EXPLORING THE ANATOMY AND PHYSIOLOGY OF AGEING

PART 2 – THE RESPIRATORY SYSTEM

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This second article in our series on the effects of ageing explores the major anatomical and physiological changes that occur within the respiratory system.

The respiratory system has numerous functions. In addition to its major role in gaseous exchange, it is involved in regulating blood pH and controlling blood pressure, and plays an important role in the non-specific immune responses (Montague et al, 2005).

Every living cell in the body requires oxygen for cellular respiration and generates carbon dioxide as a waste product. Therefore an efficient respiratory system, allied with a healthy cardiovascular system, is essential for optimal cellular function and general health.

Unfortunately, the efficiency of the respiratory system progressively diminishes with advancing age – see below.

ANATOMICAL CHANGES

Changes to the chest wall
In early life, the chest wall is relatively supple and elastic. With age, there is a gradual increase in rib calcification, particularly in the anterior cartilaginous (costal) areas close to the sternum (Figs 2 and 3) and, to a lesser extent, in the areas where the ribs articulate with the vertebral column.

These changes lead to a progressive increase in the rigidity of the chest wall (Janssens et al, 1999). Several studies have also revealed a gradual age-related reduction in the strength of the respiratory muscles, which is thought to be primarily due to a loss of muscle mass (motor units) within the diaphragm and intercostals.

As a result of these changes, the process of breathing can become laboured. This may be particularly apparent in individuals who have led a sedentary lifestyle as this is known to promote muscle wastage and weakness.

Airway changes
The ciliary escalator is an important part of the mechanical non-specific immune defences, producing mucus which coats the inner surface of the bronchial tree and traps inhaled particles such as dust and bacteria.

Ciliated cells lift contaminated mucus away from the lungs. On arrival at the pharynx (throat), this mucus is swallowed and passes into the acidic sterilising environment of the stomach. Several studies have shown that the frequency at which cilia beat decreases with age, slowing down the ciliary escalator. There is also a gradual reduction in the number of cilia (Levitzky, 1984). These changes effectively reduce the clearance of pathogens and debris from the lungs, increasing the chance of infection.

In young people, the airways are extremely sensitive to mechanical stimulation. Inhaled debris will usually invoke a vigorous coughing reflex to dislodge and expel it. However, the sensory receptors that monitor the airways appear to become less sensitive with age, so a coughing reflex may not be initiated in response to inhaled material in older people. This increases the chances of pathogens and irritants reaching the deep lung tissues and causing respiratory tract infections.

The airways between the nose and the bronchioles are known as the conduction zone. The volume of these areas forms an anatomical dead space (where no gas exchange takes place). The cartilaginous rings holding open the upper airways gradually undergo calcification with age. This increases the diameter of the larger airways, particularly the trachea, and primary and secondary bronchi, causing a progressive increase in the volume of the anatomical dead space (Janssens et al, 1999).

Although the amount of elastin and collagen fibres within the lungs remains relatively constant, the lungs themselves gradually lose their elasticity and become more distensible (dilated). It is thought this is primarily due to changes in nature of the collagen and elastin fibres, which become cross-linked, progressively reducing the recoil of lung tissue (Levitzky, 1984).

Senile emphysema
As middle age approaches, the loss of elasticity within the lung tissue and airways leads to a progressive increase in the diameter of the respiratory bronchioles and alveolar ducts. This gathers up the alveoli, widening their structure and reducing their depth.

Gradually the alveoli begin to take on a flattened appearance, resulting in a reduction in the alveolar surface area. Individuals in their 90s will typically have lost around 25% of their alveolar surface area. Although this is not related to true emphysema (where the walls of the alveoli break down), the term senile emphysema is often used to describe these changes (Verbeken et al, 1992).

Changes in pulmonary circulation
The pressure within the pulmonary artery (wedge pressure) gradually increases in older people, even in the absence of any...
FUNCTIONAL CHANGES

The structural changes described above lead to changes in lung function. Some of these can be recorded via spirometry and other clinical techniques (Spirduso, 1995).

Lung volume changes

- Residual volume (RV) is the air remaining in the lungs following a full and forced expiration. It is normally around 1.2L at age 25 and gradually increases with age due to loss of lung elasticity. Less elastic lungs are more distensible and also have reduced recoil during expiration. This results in ‘air trapping’. A typical 70-year-old’s RV will have increased to around 1.8L.
- Vital capacity (VC) is the total volume of air that can be exhaled following a full inspiration. In an average male aged 25 this is around 5L, declining to around 3.9L at age 65. A similar decline is seen in females, from an average of around 3.5L at 25 to around 2.8L at 65 (Fig 1). These reductions in VC are primarily due to the gradual increase in chest wall rigidity and loss of respiratory muscle strength described above.
- Total lung capacity (TLC) is the total volume of air within the lungs following a full inspiration. In an average male it is around 6L and in an average female around 4.2L. The TLC does not change significantly throughout life. It has been hypothesised that this is because the reduction in lung elasticity is counterbalanced by the increased rigidity of the chest wall.
- Tidal volume (TV) is the amount of air exchanged during normal breathing. It is typically around 500ml and in the absence of pathology, does not change significantly with age. But, because of increased chest wall rigidity and reduction in lung elasticity, it is estimated a 60-year-old will expend 20% more energy during normal breathing than a 20-year-old (Janssens et al, 1999).

As with the cardiovascular system, taking regular exercise is essential to help maintain a healthy respiratory system. In the absence of pathology, the respiratory system remains capable of maintaining adequate gas exchange and carrying out its other functions throughout our life.

REFERENCES


NEXT WEEK

The physiology of ageing: the digestive system