is converted to heat, allowing for denaturation of tissue proteins. Cell death is dependent on thermal intensity and duration but generally begins at 40°C to 50°C.[7] One advantage of this modality is that it allows for magnetic resonance imaging (MRI) for stereotactic spatial orientation of the ablating source as well as real-time thermoablation monitoring with MRI thermometry during the procedure. In some children, the use of LITT may obviate or delay the need for radiation or chemotherapy.[5,8]

We present the case of a young male with left-sided weakness from a PA of the right thalamus and basal ganglia with a large cyst causing significant mass effect in whom reservoir placement was used to reduce mass effect and alleviate symptoms, followed by LITT.

Illustrative Case

History

A previously healthy 12-year-old male presented with 3 months of progressive left-sided weakness. Over the preceding 2 weeks,

ABBREVIATIONS LITT = laser interstitial thermal therapy; MRI = magnetic resonance imaging; PA = pilocytic astrocytoma.

INCLUDE WHEN CITING Published March 14, 2022; DOI: 10.3171/CASE21363.
SUBMITTED July 12, 2021. **ACCEPTED** September 2, 2021.

* R.J.B. and S.C. contributed equally to this work and share senior authorship.

his weakness had rapidly worsened, and he developed ataxia with dragging of his left foot, leading to numerous falls. The patient was also experiencing morning emesis. MRI of the brain demonstrated a right thalamic and basal ganglia heterogeneously enhancing mass with a large rim-enhancing cyst extending laterally. The solid portion measured 2.3 × 2.5 × 1.5 cm, whereas the cyst measured 4 × 4 × 3.5 cm (Fig. 1A–C). The lesion produced mass effect on surrounding structures, compressing the intraventricular foramen with mild obstructive hydrocephalus.

Examination

On examination, the patient was alert and fully oriented. His pupils were equal and reactive, and he had conjugate gaze. His face was symmetric, and he had normal sensation to his face and extremities bilaterally. He had weakness of his left upper and lower extremities, with 4/5 strength diffusely on the left. He had full strength in his right upper and lower extremities.

Intervention

Biopsy of Lesion and Placement of Ommaya Reservoir with Cyst Drainage

The procedure was planned using the Stealth surgical navigation system (Medtronic) and high-resolution MRI to determine the optimal position for a right frontal burr hole for the biopsy and catheter placement. The burr hole was made, and a Vertek biopsy device (Medtronic) was used to guide the biopsy needle to obtain multiple core tumor specimens. An antibiotic-impregnated catheter was then passed into the cyst under stereotactic guidance, and 20 ml of xanthochromatic fluid was aspirated. The catheter was then cut distally and connected to an Ommaya reservoir. Postoperative MRI brain demonstrated a substantial decrease in cyst size and reduced compression of surrounding structures (Fig. 1D–F). Pathological evaluation by immunohistochemistry and next-generation sequencing revealed a PA, World Health Organization grade 1, with a KIAA1549-BRAF gene fusion.[9]

Laser Interstitial Thermal Therapy

A multidisciplinary pediatric neuro-oncology team presented chemotherapy, irradiation, resection, and LITT as treatment options. Because of the tumor's sensitive location and the desire for a minimally invasive approach and to reduce potential therapeutic toxicities and avoid any short- and long-term complications of chemotherapy or irradiation, the family elected to proceed with LITT. A Leksell head frame was placed for stereotactic navigation. A high-resolution computed tomography scan was obtained and merged with the preoperative brain MRI. An entry point at the right frontal region just medial to the previously placed Ommaya reservoir was made. The Leksell head frame was then placed in the appropriate XYZ coordinates. A small burr hole was made, and the PMT stereotactic bolt (PMT Corp) was fixed to the burr hole. Under fluoroscopic guidance, a bomb site was created, and the obturator was placed through the stereotactic head frame to the intended bomb site. A T1-weighted MRI of the brain with contrast enhancement was obtained, which demonstrated excellent laser trajectory placement, and a test dose was administered. The tumor was then ablated at the intended depth, and the laser was slowly withdrawn within the cooling cannula with continuing ablation. Postprocedure T1-weighted MRI with contrast and fluid-attenuated inversion recovery imaging revealed excellent ablation with a possible small amount of untreated residual at the medial-anterior aspect near the eloquent area. Intraoperative images showing cannula placement are shown in Fig. 1G–I.

Postoperative Course

The patient's left-sided weakness improved significantly immediately after cyst drainage. Two weeks postoperatively, he had regained full strength of his left side. The brain MRI obtained 1 month postoperatively revealed minimal re-expansion of the cyst that was not clinically significant. Given the patient's normal neurological examination findings, no fluid was removed through the Ommaya reservoir. He was able to begin playing sports again 5 months after his reservoir placement and biopsy. At a 16-month follow-up visit, the patient was neurologically normal. MRI at that time demonstrated tumor stability (solid and cystic portions) with loss of cyst wall enhancement (Fig. 1J–L). A small ring of contrast enhancement remained in the tumor bed, which commonly occurs after these procedures; because of this, it can be difficult to delineate between a postablative process and a small amount of tumor residual.[4,10] Similar to other studies, in this patient, the remaining ring enhancement decreased with subsequent imaging.

Discussion

Observations

The mainstay of treatment for PAs is complete resection when possible and maximal safe resection when the tumor involves sensitive structures prone to neurological injury.[11] A complete resection is considered curative and should be attempted for amenable lesions.[12] For lesions that involve the brainstem or deep structures, complete resection is not always feasible. In the case presented, we judged that surgery might only afford a subtotal resection and adjuvant treatment might be necessary. Traditionally, residual tumor in sensitive regions has been treated with chemotherapy or radiation, which may cause cognitive, neurological, and multiorgan toxicities.[5,8,13] Thalamic radiation in particular may be associated with neurocognitive deficits and endcrinopathies.[1,14,15]

The authors recognize that some patients with thalamic PAs have complete surgical resection without neurological deficits; however, the literature suggests a significant risk of postoperative neurological deficits in these patients.[16,17] Therefore, it is imperative that the risks of surgical complications and benefits of a definitive cure be discussed with the patients and their families as LITT is not the only appropriate treatment for these patients. In this case, after presentation of the risks and benefits of craniotomy for resection of tumor versus cyst drainage and LITT, the parents chose the latter treatment option to minimize the risks of treatment, understanding that surgery and chemotherapy were potential options if their chosen plan failed.

Other less invasive treatment options for this tumor type include cytotoxic chemotherapy and targeted drug therapies, including MEK inhibitors.[18] The use of fluorescence in situ hybridization and next-generation sequencing in pediatric neuro-oncology has enabled identification of targetable mutations.[9] This patient had a BRAF mutation, and recent studies in PA have shown prolonged stable disease with MEK inhibitors in patients with these mutations.[19] There is an active phase I and phase II clinical trial evaluating the MEK inhibitor selumetinib in pediatric patients with recurrent or refractory low-grade gliomas.[20]

In cases of similar disease in which pediatric patients underwent treatment for thalamopeduncular PAs, resection via a transcortical

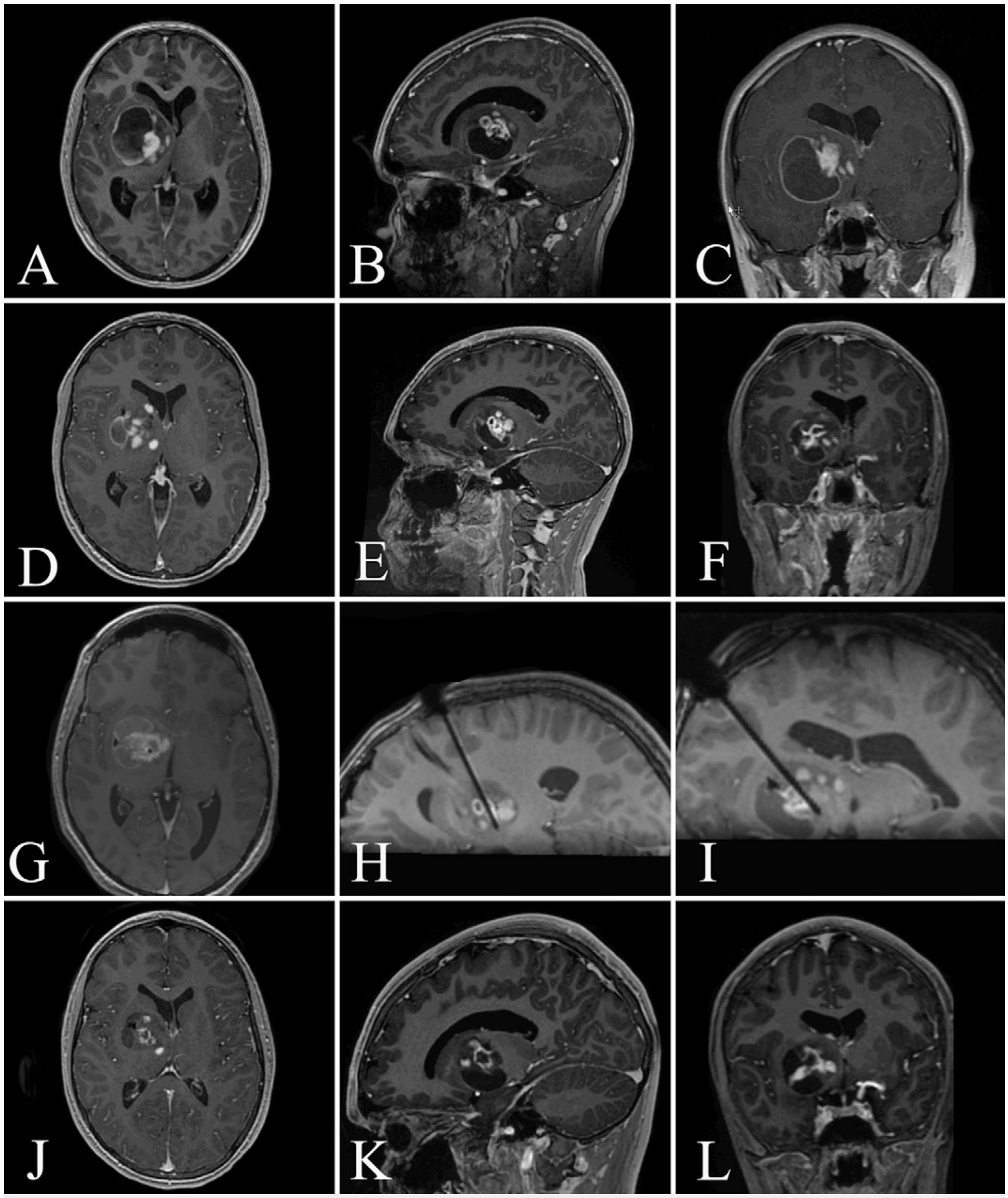

FIG. 1. Preoperative axial (**A**), sagittal (**B**), and coronal (**C**) T1-weighted contrast-enhanced MRI revealing a large cystic mass invading the right thalamus and basal ganglia with compression of the intraventricular foramen with mild obstructive hydrocephalus. Axial (**D**), sagittal (**E**), and coronal (**F**) T1-weighted contrast-enhanced imaging after biopsy of the mass and placement of the reservoir with cyst drainage. Intraoperative axial (**G**), sagittal (**H**), and coronal (**I**) MRI revealing cannula placement within the medial aspect of the tumor in preparation for LITT. Axial (**J**), sagittal (**K**), and coronal (**L**) imaging at 1-year follow-up showing stability of PA without growth of the nodule or cyst.

route resulted in persistent neurological deficits in 50% (5/10) of patients.[15] The results of patients undergoing surgery for thalamic gliomas are varied. In a large series of pediatric and adult patients with thalamic PAs, 10% (7/72) developed a new neurological deficit and 8% (6/72) developed worsening hemiparesis, with 35% having unchanged preoperative hemiparesis on immediate follow-up.[17] In this cohort, 81% (58/72) of the patients had gross total resection. In another series of pediatric patients with mixed high- and low-grade thalamic gliomas, 26% (5/19) had significant morbidity or death after resection.[16] Gross total resection was achieved in 32% (6/19) of cases. Of note, the patient we present had a PA involving the thalamus and basal ganglia, making resection even more precarious.

LITT as a treatment modality for gliomas was first described more than 20 years ago.[2] The popularity and use of LITT as an alternative surgical treatment option for other neurological processes has increased.[5,6,21] LITT offers several advantages, which include being used as an adjuvant to surgery or as primary therapy in patients with lesions in deep or eloquent areas. LITT therapy does not use ionizing radiation and is minimally invasive. Most patients are discharged from the hospital within 48 hours of the procedure.[5] There have been favorable outcomes reported in children with low-grade gliomas.[4,5] In a series of nine pediatric patients with low-grade glioma treated with LITT,[5] only one patient had recurrence of tumor at last follow-up. None of the six patients with PAs had recurrence, and only one of the nine patients had a postoperative neurological deficit after treatment of a midbrain-thalamic lesion. Follow-up time in this series ranged from 13 to 46 months.[5] Other studies have also documented the use of LITT in pediatric neoplasms other than low-grade glioma in deep locations with favorable outcomes.[3,4,6,21]

Although there were no perioperative complications in our case, the literature does report a risk of postoperative hemorrhage with LITT.[22–25] From our literature review of pediatric patients who underwent LITT, one patient had an intralesional hemorrhage after treatment for a hypothalamic hamartoma.[23] This resulted in a transient visual field deficit. There are multiple reports of postoperative hemorrhage in the adult population. Hemorrhage in these patients may result from the case series commonly involving patients with higher grade gliomas that are more prone to hemorrhage as well as treatment of larger tumors. One series reported that rates of bleeding were higher in patients with large lesions; these authors subsequently changed their practice to only use LITT on patients with tumors less than 3 cm in diameter. Since making this change, the authors have not experienced postoperative LITT hemorrhage.[24]

Lessons

Pediatric patients presenting with symptomatic cystic tumor invading deep, midline structures of the brain may be treated successfully with a combination of reservoir placement for cyst drainage and LITT. Reservoir placement can reduce mass effect on structures surrounding the cyst and thereby allow for optimal LITT treatment in deep and eloquent areas that were not amenable to resection. The Ommaya reservoir was left in place as a temporizing measure because of the possibility the cyst might recur in the future and need to be drained.

A limitation of this case is that the follow-up time is only 16 months; however, review of small case series in patients with PAs treated with LITT who have longer follow-up suggests favorable recurrence rates.[4] Reservoir placement prior to LITT was necessary in this patient in order to immediately treat the weakness. LITT without reservoir placement and cyst drainage would have been unlikely to resolve the patient's symptoms, and the post-LITT edema could have made the patient worse. Reservoir placement obviated the immediate need for extensive tumor removal, was available in case of symptomatic cyst re-expansion, and allowed for LITT in an eloquent region under more advantageous conditions.

Acknowledgments

We thank Kristin Kraus, MSc, for editorial assistance.

References

1. Bornhorst M, Frappaz D, Packer RJ. Pilocytic astrocytomas. *Handb Clin Neurol.* 2016;134:329–344.
2. Kahn T, Bettag M, Ulrich F, et al. MRI-guided laser-induced interstitial thermotherapy of cerebral neoplasms. *J Comput Assist Tomogr.* 1994;18(4):519–532.
3. Riordan M, Tovar-Spinoza Z. Laser induced thermal therapy (LITT) for pediatric brain tumors: case-based review. *Transl Pediatr.* 2014;3(3):229–235.
4. Tovar-Spinoza Z, Choi H. Magnetic resonance-guided laser interstitial thermal therapy: report of a series of pediatric brain tumors. *J Neurosurg Pediatr.* 2016;17(6):723–733.
5. Tovar-Spinoza Z, Choi H. MRI-guided laser interstitial thermal therapy for the treatment of low-grade gliomas in children: a case-series review, description of the current technologies and perspectives. *Childs Nerv Syst.* 2016;32(10):1947–1956.
6. Kuo CH, Feroze AH, Poliachik SL, Hauptman JS, Novotny EJ Jr, Ojemann JG. Laser ablation therapy for pediatric patients with intracranial lesions in eloquent areas. *World Neurosurg.* 2019;121:e191–e199.
7. Koutsouras GW, Ascencio MA, Tovar-Spinoza Z. LITT for pediatric brain tumors. In: Chiang VL, Danish SF, Gross RE, eds. *Laser Interstitial Thermal Therapy in Neurosurgery.* Springer International Publishing; 2020:75–83.
8. Beebe DW, Ris MD, Armstrong FD, et al. Cognitive and adaptive outcome in low-grade pediatric cerebellar astrocytomas: evidence of diminished cognitive and adaptive functioning in National Collaborative Research Studies (CCG 9891/POG 9130). *J Clin Oncol.* 2005;23(22):5198–5204.
9. Kline CN, Joseph NM, Grenert JP, et al. Targeted next-generation sequencing of pediatric neuro-oncology patients improves diagnosis, identifies pathogenic germline mutations, and directs targeted therapy. *Neuro Oncol.* 2017;19(5):699–709.
10. Hawasli AH, Bagade S, Shimony JS, Miller-Thomas M, Leuthardt EC. Magnetic resonance imaging-guided focused laser interstitial thermal therapy for intracranial lesions: single-institution series. *Neurosurgery.* 2013;73(6):1007–1017.
11. Knight J, De Jesus O. Pilocytic astrocytoma (juvenile). In: *StatPearls*. StatPearls Publishing; 2020.
12. Maharaj A, Manoranjan B, Verhey LH, et al. Predictive measures and outcomes of extent of resection in juvenile pilocytic astrocytoma. *J Clin Neurosci.* 2019;70:79–84.
13. Pollack IF, Agnihotri S, Broniscer A. Childhood brain tumors: current management, biological insights, and future directions. *J Neurosurg Pediatr.* 2019;23(3):261–273.
14. Austin EJ, Alvord EC Jr. Recurrences of cerebellar astrocytomas: a violation of Collins' law. *J Neurosurg.* 1988;68(1):41–47.
15. Lee RP, Foster KA, Lillard JC, et al. Surgical and molecular considerations in the treatment of pediatric thalamopeduncular tumors. *J Neurosurg Pediatr.* 2017;20(3):247–255.
16. Albright AL. Feasibility and advisability of resections of thalamic tumors in pediatric patients. *J Neurosurg.* 2004;100(5 Suppl Pediatrics):468–472.
17. Moshel YA, Link MJ, Kelly PJ. Stereotactic volumetric resection of thalamic pilocytic astrocytomas. *Neurosurgery.* 2007;61(1):66–75.
18. Schreck KC, Grossman SA, Pratilas CA. BRAF mutations and the utility of RAF and MEK inhibitors in primary brain tumors. *Cancers (Basel).* 2019;11(9):1262.
19. Fangusaro J, Onar-Thomas A, Young Poussaint T, et al. Selumetinib in paediatric patients with BRAF-aberrant or neurofibromatosis type 1-associated recurrent, refractory, or progressive low-grade glioma: a multicentre, phase 2 trial. *Lancet Oncol.* 2019;20(7):1011–1022.
20. Banerjee A, Jakacki RI, Onar-Thomas A, et al. A phase I trial of the MEK inhibitor selumetinib (AZD6244) in pediatric patients with recurrent or refractory low-grade glioma: a Pediatric Brain Tumor Consortium (PBTC) study. *Neuro Oncol.* 2017;19(8):1135–1144.
21. Hoppe C, Helmstaedter C. Laser interstitial thermotherapy (LiTT) in pediatric epilepsy surgery. *Seizure.* 2020;77:69–75.
22. Patel P, Patel NV, Danish SF. Intracranial MR-guided laser-induced thermal therapy: single-center experience with the Visualase thermal therapy system. *J Neurosurg.* 2016;125(4):853–860.
23. Buckley RT, Wang AC, Miller JW, Novotny EJ, Ojemann JG. Stereotactic laser ablation for hypothalamic and deep intraventricular lesions. *Neurosurg Focus.* 2016;41(4):E10.

24. Murayi R, Borghei-Razavi H, Barnett GH, Mohammadi AM. Laser Interstitial Thermal Therapy in the Treatment of Thalamic Brain Tumors: A Case Series. *Oper Neurosurg (Hagerstown)*. 2020;19(6):641–650.
25. Chen C, Lee I, Tatsui C, Elder T, Sloan AE. Laser interstitial thermotherapy (LITT) for the treatment of tumors of the brain and spine: a brief review. *J Neurooncol.* 2021;151(3): 429–442.

Disclosures

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: Cheshier, Baker, Crevelt. Acquisition of data: all authors. Analysis and interpretation of data: Cheshier, Crevelt, Whipple, Bollo. Drafting the article: Cheshier, Baker, Crevelt, Whipple. Critically revising the article: Cheshier, Whipple, Bollo. Reviewed submitted version of manuscript: Cheshier, Whipple. Approved the final version of the manuscript on behalf of all authors: Cheshier. Administrative/technical/ material support: Cheshier. Study supervision: Cheshier.

Correspondence

Samuel Cheshier: Intermountain Primary Children's Hospital, University of Utah, Salt Lake City, UT. neuropub@hsc.utah.edu.