# Neuroanesthesia In Pediatrics

***Essay***

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***In Anesthesiology***


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# List of contents

# List of Figures

# List of Tables

# List of Abbreviation

| | |
|---|---|
| MAc | Minimal alveolar concentration |
| BBB | Blood Brian Barrier |
| BPM | Beat Per Minute |
| BPS | Systolic Blood Pressure |
| CBF | Cerebral blood flow |
| $CMRO_2$ | cerebral metabolic requirement for oxygen |
| CNS | Central Nervous System |
| CPP | Cerebral perfusion pressure |
| CRAO | Central retinal artery occlusion |
| CSF | cerebrospinal fluid |
| CVP | Central venous pressure |
| ECG | Electrocardiography |
| EEG | Electroencephalography |
| GCS | Glasgow Coma Score |
| HR | Heart Rate |
| ICp | Intracranial pressure |
| IM | Intramuscular |
| IV | Intravenous |
| MAP | Mean arterial pressure |
| MEP | motor evoked potential |
| NMDA | N-methyl D-aspartate receptors |
| $PaCO_2$ | Arterial carbon dioxide tension |
| PaCU | Postanethetic Care Unit |
| $PaO_2$ | Arterial oxygen tension |
| peep | Positive end expiratory pressure |
| PICU | Pediatric Intensive Care Unit |
| PONV | Postoperative Nausea and Vomiting |
| POV | Postoperative Vomiting |
| RR | Respiratory Rate. |
| SBI | Secondary Brain Insult. |
| $SjVO_2$ | Jugular venous oxygen saturation. |

# List of Abbreviation (Cont.)

| | |
|---|---|
| SSEP | Somatosensory Evoked potential. |
| TBI | Traumatic brain injury. |
| TCD | transcranial Doppler sonography |
| V/Q ratio | Ventilation /perfusion ratio |
| VAE | Venous air embolism |
| VPS | Ventriculo-peritoneal Shunt |

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# Introduction

Pediatric neuroanesthesia can be seen as a specific branch of anesthesia half way in between pediatric anesthesia and neuroanesthesia. As a matter of fact, we must keep well in mind the peculiarities of the pediatric patient and the different pharmadynamic and pharmacokinetic properties of the anesthetic drugs, particularly in neonates and infants **(Pietrini D, et al., 2003).**

The perioperative management of pediatric neurosurgical patients presents many challenges to neurosurgeons and anesthesiologists. Many conditions are unique to pediatrics. A basic understanding of age-dependent variables and the interaction of anesthetic and surgical procedures are essential in minimizing perioperative morbidity and mortality (**Soriano SG, et al., 2002**).

Recent advances in pediatric neurosurgery have drastically improved the outcome in infants and children afflicted with surgical lesions of the central nervous system (CNS). Because most of these techniques were first applied to adults, the physiologic and developmental differences that are inherent in pediatric patients present challenges to neurosurgeons and anesthesiologist (**Soriano SG, et al., 2007**).

# Aim of the work

The purpose of this essay is to attain knowledge about the anesthetic management of pediatric neurosurgery patient and to choose and perform an appropriate anesthetic techniques, throughout surgical procedures and postoperative care.

## Introduction about developmental considerations:

Age-dependent differences in cerebrovascular physiology and cranial bone development influence the approach to the pediatric neurosurgical patient. Cerebral blood flow is coupled tightly to metabolic demand, and both increase proportionally immediately after birth. Estimates from animal studies place the autoregulatory range of blood pressure in a normal newborn between 20 and 60 mmHg. This range is consistent with relatively low cerebral metabolic requirements and low blood pressure during the perinatal period. More importantly, the slope of the autoregulatory slope drops and rises significantly at the lower and upper limits of the curve, respectively. This narrow range, with sudden hypotension and hypertension at either end of the autoregulatory curve, places the neonate at risk for cerebral ischemia and intraventricular hemorrhage, respectively **(Pryds O, 1991)**.

Another developmental difference between adults and pediatric patients is the larger percentage of cardiac output that is directed to the brain, because 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. The infant cranial vault is also in a state of flux. Open fontanels and cranial sutures lead to a compliant intracranial space. The mass effect of a tumor or hemorrhage are often masked by a compensatory increase in the intracranial volume through the fontanels and sutures. As a result, infants presenting with signs and symptoms of intracranial hypertension have fairly advanced pathology **(Pryds O, 1991).**

# Neuroanatomy:-

- **Skull and Brain:**

The infant's brain grows rapidly, it doubles in size in the first year and reaches 80%of adult weight by the age of 2. Brain weight at birth represents a larger percent of total body weight than in the adult (10%versus 2%), and a proportionally larger part of the cardiac output is directed to the brain. The infant skull sutures are not fused, the fontanelles are open until the age 2 to 3 months (anterior) and 7to 19 months (posterior), open fontanelles allow for non invasive assessment of intra cranial pressure (ICP) and ultrasound imaging of intracranial structures. A bulging fontanelle suggests elevated ICP. The skull bones grow in response to increases in intracranial volume, children with untreated progressive hydrocephalus can have very large heads **(Bisonette B, et al., 2002)**.

- **Spinal cord:**

The anatomic position of the spinal cord is age related. In infants, the end of the spinal cord is at the level of L3 cauded to the adult position opposite the L1-2disk. Spinal cord migration is hindered in children with a tethered cord who develop proggrssive neurologic defecits (bladder and bowel dysfunction and sensory loss) without surgical correction. A midline dimple over the spine above the gluteal fold may signal a tethered cord in the asymptomatic child and an increased risk of neurologic injury with regional anesthesia or diagnostic lumbar puncture **(Soriano SG et al., 2002).**

- **Cerebral blood flow and metabolism:**

Cerebral metabolism and cerebral blood flow (CBF) are age-related (40 and 100ml/100 gm brain tissue/min in neonates and children respectively), Global cerebral blood flow(indexed to weight of brain tissue) is lower in neonates than adults and higher in children than adults (Fig. 1). Similary compared with adults, brain oxygen and glucose utilization are lower in neonates and higher in children. In neonates, autoregulation of CBF occurs at lower absolute pressures and over a narrow range of blood pressures. A linear relationship between the upper limit of autoregulation and postconceptual age was shown in a study of healthy neonates, with the upper limit between 45 and 60mmHg at 33 to 35 weeks postconceptual age and at 100mmHg at 47 weeks. Experimental evidence suggests that the mechanisms that regulate CBF and autoregulation also vary as a function of age **(Valvilala MS, et al., 2003).**

**Factors that influence cerebral blood flow and intracranial pressure (ICP):-**

***A) Blood gases :***

A high $PCO_2$ is the most potent stimulator of cerebral blood flow (C.B.F) **(RammohanN, 2007).**

While C.B.F is not affected until $PO_2$ decreases to about 50 mmHg, beyond this, cerebral vasodilation occurs. Hypoxia and hypercarbia produce a synergistic effect to produce a marked increase in C.B.F. and therefore cerebral blood volume as shown in (Fig. 2) **(Clayton T &Manara A, 2008).**

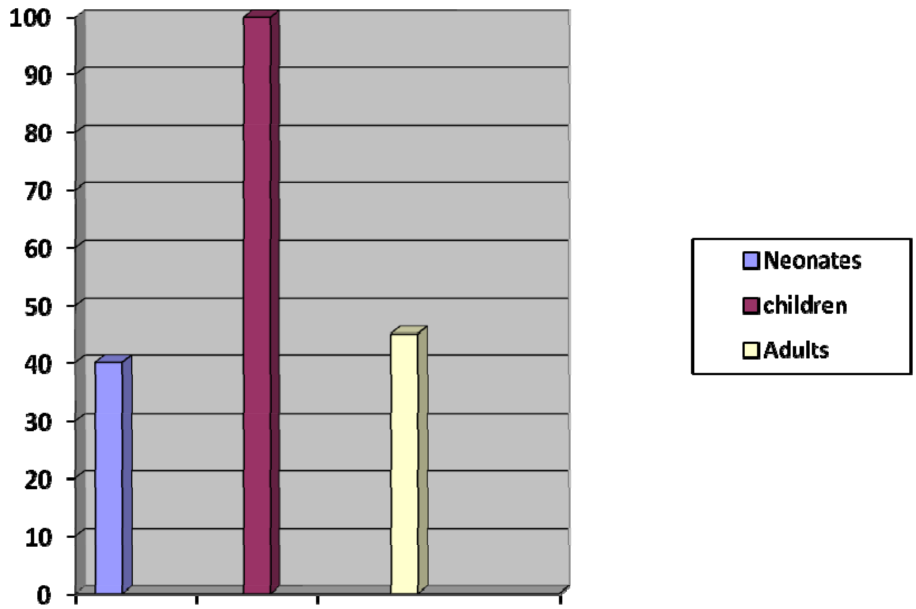


**Fig.(1):** Age related difference in global cerebral blood flow (ml/100g/min) **(Faillace WJ, 2002).**

***B) Blood pressure*** *:*

Normally, cerebral autoregulation keeps flow steady despite variations in blood pressure. Sudden increase in blood pressure can raise C.B.F. The most common stimuli are laryngoscopy and intubation, suctioning and skeletal fixation of the head, which must be considered during perioperative visits. Wide fluctuations in blood pressure are poorly tolerated **(Rammohan N, 2007).**

**C) Venous pressure**:

Increase in central venous pressure is directly transmitted to the intracranial cavity and so increase the ICP This can be harmful if there is:

1) Coughing and straining on the endotracheal tube.
2) Flexion of the neck, producing kinking of the neck veins.
3) A head position in which the head hangs too low

**(Rammohan N, 2007).**

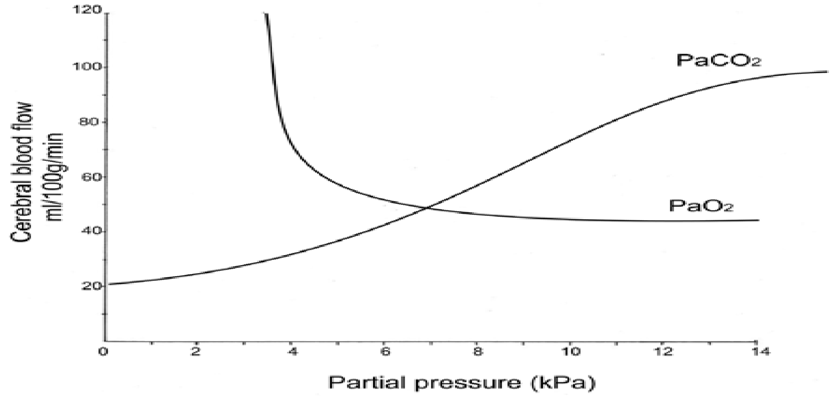


**Fig. (2):**The effect of changes in $PaCO_2$ and $PaO_2$ on cerebral blood flow **(Clayton T &Manara A, 2008).**

**D) Anesthetic agents:**

Both anesthetic techniques and agents greatly influence the I.C.P curve by their effect on intracranial blood volume, which is affected through change in blood flow **(Reza G, 2007).**

Most intravenous (IV) anesthetic agents reduce neuronal activity and so reduce the brain cerebral metabolic requirement for oxygen ($CMRO_2$) as shown in Fig. (3). They provide a protective mechanism when oxygen demand may outweigh supply (S**tanley B & Norfolk M, 2008).**

All inhalation agents are cerebral vasodilators causing increase in intracranial blood volume and ultimately I.C.P **(Reza G, 2007).**

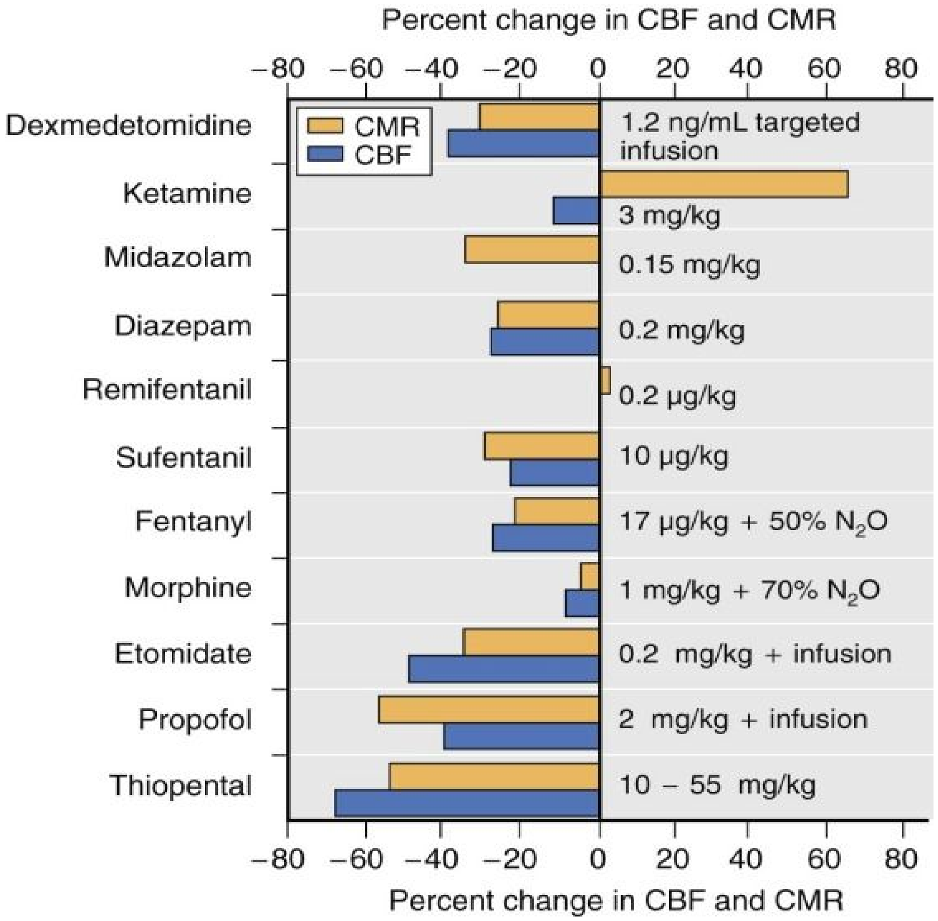


**Fig.(3):** Change in cerebral blood flow and cerebral metabolic rate of oxygen caused by intravenous anesthetics **(Drummond JC, et al, 2008).**

## Pressure Volume Relationships :-

The cranial cavity is a semi-closed, non-distensable cavity containing brain and water (80%), blood (12%) and CSF (8%); as change in the volume of any one will require acute changes in the other two to avoid sudden shifts in pressure **(Reza G, 2007).**

Pathophysiological consequences of injury depend upon the speed of onset and efficiency of the compensatory