Approaches to Cerebellar Astrocytoma in Pediatric Patients

27

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Key Points

- Benign astrocytomas are common pediatric tumors with an excellent survival rate of 80–100 %.
- Tumors can have significant neurological consequences, including invasion of the brainstem.
- Surgical excision is the first- and best line of treatment.
- Surgical technique for excision can be used to address other infratentorial tumors, e.g., medulloblastomas and ependymomas.

27.1 Introduction

The majority of posterior fossa astrocytomas (85 %) are juvenile pilocytic astrocytomas (JPA) and are grade I tumors. These are slow-growing, intra-axial tumors that usually present as large masses of the midline vermis or hemisphere, causing obstruction to CSF flow and cerebellar signs. They rarely metastasize. Because of their benign nature, surgical resection is the mainstay of treatment. The extent of surgical resection is the best predictor of the patient's outcome [1, 7, 10, 15]. Complete surgical resection is not always possible. In this group, there are often good long-term outcomes that are well documented even for subtotal excision of tumors [10]. Thus, subtotal resection remains a viable option in situations where complete surgical resection may significantly affect quality of life.

While JPAs are the most common astrocytic tumor of the cerebellum, other astrocytic tumors such as fibrillary astrocytomas (grade II), high-grade astrocytoma, and pilomyxoid astrocytomas also occur. These have implications for prognosis, but such information can only be determined by formal pathological assessment after surgery.

This chapter focuses on the construction and execution of a surgical plan to manage benign cerebellar astrocytomas in pediatric patients. The pathology and epidemiology of these tumors are discussed elsewhere in this book.

The nature of the tumor, by its location, features, and behavior, as well as the age of the patient, provides its own unique challenges. These challenges include surgical approach, perioperative care, and postoperative evaluation. We will also briefly consider the management of recurrent and malignant cerebellar astrocytomas. There still exists debate regarding the management of certain features, such as the cyst wall and

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tumors that are involved. The authors aim to provide an overview of the surgical management, for both surgeons and clinicians, and, for experienced surgeons, an advance on the debate on the optimal management of cerebellar astrocytomas.

27.2 Preoperative Assessment

CT is often the instrument of initial diagnosis, but it is rarely of use in surgical planning unless bony structures need to be assessed [5, 13, 14].

The mainstay of preoperative planning is MRI. It allows assessment of the location, size, and morphology of the tumor to plan the surgical approach. It can show involvement of surrounding structures (exophytic tumors) or invasion of the brainstem which have prognostic implications. It has the added benefit of being able to assess the viability of performing a third ventriculostomy if this is planned as the initial procedure.

MRI of the brain and spine, with and without contrast, should be performed. T1-weighted images demonstrate a mass that is hypo- or isointense to the surrounding brain; on T2-weighted images, the lesion is often hyperintense, particularly if there is a cystic component. Gadolinium may show a mural nodule in a cyst and enhancement of the cyst wall. MRI of the whole spine will exclude spinal drop metastases that may suggest an alternative pathology and assist in staging.

Preoperative blood test should include routine full blood count, electrolytes, coagulation studies, and a crossmatch. Crossmatch is preferable to a simple group and hold as torrential bleeding is a potential complication of surgery.

27.3 Anesthetic Considerations

A detailed discussion of neuroanesthesia is beyond the scope of this chapter. However, all patients require a full neuroanesthetic, nasotracheal intubation, arterial and central lines to monitor BP and venous filling, and an indwelling catheter to assist aggressive monitoring.

There are some specific considerations for these cases.

- Positioning of the patients can require extreme positions for the neck. A reinforced endotracheal tube may be needed to prevent kinking. Further, venous hypertension caused by such positions may add to the risk of bleed with venous sinus injuries.
- Venous sinus injuries can cause air embolism or torrential bleeding. A precordial Doppler ultrasound is useful in detecting the former. Transfusable blood ready and available is important for the latter.
- Choose an inhalational anesthetic agent when using neuromonitoring, as this may avoid depressing potentially useful recordings.
- Manipulation of the brainstem and surrounding structures may cause bradycardia or even asystole. Communication between the surgical and anesthetic team is important: the surgeon should let the anesthetist know when he is approaching the brainstem; the anesthetist in turn should notify the surgeon immediately of any variations in heart rate or blood pressure.

Preoperative medications include corticosteroids, which are given as a loading dose of 0.5–1 mg/kg to continue postoperatively at a maximum dose of 4 mg q6 hours (for adult-sized pediatric patients). This can be weaned over 2–4 weeks. Mannitol can be considered in extreme conditions. There is no indication for prophylactic anticonvulsants for posterior fossa pathology.

27.4 The Approach to Surgery

The aims of surgery are:

- To manage any associated hydrocephalus
- To obtain tissue diagnosis
- To treat the mass effect of the tumor
- To achieve maximal safe debulking of the tumor

All four may be achieved from a single surgical procedure. The location and size of the tumor determine the surgical approach. Involvement of surrounding structures, including invasion of the brainstem, have implications for the extent of surgical resection possible and hence the long-term prognosis.

In planning surgery, the complications specific to these procedures should be considered to minimize the risks to the patient. These include the risks of the different positions, the risks of air embolus and bleeding from injury to venous sinuses, and the risks of injury to important local structures.

27.5 Management of Hydrocephalus

Hydrocephalus is commonly occurring in up to 93 % of patients with a posterior fossa astrocytoma that have hydrocephalus at presentation [15]. It is often symptomatic (79 % of patients in Due-Tønnessen and Helseth's retrospective series of 87 pediatric patients).

The acuity of the hydrocephalus may establish the first step in treatment. A child with grossly symptomatic hydrocephalus – headaches, gross papilledema, vomiting, etc. – may require urgent treatment of the hydrocephalus prior to considering the tumor mass. Options include a third ventriculostomy, with or without a reservoir, or a ventriculoperitoneal shunt. The former is preferable in a setting where the histological diagnosis of the tumor has not yet been established. On rare occasions the patient may present in extremis directly due to tumor mass, in which case urgent surgery for diagnosis and to prevent death may be required.

More usually the hydrocephalus and the tumor are significant but not immediately life-threatening. This allows for preoperative planning. Minor symptoms may improve with steroids, to continue until after surgery has been performed. Hydrocephalus resolves without treatment in up to 60 % of patients after the posterior fossa tumor has been removed [9]. In these cases, a temporizing EVD placed prior to surgery via Kocher's point or at surgery via a Dandy/Frasier approach allows CSF decompression initially. Overdrainage should be avoided to prevent the risk of upward herniation before the posterior fossa is opened.

Hydrocephalus can be cured in up to 90 % of patients with primary tumor surgery or third ventriculostomy [9]. In resistant cases, a ventriculoperitoneal shunt may be required. Postoperatively, persistent hydrocephalus may occur. Postoperative hydrocephalus can be prevented by avoiding entry into the normal CSF pathways such as the fourth ventricle or cisterna magna. This is easier in the case of JPA as the tumors are more often intra-axial and do not necessarily extend into the CSF pathways. In cases where there is likely to be a breach of the normal CSF pathways, Pencalet et al. [15] recommend conducting a third ventriculostomy prior to definitive tumor surgery.

Recurrent or new onset hydrocephalus more than 30 days after surgery may herald tumor recurrence and should be investigated as such [9].

27.6 Surgical Approaches

There are two main surgical approaches:

1. Midline suboccipital craniotomy which is suitable for most midline and large hemispheric lesions
2. Retromastoid approach for more laterally placed tumors

27.6.1 Midline Suboccipital Craniotomy

This is suitable for the vast majority of cerebellar astrocytomas but is particularly good for midline and large hemispheric lesions. A good lateral extent of resection can be obtained.

27.6.1.1 Positioning

The patient can be positioned in either a prone or a seated position for the retrosigmoid approach:

(a) *The prone position* is adequate for nearly all midline approaches. It can be used to adequately expose midline or hemispheric lesions that do not extend deep to invade the peduncles and brainstem. For more lateral lesions a modified unilateral approach using a hockey stick incision can aid exposure.

In the prone position, the neck must be in a posturally neutral position with the head flexed at the craniocervical junction to flatten out the horizontal portion of the occipital bone. This also opens out the dura between

the foramen magnum and C1. Three-pin fixation is required to adequately achieve this position. Over-flexing the craniocervical junction can compress the endotracheal tube and can obstruct venous outflow, so the degree of flexion must be checked with the anesthetist. The head of the operating table can then be elevated to allow adequate venous drainage.

This position has the advantage of being ergonomic for the surgeon, with the microscope directly above the opening. As long as the neck is not too flexed, a balance between venous drainage and venous outflow can be achieved, minimizing the risk of air embolism and blood loss.

The main disadvantage of the prone position is the pooling of blood and CSF into the wound. Also, retraction of the cerebellar tissue is more likely to be required for adequate exposure.

(b) *The sitting position* has gone somewhat out of vogue, but it is useful for midline and superiorly placed lesions. It allows natural drainage of blood and CSF away from the surgical site and allows natural retraction of the cerebellum from the tentorium. Care should be taken that the small superior cerebellar veins do not tear and cause bleeding.

This position needs careful anesthetic planning. The head is well above the heart and the ensuing negative pressure in the venous sinuses increases the risk of air embolism. Strict precordial monitoring is required. Some of the negative venous pressure can be obviated by the use of a mast suit, compressing distal veins and increasing venous return to the heart.

Another potential complication includes slumping of the brain causing traction on midbrain structures (Goodrich p. 276). The elevation of the head may also decrease cerebral perfusion pressure adding risk in situations where blood loss occurs.

Ergonomically the surgeon must have the operating microscope horizontally and his arms elevated, a tiring position for long procedures, and one that requires longer arms.

27.6.1.2 Exposure

Incisions should be marked prior to opening so that adequate draping can be done after the skin prep. If an EVD is used, a linear incision over Frazier's point (6 cm above and 4 cm lateral to the inion) should be marked out along with the main midline incision which extends from the greater occipital protuberance (inion) to the level of the C2 spinous process. The fascia deep to the skin is opened in the same line, except at its superior extent just below the inion, where a Y-shaped incision allows a more airtight closure to prevent CSF leak.

A deeper dissection should follow the avascular midline. This can be done with sharp dissection or cautery. The final exposure should provide a wide view of the squamous occipital bone down to the arch of C1. As wide a periosteal dissection as possible should be performed for large lesions. This can be modified for smaller lesions or more lateral lesions.

The occipital bone can be exposed using cautery to prevent blood loss from the bone. Cautery should be used with care between the foramen magnum and the C1 arch. It is useful for clearing muscles from the occiput, but one should be cautious in infants in whom cautery can penetrate thin bone. The foramen magnum and C1 arch should be exposed using sharp and blunt dissection, with dissecting scissors preferred over cautery as the dura can easily be breached, and the C1 arch may be incomplete or cartilaginous in the young. It is also best to avoid dissection of muscles off the C2 spinous process, where there are significant muscular attachments of the axial cervical spine to the skull. This minimizes postoperative pain. Bleeding can occur laterally, at the edge of the foramen magnum, or on the C1 arch. This indicates that one is approaching the vertebral artery laterally and no further dissection is needed. Bleeding can be controlled with Surgicel or Gelfoam.

27.6.1.3 Occipital Craniotomy

The superior and lateral borders can be cut using a match-head bur and tracing the outline of the craniotomy or by placing two bur holes at the superolateral edges of the craniotomy and finishing with the cutting blade. If the latter is done, the

dura should be separated from the skull using a Penfield no. 3 or a Watson-Cheyne dissector. The authors prefer to use a matchstick bur to cut the whole bone flap, as there is less risk of entering the transverse sinus or torcula, but this has the disadvantage of more bone loss. At the inferolateral margins, if there is still bone, a small Kerrison rongeur can be used to remove the last connections.

The occiput can be hinged up a little on the inferior edge, stripping the dura from the bone using a round periosteal elevator. The inferior edge of the occiput at the foramen magnum is tightly adherent to the underlying periosteum but can be dissected off using a curette, a periosteal elevator, and/or sharp dissection with a 15-blade knife. The bone can be replaced and secured at the end of a case. In general, a craniotomy is preferable to a craniectomy [15], and its replacement assists in the prevention of CSF leaks.

There are some controversy as to whether removing the C1 arch is of benefit. The arch is not important for spinal stability, so it can be sacrificed. It is probably not required if the tumor does not extend beyond the foramen magnum.

27.6.1.4 Dural Opening

A Y-shaped incision starting laterally over the hemispheres allows safe approach to the dural sinuses. These are always encountered in the midline (cerebellar or occipital sinus).

Failure to control the opening can result in air embolism or significant blood loss. Opening bilaterally toward the midline allows judicious application of Ligaclips across the sinus, occluding the sinus and allowing the dura to be opened fully. Similar care should be taken as the durotomy crosses the foramen magnum as a circular sinus is present in a significant number of patients. Diathermy to control dural bleeding should be avoided as this causes shrinkage of the dura, which is then hard to close later.

27.6.1.5 Tumor Resection

At this point, the operating microscope is introduced. A stereotaxy can be used to help locate the tumor, though this is rarely necessary with large tumors.

These are intra-axial tumors and may not present to the surface. The corticectomy should be planned accordingly. For vermian tumors, a vertical vermian split can be used, with care not to extend the corticectomy too superiorly. If hemispheric, a horizontal approach following the natural line of the folia is recommended to minimize neurological damage. If there is a large cystic component, fluid can be drained using a brain needle prior to conducting the corticectomy to provide some decompression.

Once the cortex is opened, the tumor is often readily identified, being a pinkish gray or brown that contrasts with the normal white matter of the cerebellum. Often a plane can be established between the tumor and brain. Tumor removal can be performed using bipolar cautery and suction or the ultrasonic aspirator or laser. Bipolar cautery should be used with care when near the brainstem. Sometimes a cyst wall can be gently teased off surrounding the brain [17]. Controversy exists as to whether the cyst wall should be removed [15, 17]. Resection should continue as far as is safely possible.

If a good plane is seen around the tumor, gross total resection can be achieved. Factors which limit this include loss of a good plane between normal and abnormal tissue, invasion into the brainstem, and leptomeningeal spread [3, 16].

Complete resection may be limited by invasion into the brainstem or gross leptomeningeal spread [3, 16]. Intraoperative MRI, where available, may be helpful in demonstrating additional resectable tissue to achieve maximal safe resection.

27.6.1.6 Closure

Hemostasis can be achieved using irrigation, Surgicel, Gelfoam, and cautery. Hemostatic agents such as Surgicel and Gelfoam can cause artifacts in the postoperative MRI and should be avoided if possible. Cautery should be used cautiously near the brainstem. Patience is sometimes a virtue using irrigation.

The rest of the closure should be done carefully and thoroughly to minimize the risk of CSF leak.

The dural should be closed in a watertight fashion using muscle or fascia if needed. The bone flap is best replaced and can be held in place with a rigid fixation system such as plates and screws or CranioFix. Muscle, fascial, and skin closure should be done carefully and meticulously.

27.6.2 Retrosigmoid craniotomy

This is useful for lateral hemispheric lesions with extension into the cerebellopontine angle and for tumors of the brainstem. It is not as commonly needed but can be useful in resecting exophytic brainstem tumors.

27.6.2.1 Positioning

Again there are two main positions: either a lateral position or a supine position.

(a) *The lateral position* provides good access and view of the cerebellopontine angle. The patient is positioned with the side of access up. The head is rotated away to allow a more vertical projection of the petrous temporal bone. It is then laterally flexed away from the ipsilateral shoulder to allow for a degree of head elevation without loss of a direct line of vision. The shoulder should be retracted inferiorly away from the neck to allow better access, but with care not to pull too hard to avoid inadvertent brachial plexus injury.

The advantage of the lateral position is a good line of sight into the CP angle which can be adjusted with minimal bed rotation during the procedure if needed. There is little venous compression, minimizing raised ICP and bleeding.

The main disadvantage is the risk of pressure areas which must be cushioned, especially under the axilla and the hip.

(b) *The supine position* is the most familiar with surgeons. Access to the retrosigmoid incision is much easier in children whose necks rotate with ease. A roll under the shoulder aids rotation and is useful to prevent extreme rotation of the neck. There are fewer risks of pressure areas, but more neck rotation is required which may affect venous drainage and increase the ICP [1]. It may also have implications with endotracheal tube obstruction.

27.6.2.2 Opening

The incision is planned according to the location of the transverse and sigmoid sinuses. Surface anatomy can be used to trace both sinuses from the greater occipital protuberance to horizontally to a point directly above the mastoid for the transverse sinus and from the mastoid up to join this line at a right angle. A stereotaxy can provide these landmarks.

The incision can be linear, a lazy S shape, or C-shaped. The choice depends on the inferior extension and whether modification to a far-lateral approach is needed. It must allow enough exposure such that the dura over the transverse and sigmoid sinus is exposed.

Dissection with diathermy can proceed directly down to the skull and can be used to dissect the muscle and periosteum off as well. There is often an emissary vein at the transverse sigmoid junction which should be controlled with bone wax.

27.6.2.3 Craniotomy

The aim is to expose the transverse and sigmoid sinuses, thus allowing access to the lateral extent of the cerebellar hemisphere. The bone is quite thick as one approaches the mastoid. A disk of bone can be removed by tracing a thin bur line with a match-head drill, with care taken over the sinuses. The sinuses should be exposed by the craniotomy as important guiding landmarks.

27.6.2.4 Durotomy

Once open, the dura can be opened in a T or X shape with the long arm of the T extending up to the transverse sigmoid junction. One of the arms should then extend down toward the mastoid stopping just short of the sigmoid sinus.

27.6.2.5 Tumor Resection

Once the dura is opened, patient is drained of CSF to allow for some natural brain relaxation and the ventral aspect of the cerebellar hemisphere can be exposed and traced medially. Retraction should be kept to a minimum to avoid

traction on nerves which may be tethered by tumor and to prevent tearing of small veins entering into the superior petrosal sinus superiorly.

Exophytic tumors will envelope and obscure important anatomical structures. If the intention is to explore the brainstem, important structures should be identified: cranial nerves VII, V, and VI superiorly and cranial nerves IX, X, and XII; the vertebral artery with its branches (anterior spinal artery); and the posterior inferior cerebellar artery inferiorly. Damage to any of these structures can result in significant morbidity, particularly in the case of the lower cranial nerves.

Complete tumor resection may not be achievable if these are obscured or if there is significant invasion of the brainstem.

27.6.2.6 Closure

Again this involves careful hemostasis and then a tight dural closure. The latter can be difficult to achieve if the dura has dried out or if it has been cauterized at any time. If this is an issue, galea can be harvested as dural replacement and sewn in place. The disk of bone can be replaced and secured. This minimizes headaches caused by muscle traction on the dura. Careful, multilayered muscular and skin closure is also required to help prevent CSF leaks.

27.7 Complications

Common complications of surgery include the formation of a pseudomeningocele deep in the wound which may progress to a CSF wound leak; meningitis; aggravation of hydrocephalus; cerebellar mutism; cerebellar symptoms of truncal ataxia, or peripheral ataxia and nystagmus depending on the location of the tumor; and rarely disabling symptoms such as bulbar dysfunction from cranial nerve or brainstem injury. Dirven et al. [8] report an overall surgical morbidity rate of 15 %.

As noted above, it is easier to prevent problems than to treat them, so the surgical technique is important in minimizing complications. Table 27.1 delineates risk factors for and methods to minimize complications when operating on posterior fossa tumors.

Cerebellar mutism is a disturbing complication, more commonly seen in younger patients, and with larger midline tumors that extend into the fourth ventricle. Originally reported in 1985 by Rekate et al. and Yonemasu, cerebellar mutism may occur in as many as 30 % of patients after resection of a cerebellar tumor [4, 11, 18, 21]. It is thought to be less common in patients with cerebellar pilocytic astrocytomas. The symptoms may last for weeks to months with a gradual return of speech that is often dysarthric as it improves. Persistent cognitive and verbal deficits are common [11, 19].

Longer-term consequences including learning difficulties, motor planning, as well as ongoing cerebellar motor symptoms may be due to direct cerebellar injury. Patients with preoperative deficits are more likely to have postoperative deficits. These may affect a child's learning abilities, and early intervention should be organized to maximize learning.

Death is, thankfully, rare with modern techniques and is reported in <1–5 % of patients in most series (Dirven, Villarejo, DiRocco). In Villarejo's series, perioperative mortality was 17.5 % prior to 1974 and 3.2 % after 1974. DiRocco notes that in more modern series, mortality is approaching zero.

27.8 Surgical Outcomes

The most important prognostic factor in the management of cerebellar astrocytomas is the extent of surgical resection [2, 20]. Complete resection for juvenile pilocytic astrocytoma affords a nearly 100 % long-term survival rate compared with the overall 10 year survival rate of 65. Gross total resection, as judged by an immediate postoperative MRI, occurs in 60–70 % of cases [2, 8, 12]. Location is a good determinant of how easily a GTR may be achieved, with Akay's series describing a higher percentage in patients with single hemispheric lesions. The extent of resection is often overestimated by the operating surgeon [8]! This is reflected in Desai's series in which the surgeon reported an 80 % incidence of GTR, while this was seen in only 70 % of postoperative scans [6].

Table 27.1 Common complications and techniques to avoid them

Complication	Predisposing factors	Preventive techniques
CSF leak/pseudomeningocele	Hydrocephalus wound infection	Clean cuts to structurally important tissue (fascia, dura)
		Avoid diathermy to same
		Complete dural closure using galea graft or substitute if it cannot be achieved primarily
		Y- or T-shaped incision in fascia just below the inion to assist in a tight closure
		Careful reconstruction of the normal planes
		Replacement of the bone flap (craniotomy vs. craniectomy)
		Minimize dead space in muscular layers
		Treat hydrocephalus
Blood loss	Higher risk in infants with low blood volume	Appropriate positioning to prevent venous hypertension
		Use of a Colorado needle in infants and young children
		Control of hemostasis as bleeding occurs
		Active control of the venous sinuses (occipital and circular sinuses) at dural opening
		Judicious use of bipolar and other hemostatic techniques during tumor removal
		Minimization of cerebellar retraction, use of gravity or otherwise, especially superiorly and superolaterally to the cerebellum
Hydrocephalus	Preoperative hydrocephalus	Avoid opening into CSF spaces if possible (easier with JPAs as they are mostly intra-axial tumor that do not extend into the fourth ventricle)
		Minimize blood contamination of subarachnoid space/cisterna magna
		Careful monitoring of signs of hydrocephalus
Neurological deficit/cerebellar mutism	Large tumors	Gentle handling of normal neural tissue
	Midline tumors	Avoid retraction of normal neural tissue
		Minimize use of diathermy especially near peduncles/brainstem
		Identify normal structures early

It is not surprising then that factors which limit the resection, such as the size and extent of the tumor, brainstem invasion, leptomeningeal spread or multifocal disease, are associated with a worse prognosis. Thus, the recurrence rates in patients with a gross total resection are of the order of 2–5 %, while it is 42–45 % in patients with subtotal removal of tumor [8, 12]. In patients

with residual tumor, about half progress, and the rest remain static or regress with time [8]

The histology of the tumor affects prognosis. In Desai's series of cerebellar astrocytomas, 57 % had pilocytic astrocytomas, 35 % had low-grade fibrillary astrocytomas, and 8 % had high-grade astrocytomas. Pilocytic tumors had a much better long-term survival. This has not been confirmed in all series. There is great variability in the biological behavior of the pilocytic subtype in itself. Some authors believe that cystic tumors carry a better prognosis than solid tumors [15]. At present there is still little information explaining the variable behavior of pilocytic tumors, which, while generally benign can occasionally behave in a malignant fashion, may transform later in to malignant tumors [12] or which may regress.

There are few other proven prognostic factors. Age is said to be a factor with children under 5 years or younger having a shorter survival period compared to those aged older than 5 years [10]. This may reflect different tumor biology. It may also reflect the greater dangers for smaller children. In Desai's series, in which five mortalities were recorded, 3/5 children who died postoperatively were infants less than 1 year of age.

27.9 Postoperative Care

The patient should be managed in a pediatric intensive care unit for the first 24–48 h. Where the operation has been long, or if the patient's preoperative condition was serious, extubation can be delayed. Placement of an EVD intraoperatively allows for monitoring of the intracranial pressure during this period. Neurological and other physiological observations should be closely monitored (half hourly) for the first 6 h. Steroids can continue at a higher dose for 24–48 h, but weaning should start as soon as tolerated by the patient.

A postoperative MRI with contrast should be done within 72 h of the operation, preferably within 24 h, to assess the extent of surgical resection. Where there is residual tumor that is surgically accessible, further resection is a viable option.

The patient should have a careful neurological assessment, as their condition permits, to assess potential deficits.

The CSF circulation can be tested by gradual elevation of the external drain, then clamping, prior to removal. The wound should be checked for the formation of a pseudomeningocele or a frank CSF leak, which may indicate that CSF flow is obstructed. This may need to be addressed further.

Long-term follow-up for tumor recurrence or progression is imperative. In general, postoperative review of the patient is required every 3 months for at least 2 years with a lengthening between reviews over time. In patients with disease absent at 5 years, the period of review can be lengthened still. Close review is required in patients with residual tumor and those with more aggressive pathologies. Reoperation and adjuvant therapies should be considered in patients in whom the tumor recurs.

Conclusion

Cerebellar astrocytomas typically have an excellent prognosis with surgical excision as the first line of treatment. In the era of MRI and pediatric ICU, pediatric patients are typically presenting for elective resection, allowing time to plan surgical approaches that minimize complications. Potential complications, such as cerebellar mutism, can be rare but significant and are made more likely by the extension of the tumor into the brainstem or leptomeningeal spread. The authors suggest that as surgical resection is the key prognostic factor, these lesions should be pursued to the maximum of their margin of safety, irrespective of their pathological grade.

References

1. Akalan N (2009) Intracranial tumours in childhood. In: Practical handbook of neurosurgery, Springer, Berlin, Part 6, pp 1043–1059

2. Akay KM, Izci Y, Baysefer A, Atabey C, Kismet E, Timurkaynak E (2004) Surgical outcomes of cerebellar tumors in children. Pediatr Neurosurg 40(5): 220–225
3. Auer RN, Rice GP, Hinton GG, Amacher AL, Gilbert JJ (1981) Cerebellar astrocytoma with benign histology and malignant clinical course. Case report. J Neurosurg 54(1):128–132
4. Catsman-Berrevoets CE, van Dongen HR, Mulder PG, Geuze D, Paquier PF, Lequin MH (1999) Tumour type and size are high risk factors for the syndrome of "cerebellar" mutism and subsequent dysarthria. J Neurol Neurosurg Psychiatry 67:755–757
5. Chang T, Teng MM, Lirng JF (1993) Posterior cranial fossa tumours in childhood. Neuroradiology 35(4): 274–278
6. Desai KI, Nakdarni TD, Muzumdar DP, Goel A (2001) Prognostic factors for cerebellar astrocytoma in children: a study of 102 cases. Pediatr Neurosurg 35:311–317
7. DiRocco C Cerebellar (1999) astrocytomas. In: Choux M, DiRocco C, Hockley A, Walker M (eds) Pediatric neurosurgery. Churchill Livingstone, London, p 451
8. Dirven CM, Mooij JJ, Molenaar WM (1997) Cerebellar pilocytic astrocytoma: a treatment protocol based upon analysis of 73 cases and a review of the literature. Childs Nerv Syst 13(1):17–23
9. Due-Tønnessen BJ, Helseth E (2007) Management of hydrocephalus in children with posterior fossa tumors: role of tumor surgery. Pediatr Neurosurg 43:92–96
10. Garcia DM, Latifi HR, Simpson JR, Picker S (1989) Astrocytomas of the cerebellum in children. J Neurosurg 71:661–664
11. Gudrunardottir T, Sehested A, Juhler M, Schmiegelow K (2011) Cerebellar mutism: review of the literature. Childs Nerv Syst 27(3):355–363
12. Krieger MD, Gonzalez-Gomez I, Levy ML, McComb JG (1997) Recurrence patterns and anaplastic change in a long-term study of pilocytic astrocytomas. Pediatr Neurosurg 27(1):1–11
13. Lee YY, Van Tassel P, Bruner JM, Moser RP, Share JC (1989) Juvenile pilocytic astrocytomas: CT and MR characteristics. AJR Am J Roentgenol 152(6): 1263–1270
14. Morreale VM, Ebersold MJ, Quast LM, Parisi JE (1997) Cerebellar astrocytoma: experience with 54 cases surgically treated at the Mayo Clinic, Rochester, Minnesota, from 1978 to 1990. J Neurosurg 87(2):257–261
15. Pencalet P, Maixner W, Sainte-Rose C, Lellouch-Tubiana A, Cinalli G, Zerah M, Pierre-Kahn A, Hoppe-Hirsch E, Bourgeois M, Renier D (1999) Benign cerebellar astrocytomas in children. J Neurosurg 90(2):265–273
16. Pollack IF, Hurtt M, Pang D, Albright AL (1994) Dissemination of low grade intracranial astrocytomas in children. Cancer 73:2869–2878
17. Raimondi AJ (1998) Pediatric neurosurgery. Theoretical principles art of surgical techniques. Springer, Berlin
18. Rekate HL, Grubb RL, Aram DM, Hahn JF, Ratcheson RA (1985) Muteness of cerebellar origin. Arch Neurol 42(7):697–698
19. Riva D (1997) The neuropsychology of the cerebellum. In: Choux M, DiRocco C, Hockley A, Walker M (eds) Pediatric neurosurgery. Churchill Livingstone, London, pp 452–453
20. Villarejo F, de Diego JM, de la Riva AG (2008) Prognosis of cerebellar astrocytomas in children. Childs Nerv Syst 24(2):203–210
21. Yonemasu Y (1985) Cerebellar mutism and speech disturbance as a complication of posterior fossa surgery in children. 13th Annual Meeting of the Japanese Society for Pediatric Neurosurgery, Tsukuba