INTRODUCTION

High Frequency Ventilation (HFV) is a form of mechanical ventilation that uses small tidal volumes and extremely rapid ventilator rates, allowing pulmonary gas exchange at lower mean airway pressures than conventional mechanical ventilation. When HFV was first introduced on the menu of respiratory therapies for sick babies, hope abounded that HFV would be the universal remedy for most forms of neonatal respiratory insufficiency. As most causes of neonatal respiratory insufficiency requiring mechanical ventilation are amenable to treatment with HFV or Conventional Mode of Ventilation (CMV), clinical judgment still dictates the choice of one form or the other, because the high-quality evidence currently available is still inconclusive. Ongoing studies will ideally elucidate the optimal lung volume and ventilatory strategy for specific disease states as well as provide clinicians with long-term follow-up data regarding neurologic and developmental outcomes of children treated with the various forms of ventilation ***(Andrea et al., 2007).***

High Frequency Ventilation is a method of ventilation in which alveolar gas exchange is maintained by pressure swings initiating small displacements of ventilatory gases, considerably smaller than conventional tidal volumes, it allows higher end-expiratory pressures with lower peak inspiratory pressures and higher mean airway pressures and is therefore proposed as currently the most optimal form of lung protective ventilation. Thus, despite the extremely small tidal volumes generated, changes in delivered tidal volume during HFV may have a greater effect on carbon dioxide removal than during CMV ***(Casper at al., 2003).***

Early hypocarbia of preterm infants showed significant association with both cerebral palsy and late-onset Peri-Ventricular Leukomalacia (PVL), but not with early-onset PVL. The background of the three clinical events, early hypocarbia, PVL and cerebral palsy, may not be identical in human newborns ***(Murase and Ishida, 2005).***

Hypocarbia and hyperoxia are risk factors for PVL in low birth weight infants. Cumulative exposure to hypocarbia and not hyperoxia was independently related to risk of PVL in low birth weight infants ***(Seetha et al., 2006).***

Compared with conventional mechanical ventilation, High Frequency Oscillatory Ventilation (HFOV) did not alter cardiac function. The high frequency group had lower end diastolic velocity and a higher resistance index in the anterior cerebral artery ***(Cambonie et al., 2006).***

During induced hypocapnia in dogs lightly anaesthetized and subjected to passive pulmonary ventilation, estimated renal plasma flow and urine production were greater than in normocapnia, and renal vascular resistance was decreased greatly compared with normocapnia. There was little change in glomerular filtration rate ***(Hunter et al., 1980).***

Plasma alanine transaminase, reflecting overall hepatocellular injury, was increased by hypocapnia in animal study ***(Michelle et al., 2005).***

High Frequency Ventilation has been advocated to reduce lung injury and Chronic Lung Disease (CLD) in preterm infants. Furthermore, HFV appears to increase the incidence of severe intracranial hemorrhages (IVH) and PVL. Therefore, routine elective use of HFV cannot be recommended at the present time. Limited data on rescue use of HFV suggest some benefits over continued CMV ***(Thome and Carlo, 2000).***

AIM OF THE STUDY

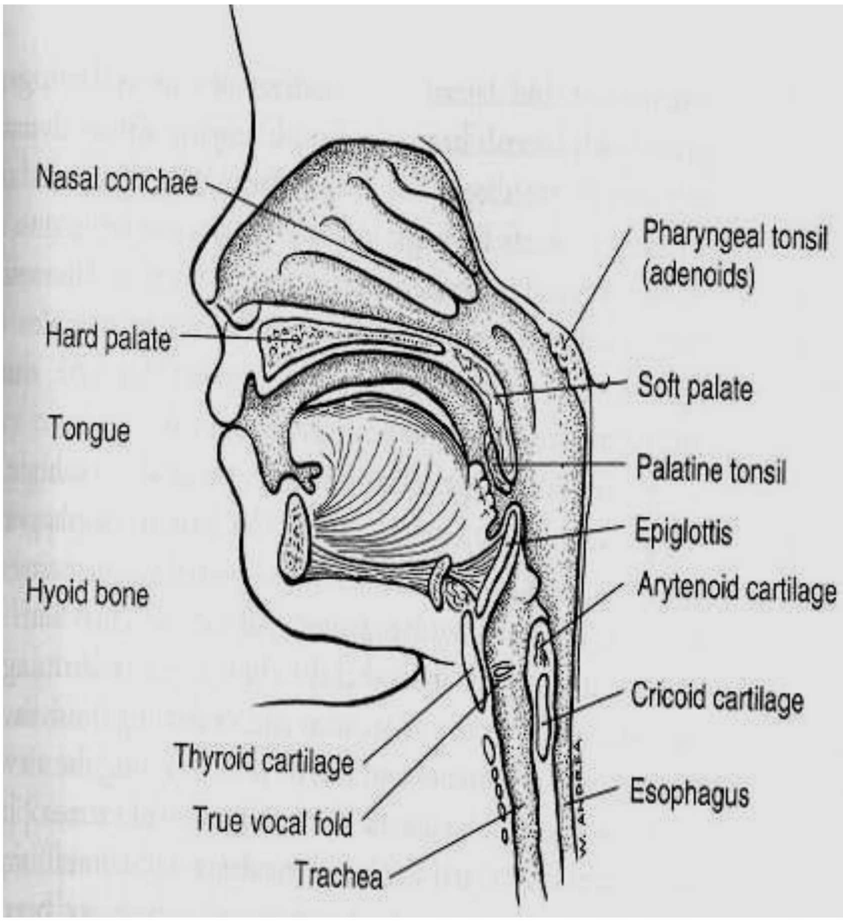
The aim of the current study is to evaluate the possible effects of rescue high frequency ventilation on different organs function (namely brain, liver and kidney) of the premature babies in comparison to the effects of conventional mode of ventilation.

RESPIRATORY DISTRESS IN NEONATES

Anatomy of respiratory tract

The respiratory system is comprised of several elements including the central nervous system, the chest wall, the pulmonary circulation, and the respiratory tract. The respiratory tract can be divided into four distinct segments: the naso-oropharynx, the conducting airways, the respiratory bronchioles, and the alveoli ***(Kochar, 2002)***.

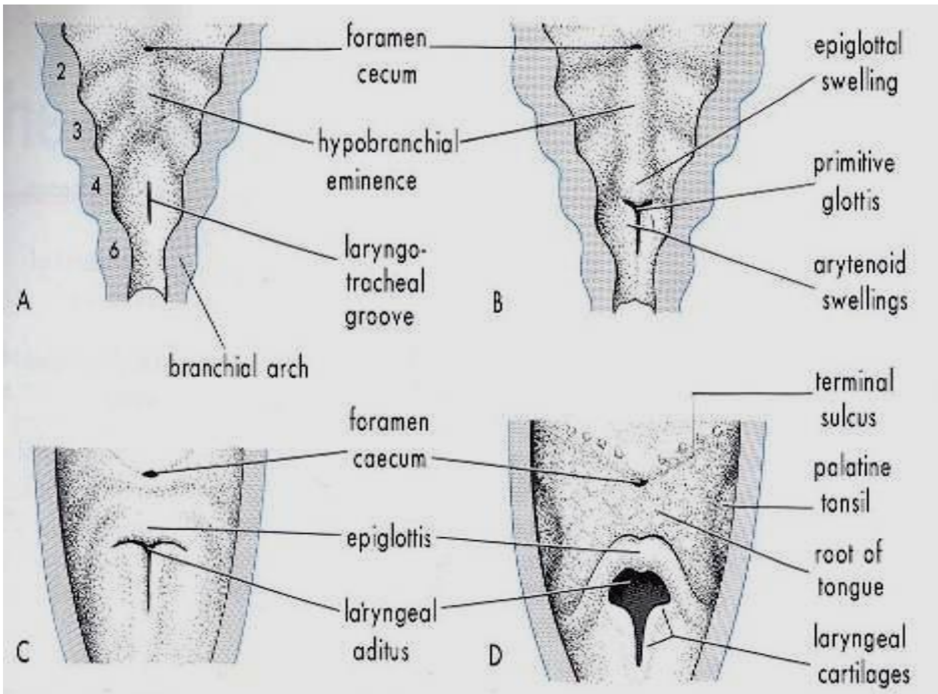
The lungs can also be divided into the conducting airways and the units of respiration. The trachea, bronchi, and bronchioles conduct and transport air from the outside world and deliver it to the respiratory units, the alveoli. Gas exchange occurs at the level of the alveoli, providing the necessary oxygen for the body's daily functions ***(Seeley et al., 2006))***.



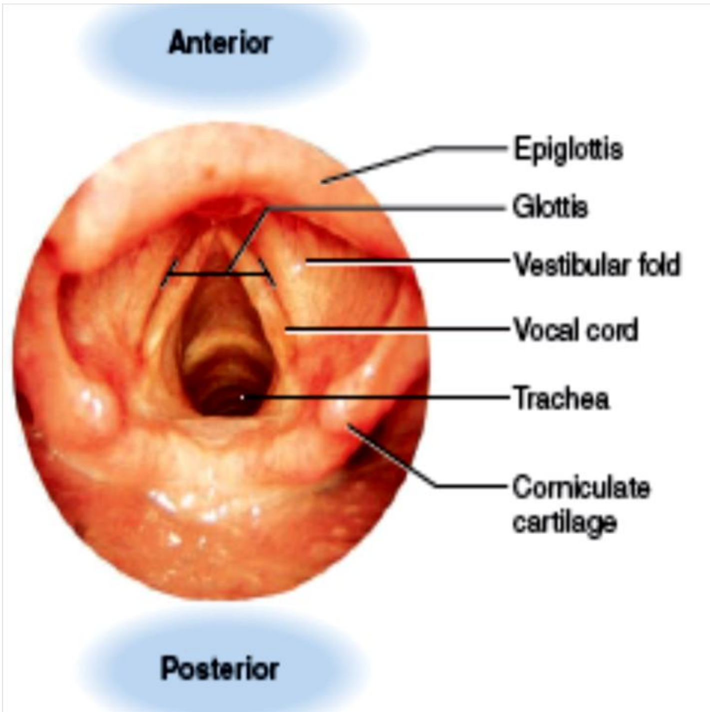
<u>Figure (1):</u> The upper respiratory system ***(Kochar, 2002)***.

The first segment of the respiratory tract is the naso-oropharynx, which begins with the nostrils and lips, and includes the nasal passage, sinuses, and glottis until reaching the trachea. The purpose of the naso-oropharynx is to filter out any large particles and to humidify and warm the air that is delivered to the respiratory units (Fig. 1) ***(Kochar, 2002)***.

The larynx is a cartilage box (voice box) of nine separate cartilages, eight of which are composed of hyaline cartilage connective tissue. The epiglottis (the ninth cartilage of the larynx) is composed of elastic cartilage connective tissue. The epiglottis stands almost vertically over the glottis. The epiglottis and muscles of the larynx coordinate the passage of food and air, and generally assure that food reaches the esophagus and air reaches the trachea (Fig. 2) ***(Reynolds, 2004)***.



<u>Figure (2):</u> The larynx ***(Shier et al., 2010)***



<u>Figure (3):</u> Vocal cord ***(Shier et al., 2010)***

The next segment is the conducting airways, beginning with the trachea, which branches repeatedly to form approximately 14 generations of conduits for air reaching several distinct pulmonary segments. The trachea bifurcates at the carina into the right and left main stem bronchi. Aspiration occurs more commonly at the right main bronchus because of its gentler angle off the trachea (Fig. 3) ***(Seeley et al., 2006)***.

From the larynx, inspired air travels to the trachea, a rigid tube with 18 to 20 C-shaped cartilages composed of hyaline cartilage connective tissue. These cartilages hold the trachea open for the easy flow of air. The C-shaped cartilages are open posterior with smooth muscle bridging the gap. This feature allows the esophagus (directly posterior to the trachea) room to expand into the tracheal space when swallowed food passes on its way to the stomach. If the cartilages were circular instead of C-shaped, a swallowed piece of meat could get hung up on each cartilage as it passed down the esophagus ***(Seeley et al., 2006)***.

The right lung is divided into upper, middle, and lower lobes, each of which is further subdivided into segments and each with its own conducting airway ***(Reynolds, 2004)***.

The upper lobe contains three segments: the apical, posterior, and anterior. The middle lobe consists of the lateral and medial segments. The lower lobe has five segments: the superior, medial basal, anterior basal, lateral basal and posterior basal. The right lung has 10 segments, as opposed to eight found in the left lung. The left main bronchus has two divisions serving the left upper lobe (Fig.4) ***(Kochar, 2002)***.

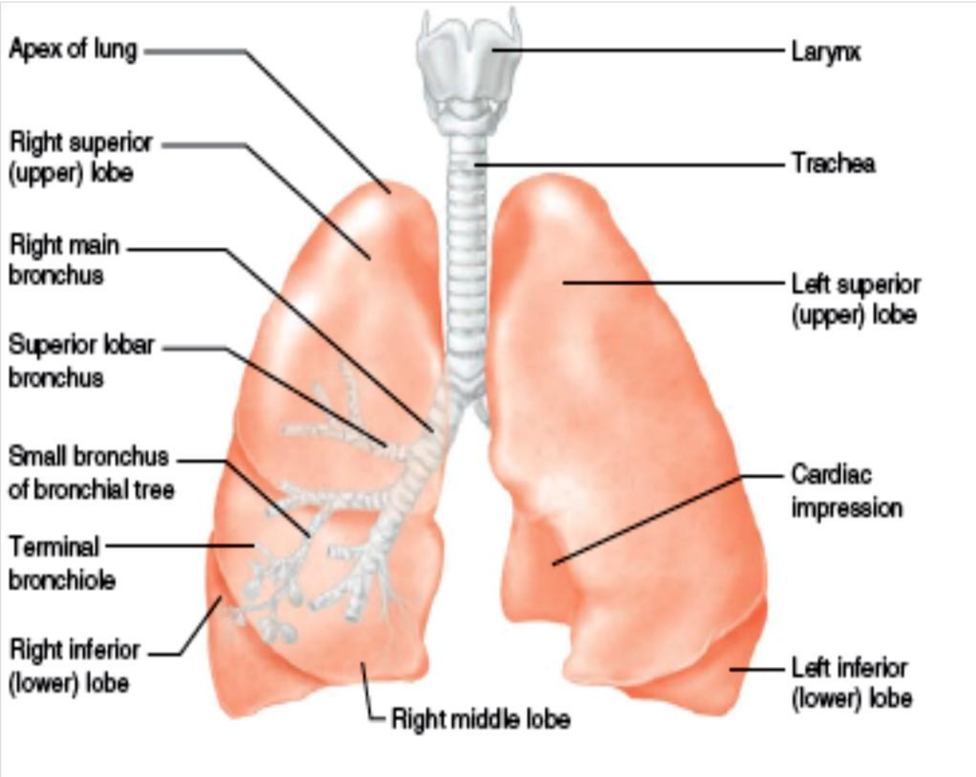
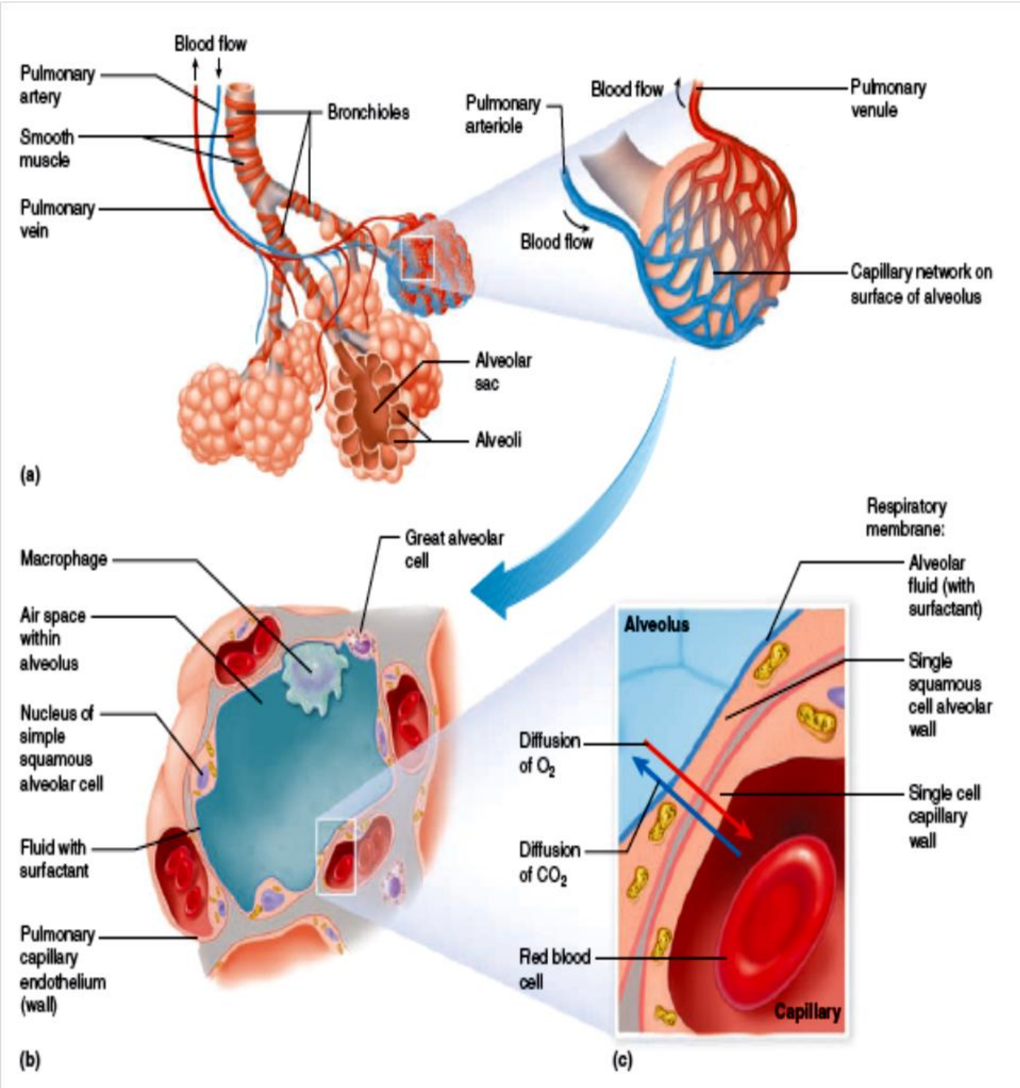


Figure (4): Gross anatomy of the lungs and bronchial tree ***(Seeley et al., 2006)***

Lobar bronchi further divide to smaller and smaller bronchi that branch to form the bronchial tree. All of the bronchi are supported by cartilage plates, which hold them open for the easy passage of air. The smallest bronchi further branch to form bronchioles. These small tubes do not have cartilage in their walls. Instead, their walls have smooth muscle that allows them to dilate or constrict to adjust airflow. Each bronchiole supplies air to a lobule (subsection of a lobe) of the lung composed of tiny air sacs called alveoli ***(Kenneth, 2010)***.

Smaller foreign particles may be trapped here, and lymphatic channels are found as well. The solitary layer of epithelial cells that compose the surface of the respiratory tract gives way to the cells that comprise the lining of alveoli. The warriors of the immune system are found at this level; macrophages, neutrophils, and eosinophils are poised to act should unknown antigens be found. Once the air reaches the alveoli, type I epithelial cells allow for gas exchange, and create a total surface area of around 130 sq. ft. among all alveoli. The millions of alveoli are embedded among capillaries to create an air–blood interface (Fig.5) ***(Kochar, 2002)***.

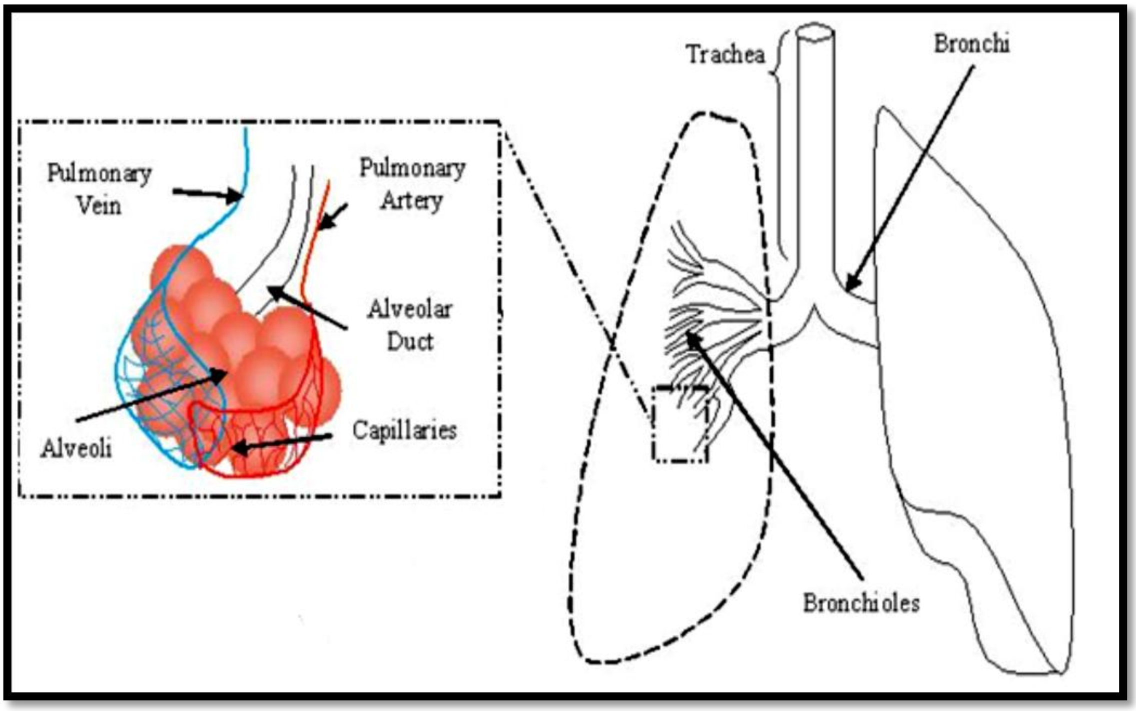


<u>Figure (5):</u> Bronchiole, alveoli, and the respiratory membrane: (a) clusters of alveoli at the end of a bronchiole and the network of capillaries covering them, (b) cells of the alveoli, (c) respiratory membrane ***(Kenneth, 2010)***.

PHYSIOLOGY OF RESPIRATION

The lungs primarily have two functions, the movement of oxygen (O_2) and carbon dioxide (CO_2) to and from the alveoli (through convection) and the provision of a surface for gas exchange (through diffusion). The lungs consist of approximately 300 million alveoli, surrounded by a network of capillaries, providing a large surface area for the transfer of gases. These gases reach the alveoli though a complex tree like structure of airways, starting from the trachea, which divides into the bronchi ***(Hardman, 2001)***.

These further divide into bronchioles, terminal bronchioles, alveolar ducts and finally the alveoli. Gas flow to and from the alveoli depends on the airway resistances and the pressure gradient (between the mouth and the lungs) created by the respiratory muscles, which causes the expansion and deflation of the lungs. The pulmonary artery brings deoxygenated blood to the lungs from the heart and divides into the pulmonary capillaries. Here O_2 is diffused to the blood and CO_2 is diffused to the alveolar units. The pulmonary capillaries containing the oxygenated blood converge into the pulmonary vein. This blood is transported to the heart that pumps the oxygenated blood into systemic circulation (Fig.6) ***(Hardman, 2001)***.



<u>Figure (6):</u> Lung structure ***(Hardman, 2001)***

The physiological makeup of the lungs maintains the delicate balance between these disparate anatomic entities. Several terms have been developed to describe the various physiological capacities of the respiratory tract ***(Reynolds, 2004)***.

Definitions:

The amount of air that the lung inhales, exhales or holds under different conditions can be described by specific lung volumes and capacities. Figure (7) introduces various lung volumes and capacities that are important clinically as their values can be affected by pathological processes. When compared to normal physiological ranges, they can help physicians in making diagnosis regarding the underlying pathological conditions ***(Gatinoni and Pesenti, 2005)***.

1. Total Lung Capacity (TLC): is defined as the volume of gas in the lungs following maximal inspiration.
2. Functional Residual Capacity (FRC): is the volume of gas in the lungs at the end of normal expiration. The functional residual capacity is comprised of the expiratory reserve volume and the residual volume.
   a. Expiratory reserve volume: is the amount of air that can be expelled with maximal expiratory effort.
   b. The residual volume: is the volume of air in the lungs after maximal expiration ***(Reynolds, 2004)***.
3. Tidal Volume (TV): is the volume of gas in any normal breath; whereas Vital Capacity (VC) is the maximal