INTRODUCTION

Providing appropriate anesthesia care for pediatric patients during eye surgery requires basic understanding of intraocular pressure and its control, pharmacology of drugs used by ophthalmologist, and the potential for drug interaction with anesthesia ***(Gregory, 2002).***

Also, the anesthesiologist must be aware that several medical problems are associated with congenital eye anomalies and acquired pathology and many anesthetic drugs and procedures have profound effect on ocular physiology ***(Gregory, 2002).***

Frequently, however, children with uncommon diseases and congenital abnormalities have a disproportionate number of ophthalmic lesions requiring surgery. In formulating a preoperative anesthetic plan for any associated systemic abnormalities apart for the eye lesion ***(France et al., 1980)***.

AIM OF THE WORK

To unfold the different ways to anesthetize pediatric patients with congenital anomalies undergoing ophthalmic surgery.

ANATOMICAL AND PHYSIOLOGICAL CONSIDERATION OF PEDIATRICS

Anatomy of the pediatric airway

A detailed knowledge of the anatomy of the respiratory tract is of great importance to anesthetist as instrumentation of the airway is part of anesthetic daily routine requiring great familiarity with the structure involved. Many clinical problems that confront the anesthetist arise from compromised airway patency. The respiratory tract begins at the anterior nares and the lips while ending in the alveoli of the lung. It is divided into upper and lower airway at the level of the vocal cords ***(Roberts, 1998).***

The Mouth and oropharynx

In children and infants the mouth is small relative to the head. It is divided into the vestibule and the oral cavity. The oral cavity proper is separated from the vestibule by the teeth and gums. Maxillary teeth, especially if prominent, bucked or capped, can interfere with laryngoscopy and intubation ***(Benumof, 1996).***

The mouth cavity is bounded by the alveolar arch and teeth in front, the hard and soft palate above, the anterior two thirds of the tongue and the reflection of its mucosa forward into the mandible below, and oropharyngeal isthmus behind ***(Cote and Todres, 1985).***

The oropharynx opens to the oral cavity at the palatoglossal folds, marking the anterior two thirds of the tongue. The palatoglossal folds and the more posterior palatopharyngeal folds form the bilateral triangles, called the fauces that contain the tonsils. Hypertrophy of the tonsils and their confluence with the adjacent soft palate, uvula, and tongue base can challenge the anesthesiologist attempting mask ventilation or intubation ***(Ovassapian and Meyer, 1998).***

The nose

The nose is anatomically divided into external nose and nasal cavity. The external nose projects from the face, its skeleton is largely cartilaginous. The nasal cavity extends from nostrils (anterior nares) to the posterior end of the nasal septum where it opens into the nasopharynx through the posterior nasal apertures ***(Last, 1994).***

The nasal cavity is divided into the right and left halves by the midline nasal septum, each half of the cavity has a roof, floor, medial wall and lateral wall .The roof is the cribriform palate of ethmoid separating it from the cranial cavity. The floor is the hard palate separating it from the oral cavity. The medial wall is the nasal septum formed by septal cartilage anteriorly, vomer and perpendicular palate of ethmoid posteriorly. The lateral wall is irregular having three conchae (superior,middle, inferior) arching over three channels called superior, middle inferior respectively.

The inferior turbinate usually limits the size of the nasotracheal tube that can be passed through the nose. The vascular mucous membrane overlying the turbinate can be damaged easily, leading to profuse hemorrhage ***(Swift and Emery, 1983).***

The fragility of the nasal turbinates assures that intubation attempts will cause epistaxis, unless, the tube is guided parallel to the hard palate and perpendicular to the face through channel beneath the inferior turbinate ***(Ovassapian and Meyer, 1998).***

The adenoids are present on the roof and posterior wall of the nasopharynx. Attempting to pass nasotracheal tube may be prevented by the adenoids, become dislodged, obstruct the lumen of the tube, and be displaced into the larynx or cause severe bleeding ***(Swift and Emery, 1983).***

The pharynx

The pharynx extends from the base of skull down to the sixth cervical vertebra. The wall is formed mainly by the constrictor muscles (superior, middle and inferior) and fibrous tissue. Anatomically, the pharynx is divided into three parts, the nasopharynx, which lies behind the nasal cavity, the oropharynx, behind the oral cavity, and the laryngopahrynx, behind the larynx containing the inlet of the larynx and pyriform fossa on each side ***(Last, 1994).***

The larynx

The larynx consists of three single cartilages (epiglottis, thyroid and cricoid) and six smaller paired cartilages (arytenoids, corniculate and cuneiform) with their mucosal coverings shape the larynx ***(Alan et al., 2000).***

The larynx serves three important functions: it acts as an airway, it serves as an instrument of phonation, and protects the lower airway. It is the narrowest portion of the entire airway system and liable to obstruction ***(Fearon and Cotton, 1972).***

Early in first year of life the superior location of the larynx elevates the epiglottis approximately to the level of the palate and helps to explain obligate nasal breathing in this age group ***(Kirschner, 1993).***

The cricoid cartilage is a complete ring with its broad aspect posteriorly in infants and children. The cricoid ring forms the narrowest part of the pediatric airway (as opposed to the vocal cords in adult. This continues until 6 to 8 years of age. This anatomic narrowing both allows and necessitates the use of uncuffed endotracheal tubes in children ***(Alan et al., 2000)***.

The most anterior structure in the neck below the hyoid is the cricoid arch, for the thyroid prominent does not develop until teenage years. This is critical in determining the placement of a tracheostomy in pediatric patient, because the cricothryroid membrane is extremely small in the infant, therefore; cricothyroidectomy does not represent a feasible emergency procedure in the child with airway obstruction ***(Mc Gill, 1984).***

In pediatrics; the epiglottis is relatively long and stiff; it is U-shaped and projects at an angle of 45 degree above the glottis. Often, it must be elevated by the tip of the laryngoscope blade before the glottis can be seen; hence the use of a straight blade laryngoscope is recommended for infants and children ***(Steward and Lerman, 1995).***

The vocal cord (fig 1) appears as a pale white structure due to absence of a submucosa with network of blood vessels. The vocal cords are slanting giving the appearance of the funnel shape to the larynx. In adults, the larynx is cylindrical and the narrowest part of the upper airway is the rima glottis ***(Salem et al., 1997).***

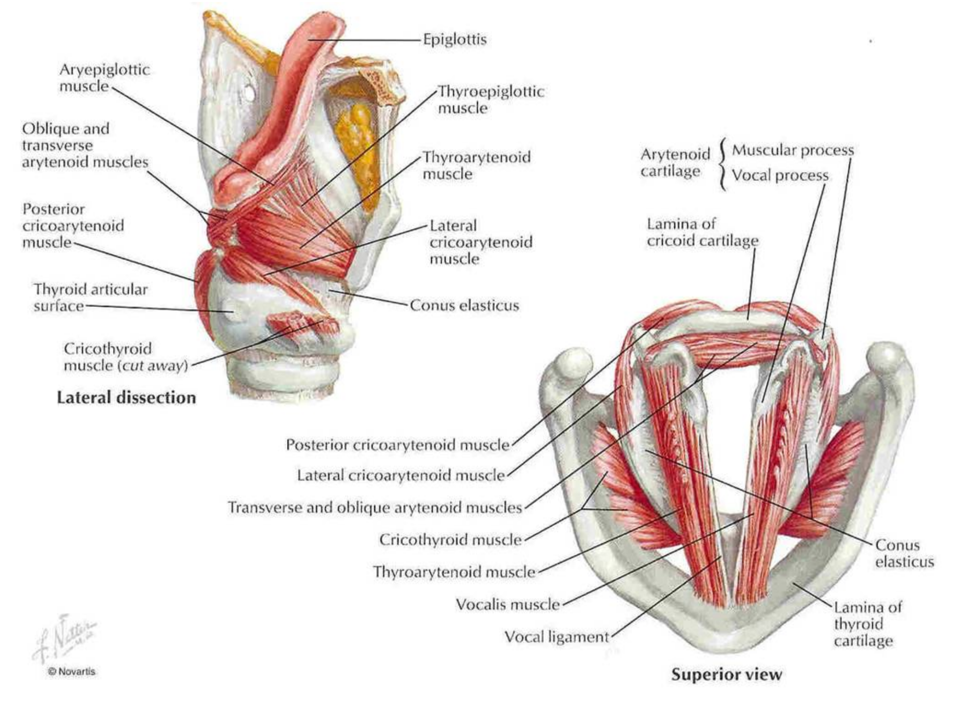

Fig. (1): Upper airway ***(Salem et al., 1997)***.

The nine intrinsic muscles of the larynx are classified as:

1. Abductors of the vocal cords (posterior cricoarytenoid muscle).
2. Adductors of the vocal cords (lateral cricoarytenoid muscle, transverse and oblique interarytenoid muscle and external portion of thyroarytenoid muscle).
3. Regulation of vocal cord tension is done by cricothryroid muscle and internal portion of thyroarytenoid (vocalis muscle)

(Robert and Stwelting, 1998)

The entire motor and sensory supply to the larynx is derived bilaterally from the branches of vagus nerve, the superior laryngeal and recurrent laryngeal nerves ***(Pracey, 1984).***

The trachea

It starts at the lower border of the larynx between 4th and 5th cervical vertebra. The relation between the size of the trachea and the age of the child can be demonstrated in the following table (Table 1).

Table (1): Difference between trachea of infants and child

Age	Diameters of trachea	Length of trachea	Distance from upper teeth to carina
Infant (1-12 month)	5 millimeters	6 cm	13 cm
Child (1-12 yrs)	8 millimeters	8 cm	17 cm

(Kubota et al., 1986)

Differences between pediatric and adult airways

- Infants are obligate nasal breathers.
- Infants have narrow nares.
- Infants have large heads in relation to their bodies.
- Infant's tongue is relatively large and easily obstructs the airway.
- Infant's larynx is higher in the neck (infant: C3-C4, adult C4-C5).
- Epiglottis in adults is broad, with its axis parallel to the trachea while the infant's epiglottis is long, narrow, floppy and angulated away from the axis of the trachea.
- Vocal folds in the infant have a lower anterior attachment to the glottis than posterior.
- Adult vocal folds are perpendicular to the axis of the trachea.
- The narrowest portion of the child's larynx is at the cricoid ring while the narrowest portion of the adult larynx is the vocal fold.
- Trachea in infants and children divides into right and left bronchi at equal angles while in adult the right bronchus is wider and at a more obtuse angle than the left brochus.

(Norton, 1996)

Physiological considerations for pediatric patients

Children especially infants differ markedly from adolescent and adults, not only from the anatomical point of view, but also from the physiological point of view. Physiological differences are related to general metabolism and immature functions of the various organs, including the heart, the lungs, kidneys, liver, blood and the nervous system ***(Motoyama and Davis, 1996).***

The autonomic nervous system (ANS):

The ANS is relatively well developed in the newborn. The parasympathetic components of the ANS are fully functional at birth. The sympathetic components, however are not fully developed until 4-6 months of age ***(Friedman, 1973).***

Baroreflexes to maintain blood pressure and heart rate, which involve medullary vasomotor centers (pressor and depressor areas) are functional at birth in awake infants. In anaesthetized newborn, however, both pressor and depressor reflexes are diminished ***(Gootman, 1983).***

The laryngeal reflex is activated by the stimulation of receptors in the nose and upper airways of the newborn. Reflex apnea, bradycardia or laryngospasm may occur. Various mechanical and chemical stimuli, including water, foreign bodies and noxious gases, can trigger this response, which is so potent that it can be fatal ***(Motoyama and Davis, 1996).***

The cardiovascular system:

Maturation of the cardiovascular system is not complete at birth. It undergoes dramatic physiologic and maturational change during the first year of life. The cardiac output is relatively high due to high metabolic rate (2-3 times that of adult) (200ml/kg/min). Cardiac output (CO) is heart rate (HR) dependent as the stroke volume is fixed by the poorly developed left ventricle. Heart rate is faster. Babies can tolerate heart rate up to 200 beats/min without evidence of heart failure, bradycardia readily occurs in presence of hypoxia or vagal stimulation (so, it needs rapid treatment with oxygen and atropine).

Arterial blood pressure (ABP) is lower due to low systemic vascular resistance due to the large proportion of vessel-rich tissues in children. The vessels are less able to respond to hypovolemia by vasoconstriction, so, the hallmark of hypovolemia is hypotension without tachycardia because the sympathetic nervous system and the baroreceptor reflexes are not fully mature ***(Strafford, 1996).***

Neonates are highly dependant on heart rate to maintain cardiac output and systemic blood pressure. Vasoconstrictive responses to haemorrhage are less in neonates than in adults. For example, a 10% decrease in intravascular fluid volume is likely to cause a 15-30% decrease in mean arterial pressure in neonates. That is why neonates are more likely to experience perioperative cardiovascular events ***(Morray and Geidvaschek, 2000).***

Table (2): Difference between neonate, infant, 5 years child and adult vital parameters.

Parameter	Neonate	Infant	5 years	Adult
Weight (kg)	3	4-10	18	70
Systolic blood pressure(mmHg)	65	90-95	95	120
Heart rate (beats/ min)	130	120	90	80
Blood volume (ml/ kg)	85	80	75	65
Haemoglobin (g/ dl)	17	11-12	13	14

(Miller, 2005)

The pulmonary system

The pulmonary system is not capable of sustaining life until both the pulmonary airways & the vascular system have matured sufficiently to allow exchange of oxygen from air to the blood stream across the pulmonary alveolar vascular bed.

Independent life is not possible until gestational age is 24 to 26 weeks. Alveoli increase in number & size until the child is approximately 8 years old, further growth manifests as an increase in the size of the alveoli & airways. At term, a full complement of surface-active proteins helps to maintain patency of the airways. If a child is born prematurely and these proteins are insufficient, respiratory distress syndrome may follow ***(Robert and Stephen, 2002).***

The most important difference in pulmonary system that physiologically distinguishes pediatric from adult is oxygen consumption. Oxygen consumption of neonates is more than 6 ml/kg, which is about twice that of adults on a weight basis, this is because of the higher metabolic rate in pediatrics than in adults. To satisfy this high demand, alveolar ventilation is double, this increase in alveolar ventilation is accomplished by increase in breathing rate. Of particular importance is the fact that hypoxemia depresses, rather than stimulates respiration

Airway is relatively narrow up to 6-8 years old increasing airway resistance which increases the incidence of respiratory diseases. Also, lower lung compliance and greater chest wall compliance (due to cartilagenous chest wall) are responsible for increased respiratory rate for ages between 1-10 years is faster due to low lung compliance and high airway resistance ***(Robert and Stephen, 2002).***

In neonates and infants in the first six months of age, oxygen dissociation curve is shifted to the left due to the presence of fetal haemoglobin, which has greater affinity to oxygen than adult haemoglobin ***(Motoyama and Davis, 1996).***

Table (3): Difference between neonates and adult respiratory parameters.

Parameter	**Neonates (3kg)**	**Adults (70 kg)**
Oxygen consumption (ml/kg/min)	6.4	3.5
Alveolar ventilation (ml/kg/min)	130	60
Carbon dioxide production (ml/kg/min)	6	3
Tidal volume (ml/kg)	8-10	6-8
Breathing frequency (min-1)	35	15
Vital Capacity (ml/kg)	35	70
Functional residual capacity (ml/kg)	30	35
Tracheal length (cm)	5.5	12
PaO2 (mmHg)	65-85	85-95
PaCo2 (mmHg)	30-36	36-44
Ph	7.34-7.4	7.36-7.44

(Robert and Stephen, 2002)