

The physiology of mucus and sputum production in the respiratory system

The main function of the respiratory system is to draw air into the lungs to allow the exchange of gases with blood circulating to the lungs. This blood supplies the cells of the body with oxygen and removes the waste products of metabolism. Tissues of the respiratory tract are thin and delicate, and become thinnest at the surfaces of the aveoli, where gaseous exchange occurs. The body has a number of mechanisms which protect these tissues and ensure that debris and bacteria do not reach them.

Tiny hairs called cilia trap large pieces of debris and waft them out of the airways; the reflexes of sneezing and coughing help to expel particles from the respiratory system and the production of mucus keeps the tissues moist and helps to trap small particles of foreign matter.

Mucus production in the airways is normal. Without it, airways become dry and malfunction. But sometimes the mucus is produced in excess and changes in nature. This results in the urge to cough and expectorate this mucus as sputum. Sputum expectoration is not normal and there is always an underlying pathological cause.

Mucus Mucus is secreted from two distinct areas within the lung tissue. In the surface epithelium, which is part of the tissue lining of the airways, there are mucus-producing cells called goblet cells. The connective tissue layer beneath the mucosal epithelium contains seromucous glands which also produce mucus.

The respiratory tract produce about two litres of mucus a day from these glands (Martini, 2003), and this is composed of water, carbohydrates, proteins and lipids. The high water content helps to humidify the passing inspired air. Mucus contains glycoproteins (or mucins) as well as proteins derived from plasma, and products of cell death such as DNA.

Mucus is sticky and this helps to trap dust particles, bacteria and other inhaled debris. Mucus also contains natural antibiotics, which help to destroy bacteria – the epithelial cells secrete a substance called defensin. Mucus also contains lysozyme, which is an antibacterial enzyme.

Movement of mucus Cilia in the nose move the mucus formed there towards the throat where it is swallowed and digested in the stomach. In cold weather, this process slows and the mucus sometimes gathers in the nose and drips or dribbles out – a winter runny nose.

Particles larger than 4mm in diameter usually become trapped in mucus in the nose and rarely get any further down the airways. The nasal mucosa has many sensory

nerve endings and large particles irritate these nerves, stimulating a sneeze – a violent burst of air – which expels the particles along with mucus.

Further down the airways, cilia in the trachea and bronchi also waft the mucus towards the pharynx to be swallowed. This movement, against the force of gravity, is sometimes called the mucus escalator. Normally, this upward movement is not noticeable, except when we clear our throats. However, if larger quantities of mucus build up, the cough receptors may be stimulated and air and mucus will be forcibly expelled from the trachea.

Moving down the airway, the mucosal epithelium gets thinner and changes in nature. There are only a few cilia and no mucus-producing cells in the bronchioles, so any airborne debris is removed by macrophages in the aveoli or coughed out.

Sputum production Irritation of the respiratory system causes both inflammation of the air passages and a notable increase in mucus secretion. A person may become conscious of swallowing the mucus or the inflammation may trigger a coughing reflex so that they expectorate these secretions as sputum.

It seems that the inflammation of the mucosa is responsible for sputum production rather than any of the other changes that occur in diseased lung tissue (Jeffrey & Zhu, 2002; Maestrelli et al, 2001).

Expectorated sputum contains lower respiratory tract secretions, as well as secretions from the nose, mouth and pharynx, and cellular debris and micro-organisms (Rubin, 2002). In some disease processes, the sputum changes in nature and colour.

Airway disease and sputum Sputum production is associated with many lung disease processes and sputum may become infected, stained with blood or contain abnormal cells.

Smoking Smoking has many effects on the airways. Inhaled smoke destroys the cilia that are important for moving mucus to the throat for swallowing. As a result, mucus accumulates in the bronchioles and irritates the sensitive tissues there, causing a cough. Coughing is vital as it is the only way smokers can remove mucus from their lungs and keep the airways clean (Rubin, 2002). This is characterised by the ‘smoker’s cough’.

Constant coughing to clear the sputum has an effect on the smooth muscle of the bronchioles which becomes hypertrophied (enlarged or overgrown). This in turn causes more mucus glands to develop.

Smoking also causes hyperplasia (excessive cell division and growth) of the mucus-producing goblet

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Marion Richardson explains the physiology of mucus production in the respiratory system and factors that lead to overproduction and expectoration. A number of diseases that lead to sputum production are reviewed

KEY WORDS

Mucus
Sputum
Respiratory tract

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cells (Maestrelli et al, 2001). Because of the constant irritation, more mucus is produced and collects in the alveoli, which can become overburdened and collapse.

Another effect of smoking is the development of emphysema when the alveoli expand, the capillary blood supply deteriorates and gaseous exchange is reduced. Smoking makes other lung diseases worse and is a major cause of lung, and many other, cancers.

Smoking cessation improves lung health – bronchial tubes relax and the work of breathing becomes easier, and cilia begin to regrow within a few months, so mucus and debris can be cleared without the need for constant coughing. Also, the risk of cancers reduces over time.

Bronchitis Bronchitis is an inflammation of the bronchial lining. It is commonly related to cigarette smoking but is also triggered by environmental irritants such as chemical vapours, exhaust fumes or pesticides. In response to the inflammation, excess mucus is produced. This can block the small airways and reduce respiratory efficiency, for example, in chronic airways obstruction. Over-production of mucus leads to frequent coughing, which further irritates the tissues and causes even more mucus production.

Chronic obstructive pulmonary disease A pattern of persistent respiratory symptoms (chronic bronchitis, chronic airway obstruction and emphysema) is termed chronic obstructive pulmonary disease (COPD). Most patients with COPD show the characteristics of mucus hypersecretion in the airways in the following ways:

- The production of sputum;
- Increased mucus in the lumen of the airways;
- Hypertrophy of submucosal mucus-producing glands;
- Goblet cell hyperplasia.

The mucus hypersecretion leads to impaired gas exchange and reduced mucociliary clearance, encouraging bacterial colonisation and exacerbations of the disease (Rogers, 2001). Mucus hypersecretion may contribute to morbidity in these patients.

Asthma (acute obstructive airways disease) Some people's airways are sensitive to allergens such as drugs, environmental pollution or bacteria, and this causes mast cells in their tissues to burst and release histamine and prostaglandin.

In response, the mucosa of the airways becomes swollen and oedematous, and mucus production increases in an attempt to rid the body of the allergen. Smooth muscle constricts, particularly around the terminal bronchioles, and breathing becomes difficult. Mucus transport slows and fluids accumulate in the air passages.

This hypersecretion of mucus is an important cause of illness and death in patients with asthma. No specific treatments for it are available (Fahy, 2002). The number of goblet cells increases and the patient stores and secretes more mucin, which makes the sputum thick and sticky. Asthma can be fatal, and death is usually caused by blockage of the narrow airways with a plug of sputum.

Cystic fibrosis Cystic fibrosis is a lethal disease which is inherited and affects Caucasians of north European descent. A defective gene located on chromosome 7 means a protein called a cystic fibrosis transmembrane regulator, responsible for the active transport of chloride ions within cells, does not function normally.

This protein is abundant in cells that produce watery secretions such as mucus. The abnormality means that secretory cells cannot transport salts and water efficiently, and secretions become thick. This affects the mucus glands in the respiratory tract and secretory glands in the gastro-intestinal tract.

In the respiratory tract, the hyperviscous, sticky mucus adheres to the airways and cannot be transported properly – the mucus escalator stops working and mucus plugs block the smaller airways. Breathing becomes difficult and problems with transporting mucus may lead to bacterial colonisation.

The average life expectancy of people with cystic fibrosis in the UK is 31 years (National Services Division, 2002). People with cystic fibrosis die from chronic recurrent bacterial infections of the lungs and associated heart failure.

Sputum assessment Sputum can provide a number of clues about a patient's health. It is difficult to assess the amount of sputum produced in a day (Law, 2000) but there are many terms to describe it – mucoid, purulent, mucopurulent, frothy, viscous or bloodstained.

Mucus colour also varies considerably from white or opaque to grey, orange, green, brown or, occasionally, black. Yellow, orange or green sputum is commonly associated with bacterial infection. The more neutrophils that are present in sputum, the greener it becomes and patients may require treatment with antibiotics.

However, people with asthma often have neutrophils in their sputum – the sputum may be coloured but is free from infection. Red sputum indicates the presence of blood and may suggest tuberculosis or cancer.

Conclusion Sputum is produced when lungs are damaged or diseased and can give nurses important information about the patient and his or her illness. ■