Case Study 5

Ayesha has been asthmatic since childhood. She is now 20 years old and otherwise healthy. Her asthma is normally well controlled and she understands how to use the inhalers prescribed by her doctor. However, she has caught a bad cold, which has made her asthma worse.

Discussion Questions

1. Compare the structures of a healthy and an asthmatic bronchiole.

2. The trachea is the main airway bringing air into the lungs, but asthma mainly affects smaller bronchioles. Compare and contrast the structural differences between the trachea and a bronchiole, to explain why this is the case.

3. People with asthma use a peak flow meter to monitor their disease. Explain what a peak flow meter measures, and the changes that occur during an acute exacerbation.

4. Ayesha suffers a sudden worsening of her condition. Her peak flow readings are a third of normal and she is struggling to breathe. Which additional accessory muscles is she using to:
   a. Inhale
   b. Exhale?

5. At hospital, Ayesha's pCO₂ is found to be elevated as a consequence of her impaired respiration. Explain the role of pCO₂ in the regulation of breathing.
Answers

1. Compared to normal, the smooth muscle in an asthmatic bronchiole is hyperreactive and constricts in response to a variety of stimuli (e.g. cold air, pollen, etc.) that would not normally trigger bronchoconstriction. The airway wall is swollen and inflamed with an accumulation of inflammatory cells and a disproportionately high number of eosinophils. The endothelium is damaged and there is increased mucus production from hyperactive goblet cells. The lumen of the airway is reduced by these inflammatory changes and airflow can be severely compromised.

2. The trachea has a wide lumen, contains little smooth muscle, and is held permanently open by incomplete cartilage rings. Small bronchioles have a much higher proportion of smooth muscle in their walls, and lack the supporting cartilage, so are easily blocked by bronchoconstriction.

3. Peak flow meters measure the speed of airflow (in litres/min). Normal airways offer little resistance to airflow but in asthma the narrowed airways limit airflow and peak flow is consequently reduced. When asthma is well controlled, peak flow readings are stable and often normal/close to normal, but in exacerbations the readings can fall quite suddenly and significantly, indicating serious airflow obstruction.

4. Accessory muscles of inspiration include the scalene, the pectoralis minor and the sternocleidomastoid muscles. Accessory muscles of expiration include the internal intercostals and the abdominal muscles.

5. CO₂ is combined with water in the bloodstream to make a bicarbonate ion and a hydrogen ion. The hydrogen ion decreases pH of body fluids (i.e. makes them more acidic). The regulatory mechanisms controlling breathing are very sensitive to even slight increases in hydrogen ion concentrations, so even a slight accumulation of CO₂ stimulates respiration to excrete it. Chemoreceptors on the surface of the medulla in the brain and in the aorta and the carotid arteries constantly monitor hydrogen ion levels and regulate respiratory effort accordingly.