Chapter 36

Pediatric Neurological Tumors

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> A seven-year-old girl presents to the emergency department with recent onset of severe headaches, nausea and vomiting. Her vital signs include: BP 98/68, HR 122, RR 26/minute. An urgent CT scan demonstrates a large infra-tentorial mass. An MRI of the head with and without contrast is booked.

What Are the Different Types of Pediatric Intracranial Tumors? What Are Their Presenting Symptoms?

There are numerous types of intracranial tumors, but they can be divided into basic regions of supra-tentorial, infra-tentorial, posterior fossa tumors, and brain stem tumors. Subdivisions and common presenting symptoms are noted in the graphic, often with overlap. The most common pathologies based on intracranial location are noted in Figure 36.1 and Table 36.1.

What Are the Signs of Increased Intracranial Pressure in Children?

Increased intracranial pressure is often insidious and the signs are often subtle. These include irritability, crying, headaches, diplopia, nausea, stiff neck, vomiting, and motor weakness. The classic Cushing's triad is a more advanced stage of untreated increased ICP consisting of hypertension, bradycardia, and irregular breathing/bradypnea. Cushing's triad is potentially deleterious and requires immediate assessment and decompression to prevent morbidity/mortality.

What Is the Monro–Kellie Hypothesis?

This hypothesis states that the cranium has a fixed volume of brain tissue, blood, and CSF. Therefore, any increase in one compartment, such as tumor, is offset by decreases in one or more of the other compartments. Any increase in intracranial pressure due to tumor for example, has to be offset by either decreasing cerebral blood volume or CSF.

Since dural punctures can lead to herniation in this scenario, manipulation of the blood flow compartment through $PaCO_2$ management has been a mainstay of anesthetic management. The conundrum in these cases is that reducing the coronary blood flow (CBF) also reduces cerebral perfusion pressure (CPP). This is explained in the following equation:

$$\begin{aligned}&\text{CPP} = \text{Mean Arterial Pressure (MAP)}\\&(\text{MAP} - \text{Intracranial Pressure (ICP)}\\&\text{or Central Venous Pressure (CVP)}\\&(\text{whichever is greater})).\end{aligned}$$

By transposition:

$$\text{ICP} = \text{MAP} - \text{CPP}$$

Therefore, any increase in the MAP will directly translate to an increase in ICP. This balance however, is critical. In adult studies, reducing the MAP to decrease ICP causes secondary neuronal death due to ischemic/ischemic-reperfusion injuries.

Decreasing the CO_2 through hyperventilation compounds the problem by reducing blood return to the right side of the heart (and hence cardiac output and MAP), as well as reducing cerebral blood flow.

What Is the Optimal $PaCO_2$ for Neurosurgical Procedures?

The $EtCO_2$ is used as a surrogate for $PaCO_2$ provided that there isn't a significant Alveolar-arterial

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Table 36.1 Common neurological tumor pathologies and presenting symptoms in children by anatomic region (numbers correlate with Figure 36.1)

	Anatomic region	Common tumor subtypes	Common symptoms
1	Suprasellar/ chiasmatic	Optic glioma, cranopharyngioma, germinoma, prolactinoma, pituitary adenoma, pliomyxoid astrocytoma	Headache, nausea, vomiting, visual field deficits, precocious or delayed puberty, anorexia, diabetes insipidus
2	Pons	Pontine glioma	Diplopia, cranial nerve palsy, incoordination, headache
3	Pineal/ midbrain	Glioma, pineoblastoma, pineocytoma, germinoma, primitive neuroectodermal tumor (pNET)	Upwards gaze paralysis, vomiting, nystagmus, diplopia, tremors
4	Cerebellum	Medulloblastoma, ependymoma, pilocytic astrocytoma, atypical teratoid rhabdoid tumor (ATRT), glioma	Headache, vomiting, ataxia, tremors, nystagmus
5	Basal ganglia/ thalamus	Gliomas, germinoma, oligodendroglioma	Movement disorder, weakness, hemisensory deficit, visual field deficit
6	Cerebral cortex	Gliomas, dysembroplastic neuroectodermal tumor (dNET), pNET, ependymoma, oligodendroglioma, ganglioglioma	Elevation of intracranial pressure (ICP), seizures, weakness, language disorder, encephalopathy, visual field deficit, headache
7	Ventricular system	Choroid plexus papilloma/carcinoma, ependymoma, ATRT, astrocytoma, desmoplastic infantile ganglioglioma	Nausea, vomiting, elevated ICP
8	Meninges	Meningioma	Seizures, headache

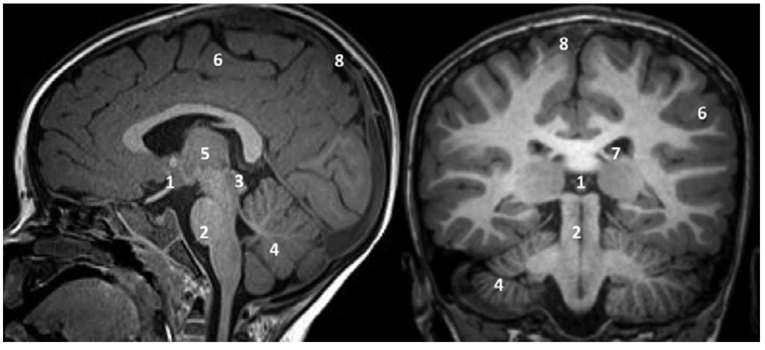

Figure 36.1 Sagittal and coronal CT images demonstrating the most common pediatric brain tumor pathologies by anatomic region (see Table 36.1 for region-specific descriptions)

(A-a) gradient. This is clinically checked with an ABG at the beginning of the procedure prior to incision and compared against the $EtCO_2$. In general, while reducing the $PaCO_2$ reduces cerebral blood flow due to cerebral vasoconstriction, this has to be balanced against maintaining CBF to critical areas. While most maintain the $PaCO_2$ around 30 mmHg, decreasing the $PaCO_2$ below 25 mmHg is not advisable.

The MRI Demonstrates a Posterior Fossa Tumor Which Is Poorly Circumscribed, Suggestive of Medulloblastoma. The Neurosurgeon Books a Tumor Resection. What Are Your Intraoperative Concerns?

It is important to look at the patient's electrolyte and volume status based on how long the child has been

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vomiting and has had poor oral intake. In cases of severe disturbances, temporization with a ventricular drain may allow for better medical optimization prior to a lengthy resection.

Monitoring should include addition of arterial lines with consideration for central venous access. Urinary output monitoring is critical for maintenance in cases where diuretics are used (mannitol/furosemide) or for the development of diabetes insipidus (DI) or syndrome of inappropriate antidiuretic hormone (SIADH).

Surgical pinning using the Mayfield pins causes an intense but very short-lasting stimulation. Specific considerations for the prone position include pressure on the eyes/nose, endotracheal tube dislodgement, and especially venous air embolism. Blood products should be readily available, especially in small children.

The Surgeon States that the Dura Is "Tight." What Is the Appropriate Management?

Bulging dura is a sign of elevated ICP. Intraoperative management includes: elevation of the head of bed, hyperventilation, avoidance of inhaled anesthetics, administration of diuretics (furosemide and/or mannitol), use of hypertonic 3% saline.

What Are the Positioning Concerns with Pediatric Neurosurgical Patients?

Based on the location of the tumor, there are multiple possible positions for pediatric patients. This includes but is not limited to prone, lateral, and head up positioning. Patients in the prone position are more prone towards facial/lingual swelling, especially in longer cases. Patients in the lateral position are prone towards brachial plexus stretching, and arm/neck positioning demands careful attention. Patients in the head up position, specifically with the head above the heart, are more prone towards venous air embolisms.

Why Is the Incidence of Venous Air Embolism (VAE) Greater in Posterior Fossa Surgery?

VAE is associated with sitting craniotomies. The incidence in pediatric neurosurgeries is less than in adult neurosurgeries. The highly vascular nature of the posterior fossa due to the presence of numerous low pressure dural sinuses predisposes this area to air entrainment. Entrained air can reduce or block blood flow in the right ventricle. If VAE is suspected, the area should be flooded with saline to prevent further air entrapment, and attempts should be made to limit travel of the embolism with jugular compression. Supportive hemodynamic management is also necessary, as hemodynamic consequences often ensue especially with large embolisms. These can lodge themselves in the right ventricular outflow tract, in the pulmonary circulation, or travel through a patent foramen ovale into the brain.

Copious urine output in this patient could be due to a number of factors, including excess hydration, use of diuretics, nephrogenic DI, and centrally mediated disorders including central DI and cerebral salt wasting (Table 36.2).

> The patient is extubated without incident and is transported to the pediatric intensive care unit. The patient begins to have copious urine output. What is the differential diagnosis? What is the difference between cerebral salt wasting, DI, and SIADH?

A fractional excretion of sodium (FeNa) is useful in this circumstance. The fractional excretion of Na is calculated by obtaining both the serum and urine Na simultaneously and using the serum Na as the numerator. If it is very low, then that is suggestive of SIADH or cerebral salt wasting (CSW). DI manifests with a high FeNa. Assessment of the patient's volume status is also critical; hypovolemic patients require fluid resuscitation (rather than restriction).

The treatment regimens similarly vary between the diagnoses. SIADH is primarily treated through fluid restriction to reduce water balance, as it is viewed as an excess of free water due to excessive water retention. Cerebral salt wasting, on the other hand, is characterized by excessive urinary Na wasting, and following the principles of osmolarity, free water loss as well. Therefore, the patients are intravascularly volume depleted with severe electrolyte disturbances. DI can be classified into either nephrogenic or central DI. For the purposes of this discussion, we are considering central DI which is

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Table 36.2 Characteristics associated with syndrome of inappropriate antidiuretic hormone, diabetes insipidus, and cerebral salt wasting syndrome

	Syndrome of inappropriate antidiuretic hormone	Cerebral salt wasting syndrome	Diabetes insipidus
Intravascular volume	Hypervolemia	Hypovolemia	Hypovolemia
Serum sodium	Low	Low	High
Urine sodium	High	High	Normal
Urine output	Low	High	High
Primary treatment	Fluid restriction	Sodium and fluid resuscitation	Fluid resuscitation

characterized by free water wasting due to concentrating defects in the renal tubules. Fluid resuscitation is the first line of therapy, and failing this, desmopressin should be considered.

Suggested Reading

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