BASIC CONCEPT ON PEDIATRIC NEUROANESTHESIA

INASNACC

- Newborn period is the first 24 hours of life.
- Neonatal period is the first 30 days of life and includes the newborn period.
- Infant is less than 1 year age.
- Child is 1-16 year age.

The most significant transition occurs within the first 24-72 hours after birth. All system change, but the most important for anesthesiologist are the CNS, circulatory, respiratory, and renal system.

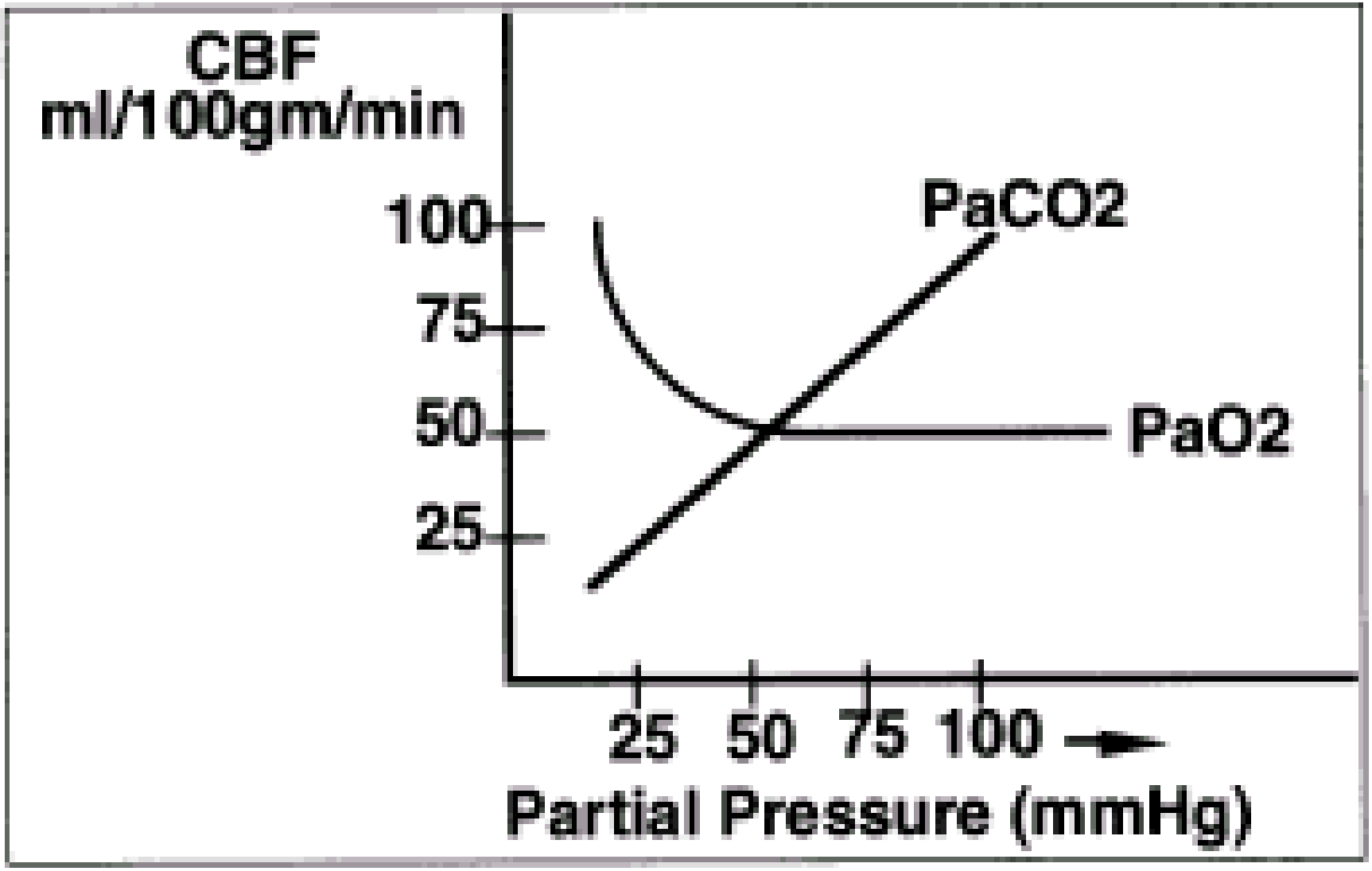
Intracranial Physiology

- The development of CNS is incomplete at birth, maturation continu until 1 year.
- CBF affect CBV, intracranial volume, and, in turn ICP.
- Autoregulation in the newborn is easily impaired or abolished.
- Under normal condition, ICP (normal 2-4 mmHg) depend more on CBF and CBV than on CSF production. All inhalation anesthetic must be used with care.

CBF, CBV, CMRO2

Age-realted variations of CBF and $CMRO_2$

	CBF ml/100g/min	$CMRO_2$ ml O_2/100g/min
Neonate	40-42	2,3 (general anesthesia)
6-40 months	90	-
3-12 years	100	5,2
adult	50	3,4



Linear variation of CBF with $PaCO_2$

Anesthetic requirement

- Vary with age and maturity. Neonate and premature infant have decreased anesthetic requirements relative to older children. Causes by: immaturity CNS, presence of maternal progesterone, elevated level of endorphins, immaturity of BBB.
- Neonate do sense pain and can develp a stress respons to surgical stimuli. They therefore require adequate levels of anesthesia to blunt the stress response.

Anesthetic requirement

- Since all anesthetic inhalation produce cerebral vasodilatation and increase CBV, they must use with great caution.
- The choice of anesthetics depend on knowledge and experience of anesthesiologist, condition of patient, nature of surgical procedure.
- Rapid induction.

Anesthetic requirement

- The causes of rapid induction are ratio alveolar ventilation to FRC is 5:1 (in adult 1,5:1), greater cardiac output, lower blood-gas partition coefficient.
- Induction of inhalational anesthetic agent is very rapid and may cause hypotension → hazardous in the premature, small for gestational age, unstable patient, and child who requires rapid airway control.
- Most neonate do well with iv anesthetics, narcotics, relaxants.

General anesthetic consideration

- Preoperative evaluation
- Premedication
- Induction of anesthesia
- Maintenance of anesthesia
- Emergence of anesthesia
- Post operative period

Pre operative assessment

- Clinical presentation of neurological dysfunction varies with the age.
- Neonates might present history of irritability, lethargy, failure to feed, enlarging head circumference, bulging fontanelle, lower extremity deficits.
- Older children might have headache, nausea, vomiting, or change in the level of alertness.
- Assessment of any fluid and electrolyte imbalance from of lack of intake or active vomiting.

Preoperative fasting

- Infant and children posses several risk factors that predispose them to aspiration : shorter esophagus, higher resting intragastric pressure, incoordination of neonatal breathing and swallowing.
- 2-4-6-8 rule of preoperative fasting.

Fluid balance

- Evaluation include assessing any fluid and electrolyte imbalance from lack of intake and active vomiting.
- Normal saline may be used because slightly hyperosmoler to plasma.
- Two large bore iv catheter necessary for craniotomy, craniofacial reconstruction or extensive spinal procedures

Administration of glucose

- Determined by intraoprative measurement of blood glucose.The automatic addition not necessery because hypoglycemia may not be a common occurence, even in infant < 1 year.
- Solutions containing 1-2,5% glucose, 2-5 mg/kg/minute.
- Monitoring blood glucose level necessery during long procedure, prolong preoperative fasting, neonate and small infant, infant of diabetic mother, infant who have intrauterine growth retardation, children who are small for their age, receiving extensive blood product, hypopituitarism, adrenal insufisiency, pancreatic islet cell adenoma, large hepatoma.

premedication

- The routine use of sedation in pediatric neurosurgical patient with increased ICP is best avoided unless administered in constant presence of the anesthesiologist.
- Patient with ICP normal may be sedated to control preoperative anxiety and avoid hypertension and rupture of the vascular abnormality.

monitoring

- Depend on the patient age and condition and the planned surgical procedure.
- Routine monitoring include the use of precordial stethoscope, ECG, pulse oximeter, EtCO2, non invasive BP, oesophageal stethoscope, temperature, TOF, urinary catheter.
- Direct BP monitor, CVP, ICP, SJO2.

Inhalation anesthetics

- Inhalation anesthetic affect MAP, ICP and CPP.
- At 0.5-1 MAC Sevo, Iso, Des in 60% N2O increase ICP and decrease MAP and CPP.
- Desfluran may increase ICP to a greater extent whose ICP is elevated preoperatively.
- Because the effect of change in MAP on CPP is 3-4 times geater than the effect of a change in ICP, maintaining MAP is the more important.

VAE

- VAE commonly occurs during craniotomy in infant.
- Pressure within superior sagital sinus decrease as the head is elevated, increasing the likelihood VAE.
- Patient with PDA or foramen ovale at risk for paradoxical air embolism.
- Because VAE has occured in the sitting, prone and supine position, the use of N2O should be avoided.

Temperature regulation

- Because hypothermia is an issue in infant and small children, they require active heating by elevating room temperature, using warm-air blanket, humidification of inspired gas and warming intravenous fluid.

Positioning

- Extreme rotation of the head can also limit venous return through the jugular vein, increasing ICP, impairing CPP, and causing bleeding from cerebral vein.

Emergence

- The goal is prompt awakening to aid early assessment of neurologic function, hemodynamic stability, minimal coughing or straining to avoid intracranial hypertension and bleeding.
- Extubation after the patient respons to command or when infant open their eyes.
- The other extubated patient stil deeply anesthetized.
- Patient delayed awakening → CT scan

Postoperative Care

- Respiratory dysfunction occurs frequently after posterior fossa craniectomy.
- SIADH after hypothalamus or pituitary gland operative.
- When children require sedation, administered propofol not recommended because there have been report about Propofol infuse syndrome (metabolic acidosis, lactic acidemia, bradyarrhythmias). Infusion propofol not longer than 5 days.

The differences of SIADH, DI, and CSW

Criteria	SIADH	DI	CSW
Intravascular volum	Increased	Decreased	Decreased
Na serum	Decreased	Increased	Decreased
Urine	Increase Na urine (> 20 meq/L)	Polyuria, low urine osmolarity	Polyuria, high Na urine (>50 meq/L)
Therapy	Fluids restriction, NaCl hypertonic + furosemid	Add volume with NaCl 0.0225% or NaCl 0.45%	Add volume with NaCl 0.9%

The Cases:

- Hydrocephalus
- Tumors
- Head Injury
- Meningoencephalocele

Hydrocephalus

- Enlargement of the ventricles from increased production of CSF, decreased absorption, or obstruction of the pathway.
- Classified as communicating (non obstructive) or non communicating (obstructive).
- The cause can be congenital or acquired.

Hydrocephalus…..(2)

- Causes an increase in the head circumference. Prevention any further increase is vital→ to avoid herniation.
- Drainage of CSF : ventricular arrhythmias may be associated with rapid removal of CSF.
- Sudden reduction in ICP → epidural or subdural hemorrhage → can cause a change in the level of consciousness although the shunt is functioning.

Surgical procedures

- VP (Ventriculo-peritoneal) shunt
- VA (Ventriculo-atrial) shunt.
- Ventriculo-pleural shunt
- Ventriculo-jugular shunt.
- Ventriculostomy

Preoperative management

- Asses for any effects of increased ICP such as nausea, vomiting, change in ventilatory pattern, irritability, decreased of level of consciousness, bradycardia, hypertension).
- CT scan : increased in the size of ventricle
- Premedication: sedation is contraindicated
- Use EMLA for vein access.

V-P shunt and AV shunt

- Anesthesia: intravenous or inhalation induction.
- Muscle relaxation is maintained throughout the procedure.
- Extubation when the patient fully awake.

Intracranial SOL

- Preoperative consideration : sign and symptom of increased ICP, cranial nerve dysfunction, definite neurological deficits.
- Anesthetic consideration: presence seizure must identified, CT scan, MRI, placement ventriculostomy or shunt before definitive operation. Dexamethasone to reduce peritumor edema, mannitol, furosemide.

Meningo encephalocele

- Embryologic neural tube fusion take place during the first month of gestation.
- Failure to fusion causes herniation of the meninges (meningocele) or element of neural tube (myelomeningocele). Abnormality occurring at the level of the head is referred to as encephalocele.
- Defects arising at higher level in the spine can produce bowel, bladder, an lower extremity dysfunction.

Head Injury : Incidence

- Nearly 200 every 100,000 children sustain head injury annually.
- approximately 10 every 100,000 children die from head trauma.
- 15% children 5-15 year age group die from head trauma.
- Head injuries are the leading cause of death and disability in children

Gopinath SP et al. In. Cottrell JE, eds.Anesth and Neurosurg 2004

Paut O et al. 4th European Congress of Ped Anes 1977

GCS (*Glasgow Coma Scale*) and PCS (*Paediatric Coma Scale*)

	GCS		PCS	
Eye opening	Spontaneous To verbal stimuli To pain None	4 3 2 1	Ditto	
Verbal	Oriented Confused Inappropriate words Non specific sounds None	5 4 3 2 1	Oriented Words Vocal sounds Cries None	5 4 3 2 1
Motor	Follows commands Localises pain Withdraws in response to pain Flexion in response to pain Extension in response to pain None	6 5 4 3 2 1	Ditto	

Treatment of Head trauma

- Monitoring
- Maintenance of a correct haemodynamic state.
- Prevention of hypercarbia and hypoxia
- Prevention and control of intracranial hypertension crisis
  - Medical treatment
  - neurosurgery

Monitoring

- Monitoring ICP if GCS≤8 or motor score of one or two,head injury with multiple injury, intracranial hypertension on CT Scan.
- CPP and SjO2:
  - high SjO2 (>75%) correspond to a high CBF or low CMR02.
  - Low SjO2 (<50%) indicate cerebral ischemia due to a low CPP (systemic hypotension, intracranial hypertension), hypocarbia, hypoxemia, vasospasm

Prevention of hypercarbia and hypoxia

- Is the paramount importance.
- To reach normal PaO2, because if PaO2 fall below 50 mmHg, CBF will increase dramatically.
- Hypercarbia is a frequent complication will increase CBF.

Pathophysiology of ICP

- Complications of elevated ICP
- Fluid management
- Diuretics to reduce ICP

Anesthetic considerations

- Resuscitation and stabilization (ABC)
- Neurologic status
- Associated injury
- Full stomach
- Age related pathophysiology
- Neuroanesthesia drugs club.

Pre-operative evaluation : Neurological status

- Recognition of intracranial hypertension and major neurological deficits.
- Sign and symptom of increased ICP differ somewhat according to age group. Neonate and infant : increased irritability, poor feeding, or lethargy, full fontanele, cranial enlargement or deformity, lower extremity motor deficits.
- Early childhood:double vision, difficulty speaking or swallowing.

Induction and intubation

- Intubation must be accomplished with minimal manipulation of cervical spine.
- Provide suitable anesthesia, reducing hemodynamic stress and rise in ICP that occurs during laryngoscopy-intubation.
- Ketamine contraindication in patient with closed head injury.
- Etomidate are appropriate if hemodynamic unstable. Pentothal if stable cardiovascular status.

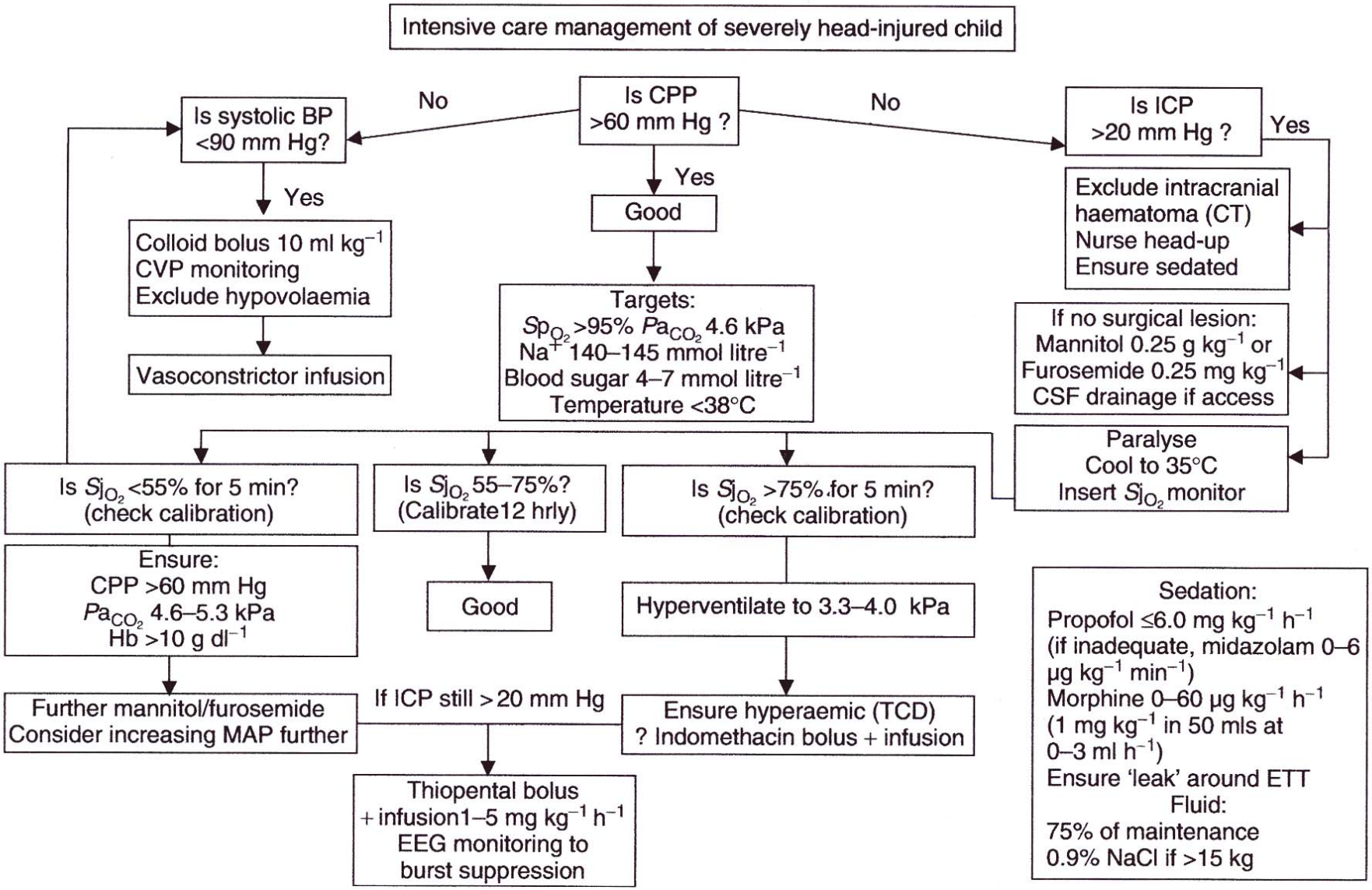
Induction of anesthesia

- Rapid control of the airway with hyperventilation to reduce CBF and then ICP.
- Avoid of systemic hypertension associated with laryngoscopy-intubation.
- Reduce possibility of aspiration
- Technique: barbiturate, lidocaine, muscle relaxant.
- Without vein access→ inhalation induction.

Clinical management of the Pediatric Airway

- Intubation with minimal manipulation of cervical spine, the neck must be stabilized.
- An awake intubation is rarely feasible→provide suitable anesthesia, reducing hemodynamic stress and rise in ICP during laryngoscopy and intubation.
- Ketamin contraindicated in patient with head injury. Small dose of etomidate, propofol or pentothal more suitable.

Postoperative Care (Clayton TJ. Br.J Anaesth 2004;93:761-7



Summary and conclusions

- Children present with their own unique responses to injury, including cerebral hyperemia, cervical spine disruption, and specific extracranial injury.
- Must able to secure airway, establish intravenous access, initiate fluid resuscitation, and begin therapy for intracranial hypertension.
- Choice of anesthetic agent must be able to maintain autoregulation, CO_2 response

Thank you very much