Teva
Diseases of the Lungs

Lung Diseases
The lungs are a pair of organs located in the thoracic cavity. Their primary function is gaseous exchange, i.e. to get oxygen into and carbon dioxide out of the blood. Air is drawn in through the nose where it is filtered by hairs and mucus to remove dust, bacteria and viruses. As it passes through the nasal sinuses it is also warmed. The surface of the airways is covered by mucus producing cells which trap anything that has not been filtered by the nose. Cilia [small hair like projections] waft the mucus up out of the lungs to the pharynx where it is normally swallowed. Any micro-organisms it contains are killed by the acid conditions in the stomach. About 1.5 litres of mucus are produced daily. Anything that reduces the movement of air into or out of the lungs reduces the availability of oxygen to the body, with a resulting decrease in energy due to a decrease in respiration.

1. Asthma
Asthma is a chronic inflammation of the bronchi causing the airways to narrow. Asthma is caused by a combination of environmental and genetic factors. The Asthma Society of Ireland estimates that there are about 500,000 people in Ireland who suffer from asthma.

People with asthma have difficulty breathing, because their airways are inflamed and become narrowed. Normally, air moves smoothly into the alveoli as a person breathes in. In a person with asthma, inhaling is not a problem as incoming air can slide past the blockage because the expansion of lung tissue during inhalation makes the airways expand. The problem comes when the person tries to exhale. The air can no longer get past the blockage, and it remains trapped in the lungs. The person can then only take shallow breaths.

Irritation of the airways can be caused by the presence of allergens such as pollen, dust mites, pet dander and atmospheric pollutants such as sulphur dioxide and oxides of nitrogen. This condition has a very rapid onset, within 10 minutes in many cases, and may last for up to a day after exposure has ceased. The presence of these allergens triggers an immune response within the airways causing the release of histamines, interleukin, T cells and B cells.

2. Exercise Induced Bronchoconstriction [EIB]
EIB, often wrongly referred to as Exercise Induced Asthma, is caused by the inhalation of large volumes of cool, dry air during strenuous exercise. It is a common abnormal reaction which quickly follows the initial bronchodilation that is brought on by exercise. It is usually at its worst within fifteen minutes of starting the exercise and normally resolves itself within the hour. This is a result of a reaction similar to the allergic response described above. Repeat of exercise within a few hours of the original exercise will often result in a less severe episode due to the release of prostaglandins. Up to twenty percent of the general population are affected but this can rise to eighty percent in those with symptomatic asthma.

Bronchodilation, as the name suggests, is the widening of the bronchi when the smooth muscle surrounding the bronchi relaxes, allowing easier movement of air into and out of the lungs. This is brought on naturally by exercise or by the production of adrenalin the “fight of flight hormone”, noradrenalin has a similar effect.

Bronchoconstriction, on the other hand, is the narrowing of the bronchi in the lungs due to any or all of the following: the contraction of surrounding smooth [involuntary] muscle or an accumulation of thick, difficult to expel mucus, which effectively blocks the bronchial tubes or inflammation of the bronchial tissue.

There are several common causes of bronchoconstriction, some of these are endogenous [originating inside the body] e.g. stress and genetic factors while others are exogenous [originating outside the body] e.g. allergens such as dust and irritants such as sulphites.
3. Bronchitis

Bronchitis most commonly occurs in the winter and is an inflammation of the bronchioles, and bronchi in the acute form of the disease, commonly caused by a viral [~90%] or bacterial [~10%] infection, but can also be caused by the inhalation of lung irritants such as tobacco smoke. The mucous membranes surrounding these airways become irritated and swollen. The swelling causes effective bronchoconstriction and symptoms similar to asthma. The irritation can also cause fluid leakage and the production of excess mucus, especially if the smaller bronchioles are affected. Coughing, a reflex action, to clear these excess secretions can be persistent and may lead to painful rib and stomach muscles.

4. Emphysema

Emphysema is perhaps the most serious condition. In this case the shortness of breath is caused by narrowing of the airways by a layer of thick mucus which is very sticky and difficult to dislodge rather than by the contraction of smooth muscle. It is most commonly caused by smoking and is effectively incurable. It is imperative that anyone suffering from this stops smoking if there is to be any improvement in the condition in response to treatment.

Treatments

1. Steroids

Steroids, or more correctly corticosteroids, are man-made drugs that resemble cortisol a substance made naturally by the adrenal glands. These chemicals suppress the body’s immune response and therefore can reduce the inflammation that causes bronchoconstriction, thus resulting in the relief of symptoms in those forms of asthma caused by allergens and irritants as well as exercise induce bronchoconstriction. These steroids should not be confused with the anabolic steroids used by athletes.

2. Mucolytics

Mucolytics are mucus thinning agents [e.g. guaifenesin] are also called expectorants and can be used for those suffering from emphysema to help them expel mucus from their lungs and thus improve the quality of life of sufferers.

3. Anticholinergics

Anticholinergics are substances that suppress the action of acetylcholine by blocking acetylcholine receptors thus preventing contraction of the smooth muscle surrounding the bronchioles. This results in the dilation of bronchioles which makes it easier for the person to breath. These substances can be administered orally [swallowed] or using an inhaler.

Administration of the dose

Pressurised metered dose inhalers (pMDIs) which have been used since the 1950’s require coordination between the press and the inhalation of the dose – not easy for paediatric and geriatric groups. Breath activated inhalers solved most of this problem. The introduction of dry powder inhalers (DPIs) improve things even more because they do not need patient coordination and they removed the need for a carrier making them even safer.

Bronchodilators may be classed according to the speed with which they produce their effect.

Reliever Medication: These short acting medications provide rapid relief from symptoms and are sometimes referred to as “rescue medications”. These are typically inhaled using a nebuliser or an inhalation aerosol and provide quick relief by causing immediate bronchodilation by muscle relaxation within 20 minutes, and last for several hours. They do not reduce swelling.

Preventer Medication: These long acting medications can either be oral or inhaled, and they need to be taken on a routine basis, usually morning and evening. They do not provide immediate relief as their effects build up over time, but once established are effective in inducing sustained bronchodilation. Swelling and inflammation as well as sensitivity to allergens and irritants are all reduced.
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Teaching Notes

Syllabus References
The relevant syllabus references are:

Junior Certificate Science
(OB12) … describe how oxygen is taken into the bloodstream from the lungs and how carbon dioxide is taken into the lungs from the bloodstream during gaseous exchange and how these processes are affected by smoking.

Leaving Certificate Biology
3.4.4 The Breathing System in the Human
• Macrostructure and basic function of the breathing tract in humans.
• Essential features of the alveoli and capillaries as surfaces over which gas exchange takes place.
• Breathing disorders: one example of a breathing disorder, from the following: asthma and bronchitis; one possible cause, prevention, and treatment.

3.5.3 Responses in the Human
Specific defence system (immune system): antigen antibody response.
H.3.5.7 Human Immune System
Role of lymphocytes: B and T cell types. Role of B cells in antibody production. Role of T cells as helpers, killers, suppressors, and memory T cells.

Learning Outcomes
On completion of this lesson, students should be able to understand and discuss:
• The basic structures of the breathing system.
• The effects of bronchoconstriction and bronchodilation on breathing.
• What asthma is, its symptoms and its causes.
• What exercise induced asthma is, its causes and its effects.
• What bronchitis is, its causes and its effects.
• What emphysema is, its causes and its effects.
• The various treatments of the above ailments.
• What bronchodilators are and their effects.
• What steroids are and their effects.
• What mucolytics are and their effects.

General Learning Points
The following points can be used to review the lesson content and to inform discussion.
• Epinephrine is the old name for adrenalin and it had many medical uses including stopping bleeding during surgery and during boxing matches, increasing hear rate and blood pressure; it also found uses in obstetric and anaesthesiology.
• Jockici Takamine was a very famous and rich man, receiving honours and gifts from the Emperor of Japan. He was not in fact the man who isolated adrenalin but he filed the patent application and therefore owned the name. He was involved in a very famous legal case but was never mentioned.
• The administration of a dose of medicine to the lungs in such a way that it is evenly distributed to all parts of the lungs is not an easy matter. How does one stop most of it landing on the first few centimetres of the bronchioles? How does on overcome the lack of co-ordination, especially in children and old people, who may not may not be able to press the button of the inhaler and breath in at the same time?
• Lack of exposure to allergens when very young can lead to the body over-reacting to exposure to these and other allergens later in life.
Student Activities

- Investigate the use of peak flow meters and other devices to investigate lung function and the effects of asthma and other respiratory diseases.
- Investigate lung volumes and how they vary with lifestyle, and location.
- At your local chemist shop look at cough bottles to see how many contain expectorants and find out what type of cough they are used to treat.
- Some people claim that the huge increase in asthma in Ireland is linked to the increased cleanliness of our surroundings. Is there any validity in this statement?
- Investigate the causes of asthma and the limitation it imposes on the lifestyle of those affected.
- Find out the difference between corticosteroids and anabolic steroids.

True/False Questions

a) Emphysema is a curable disease.
b) The nasal sinuses warm and filter air entering the lungs.
c) Bronchoconstriction is a narrowing of the airways.
d) Asthma is a chronic disease.
e) Exercise does not cause asthma.
f) Only smokers suffer from bronchitis.
g) Preventer medication is short acting and need only be taken once.
h) Mucolytics make it easier to expel mucus from the lungs.
i) Steroids suppress the body’s immune system.
j) Inhalers are a very recent development in administering drugs.

Examination Questions

Junior Certificate Higher Level 2006 Q 2

a) The diagram shows the structure of a human lung. Air passes in and out of the lungs, via the trachea, bronchi and bronchioles. Gaseous exchange takes place in the structures labelled A.
   (i) Name structure A.
   (ii) How does gaseous exchange take place in the structures labelled A?

Leaving Certificate Biology (HL) 2007 Q 3 (c)

(i) Give three ways in which the alveolus is adapted for efficient gas exchange.
(ii) Name the process involved in the passage of gas between the alveolus and the blood.
(iii) Name a breathing disorder and state:
   1. a cause
   2. a means of prevention and
   3. a treatment

Leaving Certificate Biology (HL) 2009 Q 13 (c)

The diagram shows microscopic detail from a human lung.

(i) Name the parts labelled A, B and C.
(ii) Give two features of the structures in the diagram that allow for efficient gas exchange.
(iv) Which gas, dissolved in the blood, can trigger deeper or faster breathing?
Did You Know?

- Ireland has the fourth highest prevalence of asthma in the world.
- The prevalence of asthma in young teenagers has increased by 40% or more since 1995.
- About 1 person in eight is affected by asthma.
- The volume of air you breathe in and out at rest is called the tidal volume and is usually about half a litre.
- Even when you breathe out fully there is still about a litre of air in your lungs.
- Smokers have smaller lung volumes than non-smokers.
- People living at high altitudes have greater lung volumes.
- The surface area of your lungs is around 70 m².
- You breathe between 10 – 20 times per minute at rest.
- An adult will breathe about 10000 litres of air per day.
- The fitter you are the slower you tend to breathe.

Biographical Notes

Jokichi Takamine

Asthma which is derived from a Greek word meaning "sharp breath" was mentioned in the Iliad so it was not really discovered. However Jokichi Takamine who was born in Takaoka, Japan in November 1854 gave us the first effective bronchodilator treatment for it. His father was a doctor and his mother came from a family of sake brewers. He graduated from the University of Tokyo in 1879 and then did postgraduate work in the University of Glasgow before returning to Japan to work for the Department of Agriculture. From there he went to the United States where he isolated a pure form of epinephrine which he called Adrenalin. It has since been replace by other substances because it had serious side effects, e.g. it raised blood pressure.

Revise the Terms

Can you recall the meaning of the following terms? Reviewing terminology is a powerful aid to recall and retention.

adrenalin; allergens; anticholinergics; asthma bronchitis; bronchodilation; bronchodilators; bronchoconstriction; chronic; cilia; emphysema; endogenous; exhale; exogenous; expectorants; gaseous exchange; immune response; inhale; mucolytics; mucus; nasal sinuses; noradrenalin; pollutants; preventer medication; reliever medication; smooth muscle; steroids; thoracic cavity.

Check the Glossary of Terms for this lesson on www.sta.ie