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Complications in Pediatric Anesthesia

An Essay
Submitted For Partial Fulfillment of Master Degree In Anesthesia

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﴿.....رَبِّ أَوْزِعْنِي أَنْ أَشْكُرَ نِعْمَتَكَ الَّتِى أَنْعَمْتَ عَلَيَّ وَ عَلَى وَالِدَيَّ وَ أَنْ أَعْمَلَ صَالِحاً تَرْضَاهُ وَ أَدْخِلْنِي بِرَحْمَتِكَ فِي عِبَادِكَ الصَّالِحِينَ﴾

صدق الله العظيم.
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List of abbreviations

(AChE) Acetylecholinesterase

(ADARPEF) French-Language Society of Pediatric Anesthesiologists

(ASA) American Society of Anesthesiologists

(BP) Blood Pressure

(CBF) Cerebral Blood Flow

(CNS) Central Nervous System

(CO) Cardiac Output

(CP) Cricoid Pressure

(CPAP) Continuous Positive Airway Pressure

(CSF) Cerebrospinal Fluid

(CT) Computed Tomography

(EABL) Estimated Allowable Blood Loss

(EBV) Estimated Blood Volume

(ECG) Electrocardiograph

(FRC) Functional Residual Capacity

(Hb) Hemoglobin

(HCT) Haematocrit

(HR) Heart Rate

(IO) Intraosseous

(IPPV)	Intermittent Positive-Pressure Ventilation
(IV)	Intravenous
(LMAs)	Laryngeal Mask Airways
(MAC)	Minimum Alveolar Concentration
(MH)	Malignant Hyperthermia
(MHN)	NOT Malignant Hyperthermia Susceptible
(MHS)	MH Malignant Hyperthermia Susceptible
(MRI)	Magnetic Resonance Imaging
(N)	Newtons
(NMJ)	Neuromuscular Junction
(PCV)	packed cell volume
(PEEP)	Positive End-Expiratory Pressure
(PO_2)	Partial Pressure of Oxygen
(POCA)	Perioperative Cardiac Arrest
(PS)	Physical Status
(RR)	Respiratory Rate
(SCh)	Succinylcholine
(SVR)	Systemic Vascular Resistance
(TMJ)	Temporomandibular Joint
(URIs)	Upper Respiratory Tract Infections
(VAE)	Venous Air Embolism

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Introduction

The neonate has unique requirements for equipment, intravenous access, fluid and drug therapy, anesthetic dosage, and environmental control. An understanding of the basic differences in physiology, pharmacologic and pharmacodynamic response, and the underlying pathology of the surgical problem is essential for development of a safe anesthesia plan. Most of the complications that arise are attributable to a lack of understanding of these special considerations prior to induction of anesthesia. The care of neonates is fraught with danger, sudden changes, unexpected responses, and the unknown congenital problem. If anesthesiologists are to deliver optimum pediatric anesthesia care, they must always be prepared for the unexpected, have the proper size and variety of equipment available, and obtain the highest level of support, both in the operating room and in the intensive care unit **(Charles, 2000).**

Children younger than 1 year have a higher incidence of complications than older children. These complications relate to oxygenation, ventilation, airway management, and response to anesthetic agents and medications. The neonate, particularly the premature infant, functions on a marginal basis, so that any type of stress is usually poorly tolerated. This vulnerability may relate to the technical difficulty of taking care of small patients, the immaturity of their organ systems, the high metabolic rate, the large ratio of body surface area to weight, and the ease of miscalculating a drug dose **(Keenan et al, 1991).**

Despite advances in pediatric anesthesia, unexpected cardiac arrests still occur. The risk of anesthesia related cardiac arrest appears to be inversely proportional to age, with our youngest patients at the highest risk. Of all cases of cardiac arrest submitted to the POCA Registry, 55% were less than one year of age. In the POCA study, death following anesthesia-related cardiac arrest was predicted most strongly by ASA physical status **(Morray et al, 2000).**

Anatomical and Physiological Features in Pediatrics

The provision of safe anesthesia for the pediatric patient depends on a clear understanding of the physiological and anatomical differences between children and adults. This chapter describes how the unique characteristics of pediatric patients influence the safe conduct of anesthesia **(Edward, 2007).**

Anatomy of Upper Airway:

Infants and neonates are obligate nose breathers with narrow nares, which can become easily obstructed by secretions. There large tongue may obstruct airway and make laryngoscopy and intubation difficult. They have relatively large occiput and sniffing position can be achieved with roll under shoulder. There glottis located at C3 in premature babies, C3-C4 in newborns, (C5 in adults), so the larynx appears more anterior; cricoid pressure frequently helps with laryngeal visualization. Larynx and trachea are funnel shaped, the narrowest part of the trachea is at the cricoid; the patient should have an ETT leak of < 30 cm H2O to prevent excessive pressure on the tracheal mucosa and barotrauma. There vocal cords slant anteriorly and insertion of ETT may be more difficult **(Agarwal, 2007).**

The pediatric epiglottis (often described as U- or omega shaped) may fall back over the laryngeal inlet if the tip of the laryngoscope blade is in the vallecula. A better view is usually obtained if the tip of the laryngoscope is positioned on the laryngeal surface of the epiglottis **(Volker, 2007).**

Table1. The recommended sizes of endotracheal tubes for use in pediatric patients **(Charles, 2000):**

Age of the patient	Internal diameter of endotrachial tubes (mm)
Premature (<1,250 g)	2.5
Full term	3.0
1 y	4.0
2 y	5.0
6 y	5.5
10 y	6.5
18 y	7–8

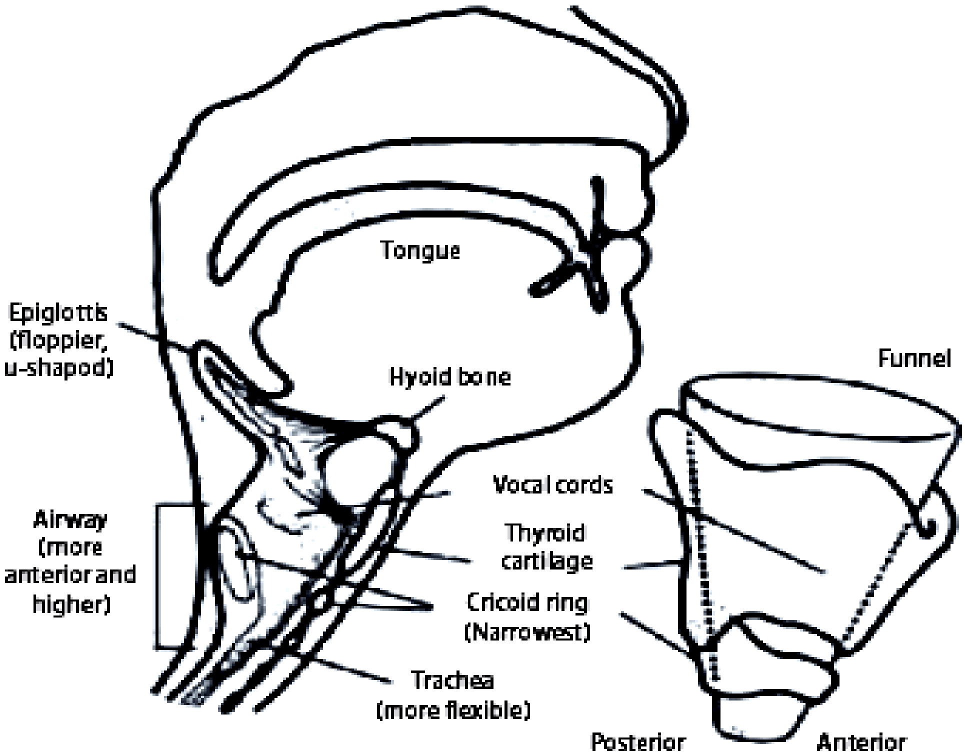
Anatomy of Lower Airway:

The tracheal length, defined as the distance from the cricoid cartilage to the carina, may be as little as 4 cm and endobronchial intubation is a continuous hazard **(Volker, 2007).**

The appropriate depth of ETT insertion: Over one year of age: oral: 13 + (1/2) age, nasal: 15 + (1/2) age. Infants (weight in kg): oral: 8 + (1/2) (weight), nasal: 9 + (1/2) (weight) **(Lau et al, 2006).**

The pediatric alveoli are fewer in number and smaller in size 13-fold growth in number of alveoli between birth and 6 years; threefold growth in size of alveoli between 6 years and adulthood. They have horizontal ribs, pliable ribs and cartilage with inefficient chest wall mechanics **(Agarwal, 2007).**

Figure 1. Anatomy of pediatric airway (Foltin et al, 1998).



<u>Physiology of Respiratory System:</u>

Neonates have high metabolic rates, resulting in an elevated oxygen consumption (6 to 9 mL/kg/minute) compared with adults (3 mL/kg/minute). Neonatal lungs have high closing volumes, which fall within the lower range of their normal tidal volume. Below closing volume, alveolar collapse and shunting occur. To meet the higher oxygen demand, infants have a higher respiratory rate and minute ventilation **(Susan, 2007).**

An infant's functional residual capacity (FRC) is less than that of an adult (FRC of an infant, 25 mL/kg; adult, 40 mL/kg). Their higher minute ventilation to FRC ratio results in rapid inhalational induction. The tidal volume for infants and adults is equivalent (7 mL/kg). Anatomic shunts including patent ductus arteriosus and patent foramen ovale may develop significant right-to-left flow which increases the pulmonary artery pressure (more liable for hypoxia, acidosis, or high positive airway pressure) **(Behrman et al, 2005).**

The characteristics of the infant's pulmonary system contribute to rapid desaturation during apnea. Profound desaturation can occur when an infant coughs or strains and alveoli collapse. Treatment may require deepening anesthesia with intravenous (IV) drugs or using neuromuscular relaxants **(Hemanth, 2007).**

The diaphragm is the infant's major muscle of ventilation. Compared with the adult diaphragm, the newborn has only half the number of Type I, slow-twitch, high-oxidative muscle fibers essential for sustained increased respiratory effort. Thus, the infant's diaphragm fatigues earlier than the adult's. By 2 years of age, the infant's diaphragm has attained mature levels of Type I fibers. The pliable rib cage (compliant chest wall) of an infant cannot maintain negative intrathoracic pressure easily. This diminishes the efficacy of the infant's attempts to increase ventilation **(Susan, 2007).**