INTRODUCTION

Bronchoscopy is a visual examination of the airway or breathing passages of the lungs that are called *bronchi*. More specifically, a bronchoscopy is a medical procedure, in which the physician can inspect the bronchi of the lung for a range of therapeutic (treatment) or diagnostic purposes. For the procedure, the physician uses a *bronchoscope*, a type of endoscope, which is an instrument for the examination of the interior of a body canal or hollow and multilayered, walled organ. Depending on the medical reason or clinical indication for the bronchoscopy, the physician may use either a rigid or flexible fiberoptic bronchoscope ***(Ernst et al., 2003).***

Common reasons to do bronchoscope include unexplained symptoms related to the chest, such as persistent cough, coughing up blood, wheezing, hoarseness, noisy breathing, or shortness of breath. The airways are examined for signs of problems and samples of tissue (biopsies) can be taken and examined for evidence of infection or cancer.

Persistent lung collapse (atelectasis) or collapse of the small air sacs in the lungs is sometimes evaluated using bronchoscope. This may reveal a blockage, called an obstruction, from thick mucus, a foreign body, or a tumor. If possible, the clinician removes the cause of the obstruction to open the airways. Biopsies of abnormal tissue may be taken. In

some cases, small tubes, called stents, are placed to hold the obstructed airway open.

An abnormal chest x-ray may suggest problems that require closer inspection with bronchoscope. Examples include a "spot" or mass, pneumonia, or other unexplained changes on chest x-ray or computed tomography (CT) scans. In most cases, fluid samples or a biopsy are obtained to look for signs of infection, cancer, or inflammation ***(Mehta et al., 2008).***

Bronchoscope is a safe procedure. Complications are infrequent and usually minor. Complications may be related to the procedure itself or to adverse reactions caused by sedatives or numbing medicines.

Bronchoscope is safe in the hands of experienced operators. Major complications have been reported in 0.08-5% of procedures, with a mortality of 0.01-0.5%. The major risks of this procedure are those associated with general anesthesia. In addition, cervical spine, mandible, or skull injuries may be aggravated due to manipulation during the procedure. The risk of major complications is highest in those with active ischemic heart disease and advanced pulmonary disease. Major complications include pneumothorax (punctured and collapsed lung), pulmonary hemorrhage, and respiratory failure. Other complications include conscious sedation-induced hypoventilation, hypoxemia, cardiac dysrhythmias, cardiac ischemia, bronchospasm, fever and, rarely, bacteremia (bacteria in the blood) ***(Hanibuchi et al., 2007).***

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 and ends in the alveoli of the lung. It is divided into upper and lower airway at the level of the vocal cords ***(Roberts, 1998).***

The Pharynx

Extending from the sphenoid bone to the larynx, the pharynx parallels the vertebrae, which are covered by the anterior longitudinal ligament and fascial layers beneath the mucosa and constrictor muscles ***(Ovassapian and Meyer, 1998).***

The anterior communication of the pharynx gives names to its subdivisions (the nasopharynx, the oropharynx, and laryngopharynx) (figure 1). The laryngopharynx merges with the esophagus, where the cricopharyngeus originating on the cricoid cartilage encircles the esophagus to form its upper sphincter. In. anesthetized patient, the same function is mimicked by pressing the cricoid ring against the cervical vertebrae (Sellick's maneuver) ***(Sellick, 1961).***

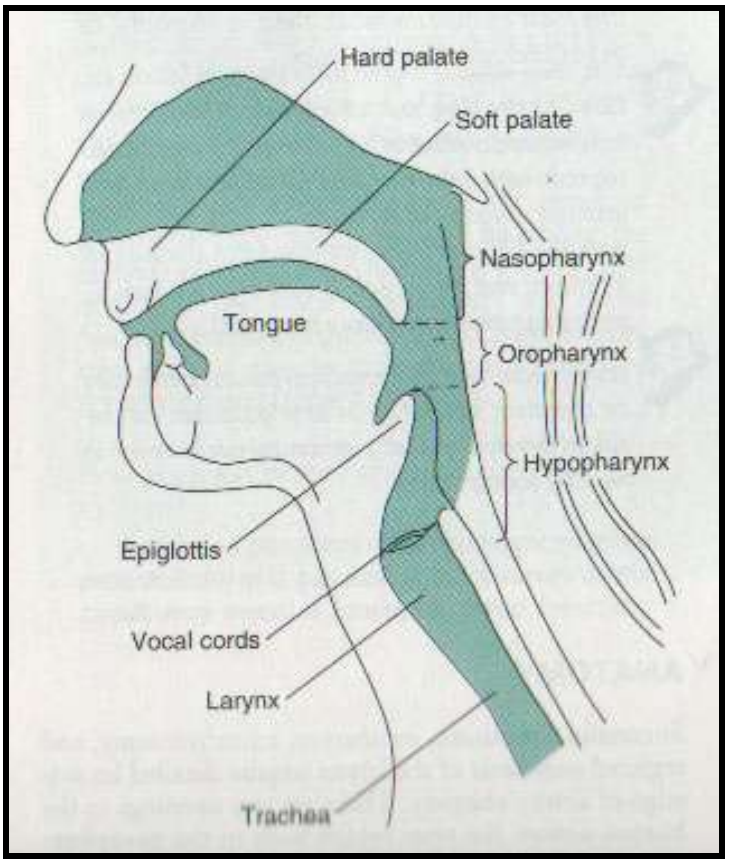

Figure (1): The three subdivision of the pharynx ***(Finucane and Santora, 1996).***

Nasopharynx and Nose

Mature and premature newborns breathe exclusively through their noses, which may result in critical respiratory problems in children with, for example, bony or membranous choanal atresia ***(Brown et al., 1996).***

Each side of the nasal cavity has a roof, a medial wall, and a lateral wall. The roof is the cribriform plate of ethmoid bone, separating it from the cranial cavity. In presence of basilar skull fractures, attempted passage of nasotracheal and

nasogastric tubes has resulted in their entry into the cranium ***(xie et al., 2001).***

Laterally the nasal cavity consists of three nasal turbinates (inferior, middle, and superior); their fragility 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 (figure 2) ***(Ovassapian and Meyer, 1998).***

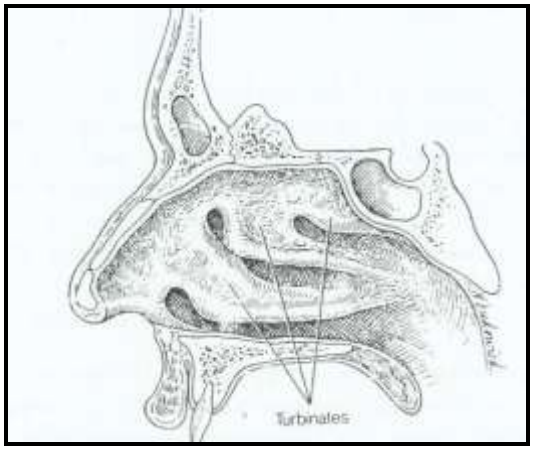

Figure (2): Lateral wall of the nasal cavity showing the turbinates ***(Finucane and Santora, 1996).***

The nasopharynx is bounded superiorly by the base of the skull, inferiorly by the soft palate, and posteriorly by the body of the first cervical vertebra, superficial to the roof of the pharynx and first cervical vertebra there is the pharyngeal tonsil (called adenoids when hypertrophied) which is a site of potential obstruction or hemorrhage during nasal intubation ***(Finucane and Santora, 1996).***

Oropharynx and Mouth

The mouth is small in children and infants, 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 ***(Logemann, 1993).***

The tongue is relatively large and readily blocks the pharynx during anesthesia; hence an oropharyngeal airway may be required. The large tongue may also hamper attempts to visualize the glottis at laryngoscopy ***(Steward, 1995).***

The oropharynx is bounded superiorly by the soft palate, anteriorly by the tongue, inferiorly by the epiglottis, and posteriorly by the bodies of the second and third cervical vertebrae ***(Isono et al., 1997).***

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 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).***

In the sleeping or anesthetized patient the supine position, muscle relaxation combined with gravity approximates the base of the tongue to the posterior oropharyngeal wall, causing varying degrees of airway obstruction, partial obstruction is aggravated by negative inspiratory pressure collapsing the loose pharyngeal wall inwards so that much of airway management amounts to avoid airway obstruction at this level ***(Nishimura and Suzuki, 2003).***

Laryngopharynx and Larynx:

It consists of three single cartilages (epiglottis, thyroid and cricoid) and six smaller paired cartilages (arytenoid, corniculate and cuneiform) and their mucosal coverings shape the larynx ***(Edward and Viki, 2008).***

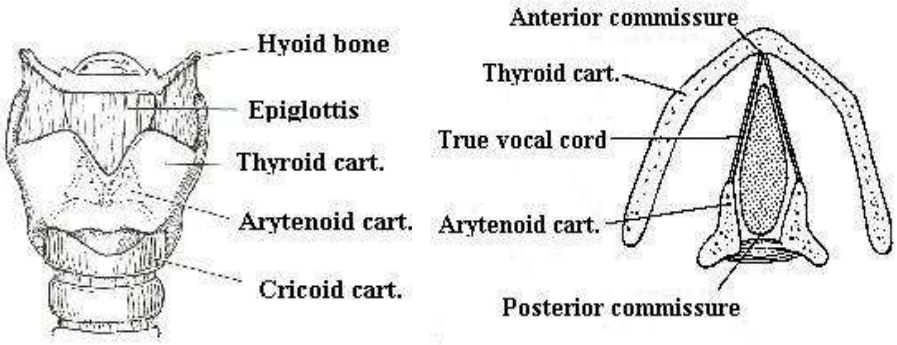

Figure (3): Anatomical view of the larynx from the front [left] and the top [right] ***(Finucane and Santora, 1996).***

The position of the larynx is relatively higher than that in adults; in the newborn, computed tomography or magnetic

resonance imaging scans reveal the larynx at the forth cervical vertebra level as compared to fifth or sixth cervical vertebrea in the adult. This might be associated with difficulties during endotracheal intubation, especially in very young patients ***(Hudgins et al., 1997).***

Positional airway obstruction in unintubated neonates may occur in the supine position by posterocephalic displacement of the mandible, leading to narrowing of the upper airway or, if intubated with an uncuffed endotracheal tube, by abutment of the bevelled distal endotracheal tube orifice against the tracheal wall. This can be relatively easily prevented by providing appropriate neck and head support, such as foam gel rolls or cushions ***(Jarreau et al., 2000).***

The cricoid cartilage is a complete ring with its broad aspect posteriorly in children and infants, The cricoid ring forms the narrowest part of the pediatric airway (as opposed to the vocal cords in an adult). This continues until 6 years to 8 years of age. This anatomic narrowing both allows and necessitates the use of uncuffed endotracheal tubes in children ***(Edward and Viki, 2008).***

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 the pediatric patient, because the cricothyroid membrane is extremely small in the infant larynx, cricothyroidectomy does not represent a

feasible emergency procedure in the child with airway obstruction (figure 4) ***(Nemec et al., 2009).***

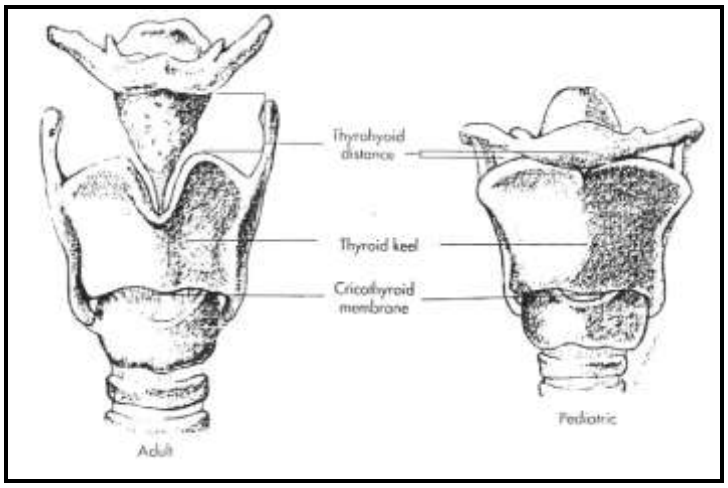

Figure (4): Anterior view of the larynx shows the difference between adult and pediatric larynx ***(Norton, 1996).***

The epiglottis is relatively long and stiff; it is U-shaped and projects posteriorly at an angel 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, 1995).***

The anterior attachment of the vocal cords is more caudal in infants. This slant in the vocal cords predisposes toward catching the lip of the endotracheal tube in the anterior commissure during intubation; turning the endotracheal tube 90 degrees during intubation improves the angle of entry into the trachea ***(Nemec et al., 2009).***

The Trachea and Main Bronchi:

The tracheal length in preterm neonates is only 2–3 cm (25th and 35th weeks postconceptional age, respectively), and at term only 4 cm, and so a meticulous positioning of the endotracheal tube is required to avoid endobronchial dislocation or accidental extubation during subsequent manipulations ***(Dooy et al., 2004).***

There are a lot of anatomical differences between pediatric and adult airway which summarized at (table 1) and illustrated at (figure 5) an impressive one that the trachea in infants and children divides into right and left bronchi at equal angles and an endotracheal tube or a suction catheter is just likely to enter the right side as left side ***(Armstrong and Netterville, 1995).***

The Lower Airway:

The highly compliant chest wall in neonates and infants increases the work of breathing. This compliance is attributable to their softer non-calcified ribs, which articulate with the vertebral column and sternum at right angles. The adult's more rigid chest wall articulates at down sloping angles with a more efficient chest wall excursion. The diaphragm is the mainstay of ventilation in neonates; however, the mechanism of contraction is less efficient compared with older children and adults ***(Soto, 1996).***

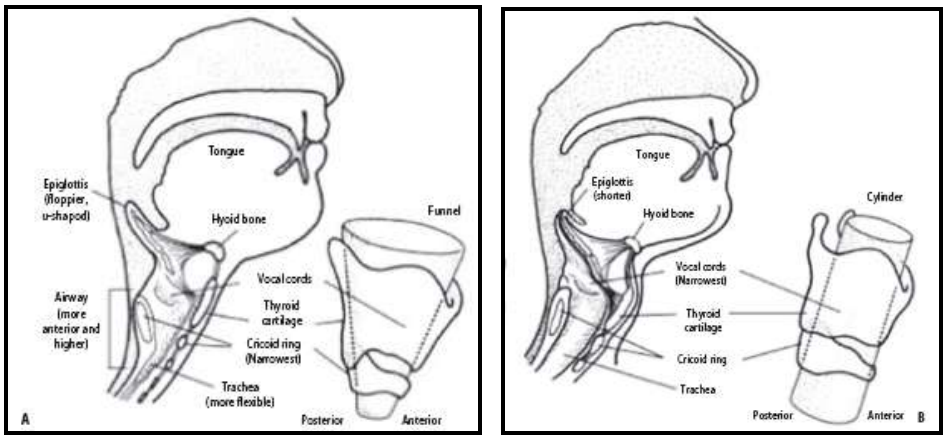

Figure (5): Anatomic differences between the pediatric (A) and adult(B) airway ***(Sapienza et al., 2005).***

Table (1): Anatomical Differences between pediatric and adult airway ***(Norton, 1996).***

1. Infants are obligate nasal breathers.
2. Infants have narrow nares.
3. Infants have large heads in relation to their bodies.
4. An infant's tongue is relatively large and obstructs easily.
5. The infant's larynx is higher in the neck (infant: C3-C4, adult C4-C5).
6. The epiglottis in adults is broad, with its axis parallel to the trachea.
7. The infant's epiglottis is long, narrow and floppy and angulated away from the axis of the trachea.
8. Vocal folds in the infant have a lower anterior attachment to the glottis than posterior.
9. Adult vocal folds are perpendicular to the axis of the trachea.
10. The narrowest portion of the child's larynx is at the cricoid ring.
11. The narrowest portion of the adult's larynx at the vocal fold.
12. Trachea in infants and children divides into right and left bronchi at equal angles.

PHYSIOLOGY OF THE PEDIATRIC AIRWAY

The upper airway has a number of sensory receptors sensitive to mechanical and chemical stimulation. Receptors in the nose, when stimulated, can produce sneezing, apnea, and changing in bronchomotor tone. Stimulation of the epipharynx causes the "sniffing reflex" which is a short strong inspiration to bring material mucus or foreign body from the epipharynx into the pharynx to be swallowed or expelled ***(Nishino, 1993).***

The most powerful reflexes mediating laryngeal closure arise from within the larynx itself, specifically the upper and lower surfaces of the epiglottis and vocal cords. These reflexes are particularly active in the pediatric patient. When removal of the stimulus abruptly terminates the response, a glottic closure reflex' occurs. Laryngospasm is characterized by sustained glottic closure even after stimulus removal, which is reversed by severe hypoxemia ***(Thach, 1992).***

Three types of laryngeal receptors have been identified: pressure receptors, drive receptors and flow receptors. The activity of pressure receptors increases markedly with upper airway obstruction ***(Nishino et al., 2004).***

Anesthetic Effects on Upper Airway Receptors:

Inhalation induction of anesthesia especially with isoflorane is often associated with reflex responses such as

coughing, breath holding, and laryngospasm. These reflexes are due to direct stimulation of the upper airway receptors (e.g., laryngeal mechanoreceptors and irritant receptors) by volatile anesthetics ***(Nishino, 1993).***

Response to Hypoxemia in Infants:

During the first 2 to 3 weeks of age, both full-term and premature infants in a warm environment respond to hypoxemia (15% O_2) by a transient increase in ventilation followed by sustained ventilatory depression ***(Rajesh el al., 2000).***

In infants born at 32 to 37 weeks' gestation, the initial period of transient hyperpnea is abolished in a cool environment, indicating the importance of maintaining a neutral thermal environment ***(Darnall et al., 2006).***

By 3 weeks after birth, hypoxemia induces sustained hyperventilation, as in older children and adults ***(Motoyama and Davis, 1996).***

The biphasic ventilatory response to hypoxemia results from changes in the mechanics of the respiratory system (thoracic stiffness or airway obstruction), rather than from neuronal depression ***(Darnall et al., 2006).***

Response to Carbon Dioxide in Infants:

Newborn infants respond to hypercapnia by increasing ventilation. The same reflex occurs in older infants

but with more extent**.** The ventilatory response to hypercapnia seems to be diminished during periodic breathing. The decreased hypercapnic response appears to result from changes in respiratory mechanics rather than from a reduction in chemosensitivity ***(Motoyama and Davis, 1996).***

Breathing Patterns

Periodic Breathing:

It is a type of breathing in which breathing is interposed with short apneic spells lasting 5 to 10 seconds. It occurs during wakefulness, active rapid eye movement (REM) sleep, and quite (non-REM) sleep ***(Martin and Abu-Shaweesh, 2005).***

The incidence of periodic breathing is 78% in full-term neonates, whereas the incidence in preterm infants is reported to be 93% ***(Nosrat et al., 2002).***

The frequency of periodic breathing diminishes with increasing post-conceptual age and decreases to 29% by 10 - 12 months of age ***(Nosrat et al., 2002).***

The addition of 2% to 4% carbon dioxide to the inspired gas mixture abolishes periodic breathing, probably by causing respiratory stimulation ***(Motoyama and Davis, 1996).***

Central Apnea:

Central apnea of infancy is defined as unexplained cessation of breathing for 15 seconds or longer, or a shorter

respiratory pause associated with bradycardia (heart rate < 100 BPM), cyanosis, or pallor ***(De Piero et al., 2004).***

Apnea is common in preterm infants and may be related to an immature respiratory control mechanism ***(Dewolfe, 2005).***

The incidence of central apnea in preterm infants is 55% while it is rare in full-term infants ***(De Piero et al., 2004).***

Life-threatening postoperative apnea sometimes occurs in premature infants whose post-conceptual age is less than 41 weeks, particularly in those with a history of apneic spells. Apnea can occur up to 12 hours postoperative ***(Motoyama and Davis, 1996).***

Both theophylline and caffeine have been effective in reducing apneic spells in preterm infants ***(Barbara, 2005).***

Pediatric Upper Airway Resistance:

The pediatric airway is much smaller in diameter and shorter in length than the adult's. For example, the length of the trachea changes from approximately 4 cm in neonates to approximately 12 cm in adults, and the tracheal diameter varies from approximately 3 mm in the premature infant to approximately 25 mm in the adult and according to Hagen-Poiseuille's law:

$$\mathbf{Q = (\Delta P\ \pi\ r^4)/\ (8\ \eta\ L)}$$

Where **Q** is flow, **ΔP** is the pressure gradient from one end of the airway to the other end, **r** is the radius of the airway**,** **η** is the viscosity of the air, and **L** is the length of the airway.