Introduction

Neurosurgical pediatric patients are very major specific cases and obstacles for the anesthetist which require intensive and special considerations. Some of the these obstacles are related to the physiological changes in pediatric patients added to disorders produced by neurosurgical disease and others to the cerebral insult of anesthetic drugs, which produce major alterations in the cerebral and cerebrovasculer function in ways that may be beneficial or deleterious ***(Turner, 2011).***

Other obstacles are presented by the special requirement by the neurosurgeon, surgical position, and positioning aids; the intentions with respect to the use of steroids, anticonvulsants, and antibiotics; the surgeons perception of the "tightness" of the intracranial space and the remaining intracranial compliance reserve; the appropriate objectives for the management of blood pressure, CO_2 tension, body temperature; the anticipated blood loss; the intended use of neurophysiologic monitoring (which may impose constraints on the use of anesthetic agents and /or on the use of muscle relaxants); brain protection and occasionally the perceived risk of air embolism ***(Domino and Krone, 2012).***

The practice of anesthesia for pediatric neurosurgery encompasses the skills and knowledge of pediatric anesthesiology as well as the knowledge of cerebral pathophysiology to provide optimal neuroanesthetic management and neurologic intensive care, the anesthesiologist must understand the physiology of central nervous system, the effects of drugs on cerebral hemodynamics, and the physiology of developing child ***(Domino and Krove, 2012).***

Aim of the Work

The aim of this subject is to highlight the updates in the management of common situations in anesthesia for pediatric neurosurgery.

Chapter (1):
Anatomical and Physiological Consideration of Pediatric Patients

A- Anatomical Consideration:

Anatomy of pediatric differs from that of adult in many aspects. The head which is larger than chest circumference at birth (35 cm in circumference). Head circumference increases by 10 cm during the first year and 2-3 cm during the second year, when it reaches three fourth adult size ***(Etsuro, 2011).***

At full time birth infant has a short neck and a chain that often meets the chest at level of second rib; these infants are prone to upper air way obstruction during sleep. In infant with tracheostomy, the orifice is often buried under the chain unless the head is extended with a roll under the neck. In addition, infants are more prone to upper airway obstruction under anesthesia or sedation because upper airway muscles, which normally support the airway patency, are disproportionately sensitive to the depressant effect of anesthesia and sedation, resulting in pharyngeal airway collapse and obstruction ***(Etsuro, 2011).***

The chest is relatively small in relation to the abdomen, which is protuberant with weak abdominal muscles ***(Etsuro, 2011).***

Arms and legs are short poorly developed. Poor development of body support by bone and muscle together with disproportion creates problems in positioning of child in surgery. In the prone position the shoulders are too small to give adequate support despite attempts to build them up with rolls underneath both shoulders, by there keeping the thorax and abdomen free for adequate ventilation (***Etsuro, 2011).*** Occasionally, when the child must sit up for a craniotomy, special attention is needed to secure the head carefully, because the neck is a very week for the heavy head ***(Etsuro, 2011).***

Several anatomic differences make respiration less efficient in infants. The small diameter of the airways increases resistance to airflow, resistance is inversely proportional to the radius raised to the fourth power for laminar flow and to the fifth power for turbulent flow. The airway of infants is highly compliant and poorly supported by surrounding structures. The chest wall is also highly compliant, so the ribs provide little support for the lungs; that is, negative intrathoracic pressure is poorly maintained. Thus, each breath is accompanied by functional airway closure ***(Keen et al., 1978).***

Another important factor is the composition of the diaphragmatic and intercostal muscles, These muscles do not achieve the adult configuration of type I muscle fibers until the child is approximately 2 years old ***(Keen et al., 1978).***

Because type I muscle fibers provide the ability to perform repeated exercise, any factor that increases the work of breathing contributes to early fatigue of the respiratory muscles of infants. These differences partially explain the infant's high respiratory rate, the rapidity with which hemoglobin desaturation occurs, and their propensity for fatigue and apnea ***(Keen et al., 1978).***

Differences in airway anatomy make the potential for technical airway difficulties greater in infants than in teenagers or adults.The airway of infants differs in five ways ***(Bansal & Hooda, 2013).***

- The relatively large size of the infants' tongue in relation to oropharynx increases the likelihood of airway obstruction and technical difficulties during laryngoscopy.
- The larynx is located higher in the neck (at a level of C4 versus C6 in adults) thus making straight blades more useful than curved blades.
- Epiglottis is shaped differently, being short and stubby and is angled over the laryngeal inlet; control with the laryngoscope blade is therefore more difficult.
- The vocal cords are angled, so a blindly passed endotracheal tube may easily lodge in the anterior commissure rather than slide into the trachea
- The infant larynx is funnel shaped, the narrowest portion occurring at the cricoid cartilage. In adults, an endotracheal tube that passes the vocal cords will readily pass into the trachea because the glottic opening is the narrowest portion of the larynx ***(Bansal and Hooda, 2013).***

Figure (1): Morphologic changes of the supraglottic structures Endoscopic views of the supraglottic larynx. The supraglottic area of a neonate has larger ventricular bands, larger arytenoids, and a shorter epiglottis, which is frequently U or Ω (omega) shaped ***(Fayoux and Marciniak, 2011)***

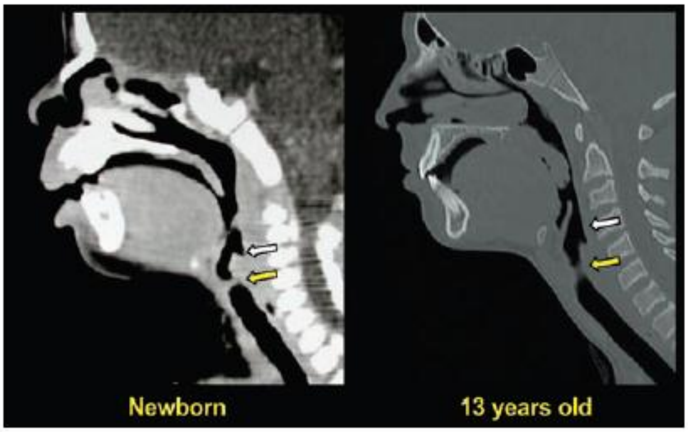

Figure (2): Maturational descent of the larynx. The maturational descent of the larynx is shown on parasagittal CT images. In the newborn, the hyoid lies opposite the junction between C2 and C3, and the glottis lies opposite the junction between C3 and C4. After 2 years of age, the hyoid and larynx have attained their adult position relative to the cervical vertebrae, as illustrated by this 13-year-old patient. The hyoid body projects opposite the junction between C3 and C4 and the glottis is opposite C5 ***(Fayoux and Marciniak, 2011)***

In infants or young children, an endotracheal tube that easily passes the vocal cords may be tight in the subglottic region because of narrowing at the cricoid cartilage. For this reason, uncuffed endotracheal tubes are usually preferred for patients younger than 6 years ***(Bernet et al., 2005).***

These differences i.e. the large head and tongue, mobile epiglottis and anterior position of the larynx, characteristic of neonates, makes the tracheal intubation easier with neonates head in a neutral or slightly flexed position than with the head hyperextended ***(Bansal & Hooda, 2013).***

Infants have often been described as obligate nasal breathers; however 8% of premature neonates and 40% of term newborns can convert to oral breathing in the presence of nasal airway obstruction. Almost all infants can easily convert to oral breathing by 5 months of age. Most infants can convert to oral breathing if the obstruction lasts more than 15 seconds ***(Bansal & Hooda, 2013).***

B- Phsiologic differences:

Physiologic differences between children and adults are important determinants when planning management of anesthesia in pediatric patients. Monitoring vital signs and organ function during the perioperative period is especially important, as neonates and infants have decreased physiologic reserves ***(Bansal & Hooda, 2013).***

Respiratory system:

The single most important difference that physiologically distinguishes pediatric patients from adults is oxygen consumption. Oxygen consumption of neonates is more than 6 ml/kg which is about twice that of adults on a weight basis. To satisfy this high demand alveolar ventilation is doubled compared with that in adults. Because the tidal volume on a weight basis is similar for infants and adults, the increased alveolar ventilation is accomplished by an increased breathing rate ***(Hines & Marschall, 2004).***

Cardiovascular system:

At birth a number of events change hemodynamic interactions such that the fetal circulation becomes an adult type circulation (***Rudolph*, 1970).**

Specifically, the placenta is removed from the circulation; portal blood pressure falls which causes the ductus venosus to close and blood becomes oxygenated through the lungs and exposure of the ductus arteriosus to oxygenated blood induces ductal closure ***(Bansal & Hooda, 2013).***

As a result of the combined effects of lung expansion, exposure of blood to oxygen and loss of low resistance through placental blood flow, pulmonary vascular resistance decreases while peripheral vascular resistance rises rapidly, An increase in pressure on the left side of the heart (caused by the rise in peripheral vascular resistance) induces mechanical closure of the foramen ovale ***(Bansal & Hooda, 2013).***

Thus all three connections between the right and left side of the circulation close, Although closure of the ductus arteriosus probably occurs primarily in response to a rise in arterial oxygen concentration, its successful completion requires arterial muscular tissue ***(Miller's, 2004).***

Many factors (hypoxia, hypercarbia and anesthesia induced changes in peripheral vascular tone) can affect this precarious balance and result in a sudden return to fetal circulation, When such a flip flop occurs, pulmonary artery pressure increases to systemic levels, blood is shunted past the lungs through patent foramen ovale and the ductus arteriosus may reopen and allow blood to shunt at the ductal level. This explains why hypoxemic events in infants are often prolonged despite adequate pulmonary ventilation with 100% oxygen ***(Bansal & Hooda, 2013).***

Risk factors increasing the likelihood of a prolonged transitional circulation include prematurity, infection, acidosis, hypoxia, hypercarbia, acidosis, hypothermia and congenital heart disease, Care must be directed to keep the infant warm, maintaining normal arterial oxygen and carbon dioxide tension and minimizing anesthetic induced myocardial depression ***(Miller's, 2004).***

Distribution of body water:

At birth total body water constitutes 80% of body weight, but it falls dramatically to around 60% by the end of the first year, Total body water content and extracellular fluid volume are increased proportionately in neonates ***(Bansal & Hooda, 2013).***

The extracellular fluid volume is equivalent to about 40% of body weight in neonates compared with about 20% in adults, By 18 to 24 months of age, the proportion of ECF volume relative to body weight is similar to that in adults. The increased metabolic rate characteristic of neonates results in accelerated turn overs of ECF and dictates meticulous attention to intraoperative fluid replacement ***(Sieber et al., 1987).***

Intra operative fluid replacement often includes glucose although the clinical impression that pediatric patients are more susceptible than adults to hypoglycemia during fasting periods has been challenged ***(Leelanukrom & Cunliffee, 2000).***

Renal function:

Renal function is markedly diminished in neonates and further diminished in preterm babies because of low perfusion pressure and immature glomerular and tubular function. Nearly complete maturation of glomerular filtration and tubular function occurs by approximately 20 weeks after birth, although maturation is somewhat delayed in premature infants. Complete maturation of renal function occurs by about 2 years of age ***(Leake et al., 1977).***

Thus the ability to handle free water and soluble loads may be impaired in neonates and the half life of medications excreted by means of glomerular filtration will be prolonged ***(Alcorn & Mc Namara, 2002).***

Neonates are obligate sodium losers and cannot concentrate urine as effectively as adults. Therefore, adequate exogenous sodium and water must be provided during the perioperative period ***(Bansal & Hooda, 2013).***

Conversely, neonates are likely to excrete volume loads more slowly than adults and are therefore more susceptible to fluid overload ***(Bansal & Hooda, 2013).***

Premature neonates often possess multiple renal defects, including decreased creatinine clearance, impaired sodium retention, glucose excretion and bicarbonate reabsorption; and poor diluting and concentrating ability. These abnormalities increase the importance of meticulous attention to fluid administration in the early days of life ***(Bansal & Hooda, 2013).***

Hematology:

Characteristics of fetal hemoglobin (HbF) influence oxygen transport, For example, HbF has a P50 of 19 mm Hg compared with 26 mm Hg for adults, which result in a leftward shift of the fetal oxyhemoglobin dissociation curve. Subsequent increased affinity of hemoglobin for oxygen manifests as decreased oxygen release to peripheral tissues ***(Bansal & Hooda, 2013).***

After 3 months there are progressive increases in erythrocyte mass and hematocrit, By 4 to 6 months, the oxyhemoglobin dissociation curve approximates that of adults,In view of the decreased cardiovascular reserve of neonates and the leftward shift of the oxyhemoglobin dissociation curve, it may be useful to maintain the neonate’s hematocrit closer to 40% than 30% as is often accepted for older children ***(Bansal & Hooda, 2013).***

Calculation of estimated erythrocyte mass and the acceptable erythrocyte loss provides a useful guide for intraoperative blood replacement, Average blood volume varies from 80 to 90 ml kg- 1 at birth. By 1 month of age, the blood volume varies between 70 and 80 mlkg-1 as in adult. The need for routine preoperative hemoglobin determination is controversial ***(Roy et al., 1991).***

Thermoregulation:

The infant is especially vulnerable to hypothermia because of both the large ratio of body surface area to weight and a limited ability to cope with cold stress ***(Bansal & Hooda, 2013).***

A premature infant even is more susceptible because of very thin skin and limited fat stores ***(Bansal & Hooda, 2013).***

This problem is compounded by cold operating rooms, wound exposure, intra venous fluid administration, dry anesthetic gases and the direct effect of anesthetic agents on temperature regulation ***(Bansal & Hooda, 2013).***

The infant may compensate by means of shivering and non shivering (cellular) thermogenesis. The minimal ability to shiver during the first three months of life makes cellular thermogenesis (metabolism of brown fat) the principle method of heat production ***(Bansal & Hooda, 2013).***

Metabolism of brown fat is severely limited in premature infants and in sick neonates who are deficient in fat stores. Brown fat is a specialized adipose tissue located in interscapular and vertebral areas and sorrounding the kidneys and adrenal glands ***(Bansal & Hooda, 2013).***

It is very important to address all aspects of possible heat loss during anesthesia, as well as during transport to and from the operating room, Heat lost by conduction is reduced by placing the baby on a warm mattress and warming the operating room ***(Bansal & Hooda, 2013).***

Heat lost through convection is minimized by keeping the infant in an incubator, covered with blankets. The head should also be covered, Heat lost through evaporation is lessened by humidification of inspired gases, the use of plastic wrap to decrease water loss through the skin and warming of skin disinfectant solutions. Hot air blankets are particularly useful ***(Bissonnette, 1992).***

Anesthesic agents can alter many thermoregulatory mechanisms, particularly non shivering thermogenesis in neonates ***(Plattner et al., 1997).***

Hypothermia is a serious problem that has been associated with delayed awakening from anesthesia, cardiac irritability, respiratory depression, increased pulmonary vascular resistance and altered drug responses ***(Dicker et al., 1995).***

Liver:

At term, the functional maturity of the liver is somewhat incomplete. Most enzyme systems for drug metabolism are developed but not yet induced (stimulated) by the drugs that