Pediatric neuroanesthesia 10/10/2018

R3Nattikan wiwatnodom

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Outline

- Neurophysiology and development
- Anesthesia for neurosurgery
- Specific for neurosurgical cases

Neurophysiology

- **Cerebral blood flow**: CBF is coupled tightly to metabolic demand, increase proportionally after birth. CFB peaked between 2-4 years and settled at 7-8years
- larger **percentage of cardiac output** that is directed to the brain: the head of the infant and child accounts for a large percentage of the body surface area and blood volume. These factors place the infant at risk for significant hemodynamic instability during neurosurgical procedures.

Neurophysiology

- **Autoregulation**: between 20-60 mmHg in a normal newborn and the slope of the autoregulatory slope drops and rises significantly at the lower and upper limits of the curve
- Sick Premature neonate don't have ability to autoregulate their cerebral circulation: linear correlation between CBF and systemic blood pressure
- High risk for cerebral ischemia and intraventricular hemorrhage.

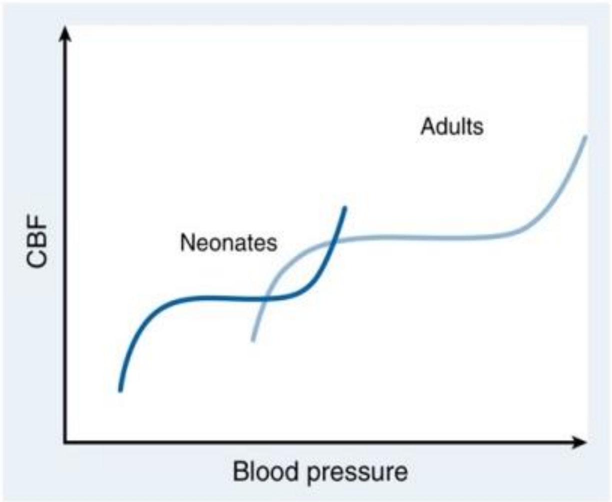

Figure 19–2 Autoregulation of cerebral blood flow (CBF) in children. The slope of the autoregulatory curve drops and rises significantly at the lower and upper limits of the curve, respectively, and is shifted to the left in the neonate and small child.

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Neurophysiology

- **Open fontanels and cranial sutures** lead to a compliant intracranial space, The mass effect are often masked. As a result, infants with intracranial hypertension have fairly advanced pathology
- Immature organ systems. Renal system, hepatic function and different total body water with age

Anesthesia for neurosurgery

- Preoperative evaluation and preparation
- Intraoperative management
- Postoperative management

Preoperative evaluation and preparation

- neonates and infants are at higher risk for morbidity and mortality than any other age group
- Respiratory and cardiac-related events account for a majority of these complications.
- the presence of **coexisting diseases**.
- complete airway examination is essential
- Congenital heart disease may not be apparent immediately after birth.
- Preoperative sedatives: Midazolam given orally or IV

Perioperative concerns for infants and children with neurological disease

Condition	Anesthetic implications
Congenital heart disease	Hypoxia and cardiovascular collapse
Prematurity	Postoperative apnea
Upper respiratory tract infection	Laryngospasm and postoperative hypoxia/pneumonia
Craniofacial abnormality	Difficulty with airway management
Denervation injuries	Hyperkalemia after succinycholine
	Resistance to nondepolarizing muscle relaxants
Chronic anticonvulsant therapy for epilepsy	Hepatic and hematological abnormalities
	Increased metabolism of anesthetic agents
Arteriovenous malformation	Potential congestive heart failure
Neuromuscular disease	Malignant hyperthermia
	Respiratory failure
	Sudden cardiac death
Chiari malformation	Apnea
	Aspiration pneumonitis
Hypothalamic/pituitary lesions	Diabetes insipidus
	Hypothyroidism
	Adrenal insufficiency

Table 19–3 Developmental Factors Affecting the Pediatric Patient in the Perioperative Period

Age Group	Concerns
Infants (0-9 months)	None; will separate easily from parents
Preschoolers (9 months–5 years)	Stranger anxiety; difficulty with separation from parents
Grade schoolers (6-12 years)	Fear of needles/pain
Adolescence (>12 years)	Anxiety about surgery and self-image

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Intraoperative management

- **Induction of anaesthesia**: aim to avoid increases in ICP
  - hypercapnia, hypoxia, and variations in MAP should avoid . Ketamine is not recommended.
  - i.v. induction with propofol or thiopental and neuromuscular block is therefore ideal.
  - if the child is distressed or has difficult i.v. access, a smooth gas induction may be better than the raised ICP: Sevoflurane confers benefits over other volatile

- **Induction of anaesthesia**:
  - rapid sequence induction: increase in ICP associated with the use of succinylcholine can be attenuated by the use of opioids or priming
  - Opioids should be used to attenuate responses to laryngoscopy, intubation, and surgery.

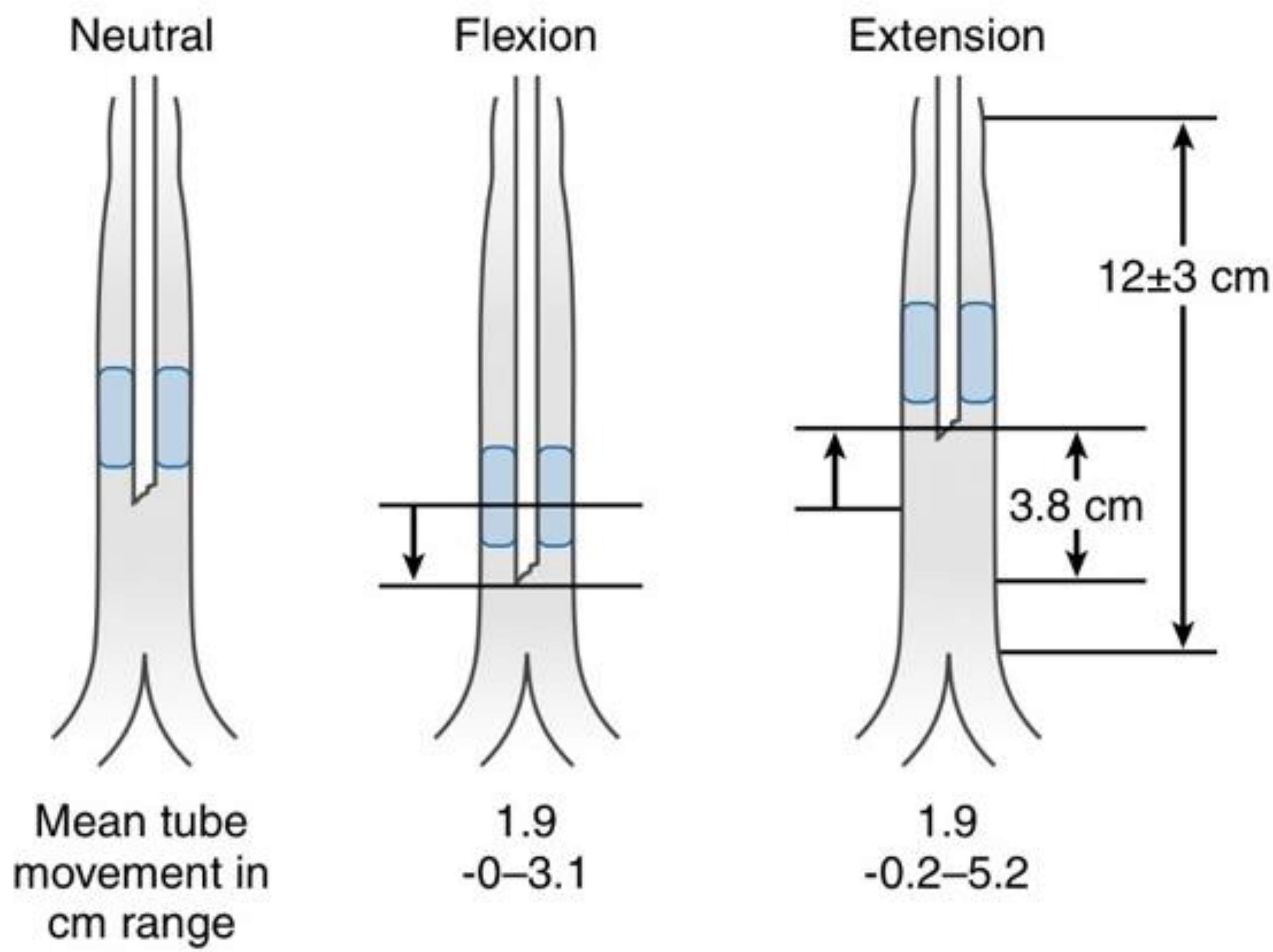

Figure 19–5 Effect of head flexion and extension on endotracheal tube position. Note that flexion of the neck causes the endotracheal to migate towards a mainstem bronchus. While neck extension can lead to dislodgement of the endotracheal from the trachea.

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- **Maintenance of anaesthesia**:
  - Maintenance of anaesthesia utilizes volatile agents or total i.v. anaesthesia (TIVA) in combination with a short-acting opioid and controlled ventilation.
  - TIVA has been limited due to the restrictions on TCI devices
  - if volatile agents <1 MAC, there will be no associated increase in CBF.
  - Sevoflurane and desflurane appear to have similar effects on cerebral physiology to isoflurane, but confer the benefits of greater hemodynamic stability and rapid emergence after prolonged surgery.
  - Nitrous oxide should be avoided since significant increases in CBF and $CMRO_2$. It also increasing the potential for raised ICP in pneumocephalus after operation.

Table 19–5 Physiologic Effects of Positioning in All Patients

Position	Physiologic Effect
Head elevated	Enhanced cerebral venous drainage Decreased cerebral perfusion pressure (potential cerebral blood flow decrease) Increased venous pooling in lower extremities Postural hypotension
Head down	Increased cerebral venous and intracranial pressure Decreased functional residual capacity (lung function) Decreased lung compliance
Prone	Venous congestion of face, tongue, and neck Decreased lung compliance Increased abdominal pressure can lead to compression of the vena cava
Lateral decubitus	Decreased compliance of down-side lung

- **Positioning** : principles relate to maintaining adequate ventilation and the avoidance of venous congestion and morbidity secondary to poor positioning.

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- **Positioning**

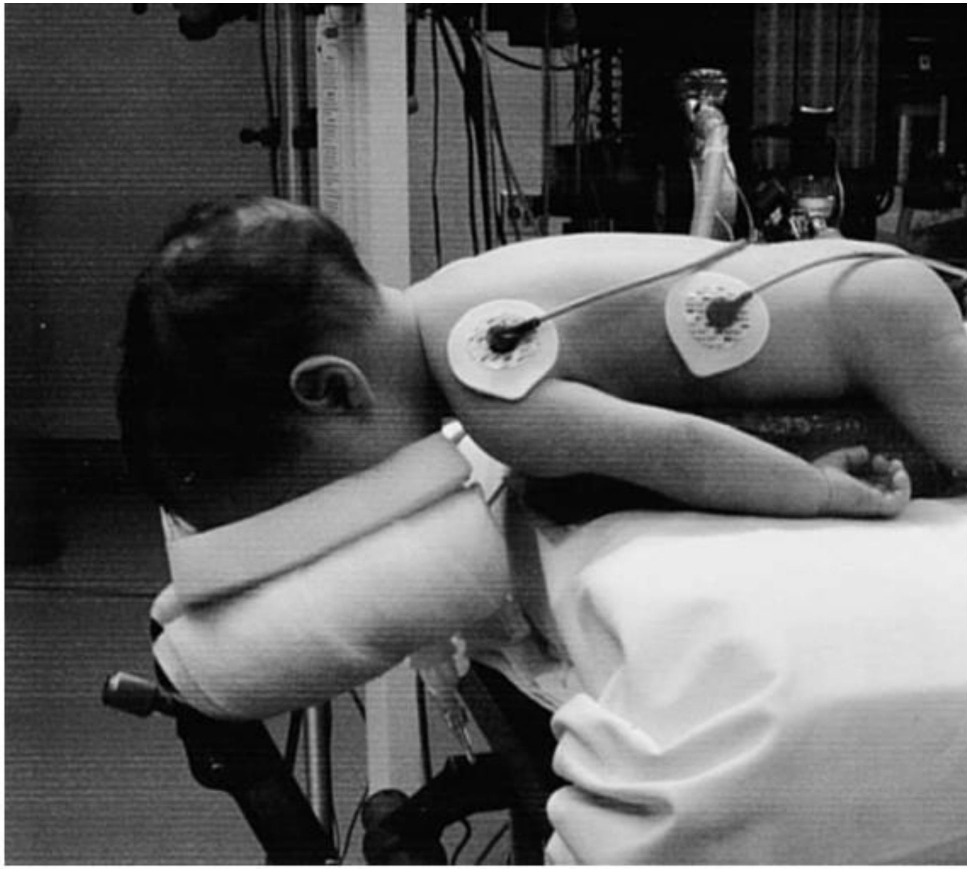

Fig. 4. Prone infant. Lateral rolls are used to elevate the infant and m abdominal pressure.

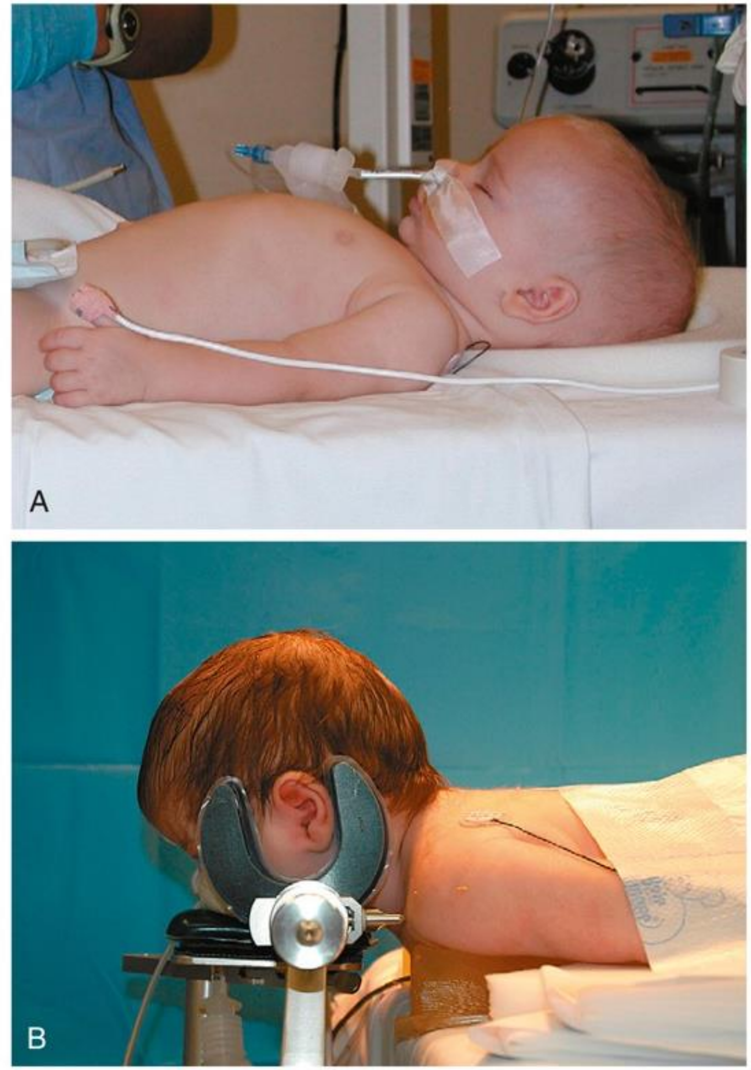

Figure 19–7 Supine (**A**) and prone (**B**) positioning for an infant. Note that the infant's head lies at a higher plane than the rest of the body. This feature increases the likelihood of venous air embolism during craniotomy.

Anesthesiology Clin N Am 20 (2002)

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- **Monitoring**
  - Routine monitoring includes capnography, pulse oximetry, electrocardiography, temperature, and invasive arterial pressure.
  - Urethral catheterization and the measurement of urine output are necessary for prolonged procedures and especially those associated with diabetes insipidus or the requirement for mannitol.
  - A central venous catheter provides large-bore access and allows for central administration of vasoactive drugs and potentially treatment of VAE. Readings can be unreliable in small children in the prone position but trends may be useful.
  - Some centres use precordial Doppler ultrasonography to detect VAE.

- **Venous air embolism**
  - the head lies above the heart rendering them more susceptible to VAE. In addition, the dural sinuses and diploic veins bridging the scalp and dura are held open by bony connections.
  - cardiac shunts are at risk of paradoxical air emboli
  - End-tidal CO_2 analysis and arterial catheterization (±precordial Doppler) detect VAE.
  - If a VAE is diagnosed, the surgeon should immediately occlude entry points and flood the surgical field with saline. Other manoeuvres include applying jugular venous compression, head-down tilt, and aspiration of air from the CVC. The mainstay of treatment is to provide cardiorespiratory support.

- **Intraoperative fluid management**
  - goal to maintain normovolemia, and thus hemodynamic stability
  - The commonly used crystalloids are Ringer's lactate or 0.9% sodium chloride.
  - Hyperglycemia worsens reperfusion injury, and hypotonic infusions increase cerebral edema.

Table 19–6 Estimated Blood Volume in Children

Age	Estimated Blood Volume (mL/kg)
Preterm neonate	100
Full-term neonate	90
≤1 year	80
1-12 years	75
Adolescents and adults	70

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- **Temperature regulation**
  - the importance of normothermia for adequate emergence from anasthesia, and the time required to rewarm even a mildly hypothermic child, especially an infant. Fluid warmers, warm air devices, and heated mattresses are required.
  - Mild hypothermia (34–35°C) encourages a decrease in $CMRO_2$ and may help to attenuate raised ICP. However, it is essential to appreciate the complications

Postoperative management

- Post-craniotomy/craniectomy children are managed on a high dependency unit.
- regular neurological observations
- Opioid in appropriate dose ranges
- Acetaminophen is usually commenced intraoperatively and continued regularly after operation.
- Antiemetics

Specific for neurosurgical cases

Hydrocephalus and shunt procedures

- commonly procedures diverting CSF from the ventricles to another body cavity; peritoneal, pleural, or right atrium. Venticuloperitoneal shunts are the commonest.
- Acute distension of the third ventricle can cause cardiac arrhythmias and cardiovascular instability due to the close proximity of the third ventricle to midbrain CVS center.
- Shunt procedures require skin exposure and preparation from the head to the abdomen. Heat conservation strategies should be instituted in young children.

Specific for neurosurgical cases

Neonatal emergencies

- neonatal myocardial function is sensitive to both inhaled and intravenous anesthetics: judicious to block surgical stress without causing myocardial depression.
- An opioid-based anesthetic is generally the most stable hemodynamic technique for neonates but have delayed emergence and may require postoperative mechanical ventilation.

Specific for neurosurgical cases

Craniosynostosis

- associated with loss of significant blood volume of an infant
- Venous air embolism detected by echocardiography and precordial Doppler occurred in 66% to 83% of craniectomies in infants.
- Occulocardiac reflex
- Airway management
- Positioning : may excessive neck extension /flexion

Specific for neurosurgical cases

Tumors

- The majority of intracranial tumors in children occurs in the posterior fossa: most in prone
- massive blood loss and/or VAE can occur.
- Surgical resection of tumors in the posterior fossa can also lead to brainstem and/or cranial nerve damage → Sudden changes in blood pressure and heart rate
- Damage to the respiratory centers and cranial nerves can lead to apnea and airway obstruction

Specific for neurosurgical cases

Epilepsy surgery

- perioperative seizures, and co-existing disease
- Chronic administration of anticonvulsant drugs, phenytoin and carbamazepine, induces rapid metabolism and clearance of several classes of anesthetic agents including neuromuscular blockers and opioids.
- Intraoperative neurophysiologic monitors can be used to guide the actual resection of the epileptogenic focus, and general anesthetics can compromise the sensitivity of these devices.

Specific for neurosurgical cases

Acute head injury

- Intracranial hematoma, diffuse axonal injury and edema.
- Autoregulation and intracranial compliance may be impaired.
- The anesthetic technique should aim to avoid further increases in ICP and minimize secondary brain injury.

Specific for neurosurgical cases

Congenital spinal lesions

- The most common are lumbosacral meningoceles
- The majority of meningomyelocele cases have an associated Arnold–Chiari malformation
- Closure of a myelomeningocele or encephalocele presents special problems → Positioning the patient for tracheal intubation may rupture the membranes.
- Latex: children with myelodysplasia have an increased risk of latex allergy
- Blood loss

Table 2

The Chiari malformations.[4] Reproduced with permission from Elsevier Publishing

Chiari Type 1	
	Tonsillar herniation >5 mm below the plane of foramen magnum
	No associated brainstem herniation or supratentorial anomalies
	Low frequency of hydrocephalus
Chiari Type II	
	Caudal herniation of the vermis, brainstem and fourth ventricle
	Associated with myelomeningocele and multiple brain anomalies
	High frequency of hydrocephalus and syringohydromyelia
Chiari Type III	
	Occipital encephalocele containing dysmorphic cerebellar and brainstem tissue
Chiari Type IV	
	Hypoplasia or aplasia of the cerebellum

- *Continuing Education in Anaesthesia Critical Care & Pain*, pediatric neuroanesthesia, Volume 10, Issue 6, 1 December 2010, Pages 172–176


Thank you

- Brain and spinal cord tumors
- Chiari malformations
- Congenital abnormalities of the nervous system
- Craniosynostosis and other craniofacial abnormalities
- Epilepsy
- Head & spine trauma
- Hydrocephalus
- Infections of the nervous system
- Spasticity & other movement disorders
- Spinal Anomalies, including tethered cord and other congenital malformations
- Vascular lesions