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Case Study 2 Report

Asthma in Adolescents: Respiratory Physiology, Monitoring and Lifestyle Management

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Introduction

Asthma is a long-term, heterogeneous condition of the airways where inflammation and variable narrowing of the bronchi result in symptoms like wheeze, cough, chest tightness and breathlessness. It is clinically significant during adolescence because young people can continue to have childhood asthma but lack the support and supervision, they need to take preventer tablets and may have less time for social interaction and more time to engage in risky behaviour that leads to decrease in adherence to preventer therapy and more exposure to triggers. Asthma is not just “difficulty breathing” but an airway structure and function disorder, in which airways are hyperreactive to external stimuli and the airways' functional capacity to expel air during exacerbations is reduced (Porsbjerg et al., 2023). Previous wheezing, allergic sensitisation, family history, air pollution, tobacco smoke, respiratory infections, obesity and occupational and environmental irritants are the risk factors (Stern et al., 2020). Adolescent education, therefore, should link normal respiratory physiology with the need for symptoms, regular monitoring and lifestyle modification in a GP asthma clinic. Rather than making young people afraid of asthma, it is intended that they will become aware of how their options, surroundings, and data patterns impact their airways prior to an exacerbation of asthma becoming an emergency.

Structure of the Respiratory System and Mechanical Respiration

The respiratory system can be subdivided into conducting zone and respiratory zone. Nose, nasal cavity, pharynx, larynx, trachea, bronchi and bronchioles are part of the conducting zone. They warm, moisten and filter inhaled air, ciliated epithelium and mucus remove particles and microorganisms. The respiratory zone consists of respiratory bronchioles, alveolar ducts and alveoli where the lungs have air very close to the pulmonary capillary blood. Trachea branches into right and left primary bronchi, which then divide into smaller bronchioles. In asthma, these tiny airways are particularly significant since a tiny narrowing of their inside diameter creates a massive boost in air resistance.

Mechanical respiration is defined as the movement of air into and out of the lungs (ventilation). During quiet inspiration, the diaphragm contracts, thus flattening it, and the external intercostal muscles elevate the ribs. This causes an increase in thoracic volume, a decrease in intrapulmonary pressure below atmospheric pressure, and the air is drawn into the lungs. In quiet expiration the diaphragm relaxes, elastic recoil decreases thoracic volume, and air is expelled from the lungs. The internal intercostal muscles and abdominal muscles are also used with forced expiration, which occurs during exercise or during an asthma attack. Airway resistance, lung compliance, and chest wall motion are all essential to respiratory mechanics, and this is why air in the lungs, but narrowed airways make breathing difficult (Gertler, 2021). Wheeze occurs when air is forced out of narrowed and inflamed airways, mainly during expiration, in adolescents with asthma.

Gas Exchange in the Lungs

The exchange of gases takes place at the alveolar-capillary membrane. Alveoli are tiny air sacs with a very large surface area, thin type I epithelial cells, surfactant-producing type II cells and an extensive capillary network. There is movement of oxygen from alveolar air to blood because PAO_2 is greater than PO_2 of venous blood. Oxygen is then largely carried bound to haemoglobin within red blood cells to be delivered to tissues for aerobic respiration. CO_2 is transported in the opposite direction because the partial pressure of carbon dioxide will be greater in venous blood than in alveolar air. The majority of carbon dioxide is transported in plasma as bicarbonate, which will then be converted to carbon dioxide in the lungs, where it will be able to diffuse into alveoli and then be expelled from the lungs (Cummins et al., 2020). The airways must be open, the alveoli must be well ventilated, the pulmonary blood flow must be good, and the distance for diffusion must be short.

Asthma may interfere with this process but not necessarily injure all alveoli. Bronchioles constriction leads to build up of mucous secretions and swelling of the airway walls, resulting in uneven air distribution. Some alveoli receive less fresh air, hence less oxygen diffusing into blood. Maintenance of carbon dioxide will typically be maintained initially due to its ease of diffusion, and a degree of hyperventilation may occur in adolescents, but if severe may cause fatigue, hypercapnia and respiratory failure. This is why it is important to have urgent medical assessment if symptoms of breathlessness deteriorate, if it is difficult to complete sentences, if the child develops a blue-colored appearance (cyanosis), or if they become sleepy or unresponsive to reliever medication.

Irritants, Airway Swelling and Effects on Respiration

Asthmatic airways are "hyper responsive". The airway epithelium is not simply a passive lining of the airways, it also produces signals to recruit and activate immune cells and to drive inflammation when it is exposed to irritants, allergens and infectious particles. Type 2 inflammatory pathways are associated with mast cells, eosinophils, airway wall oedema and mucus secretion, as well as a contraction of the bronchial smooth muscle (Hammad & Lambrecht, 2021). Asthma can also be characterized by varying inflammatory patterns, meaning that the triggers or response to treatment are not identical for all people with asthma (Habib et al., 2022). The result is the same: the airway becomes narrow, air eases out more slowly and the individual must expend more effort to get the air out.

Smoking and vaping are significant issues during the adolescent period. Cigarette smoke includes particulate matter and toxic gases that cause inflammation and irritation of the lining of the airways, which causes more mucus to be produced and exacerbates inflammatory responses. There is also evidence of second-hand smoke effects on childhood asthma and wheeze, and adolescents should

be shielded from second-hand smoke in the home, car, and social areas (He et al., 2020). Vaping is not a harmless alternative, as e-cigarette aerosols may contain fine particles which irritate airways, flavouring chemicals and nicotine. A large study among adolescents and young adults was found to be associated with negative respiratory health outcomes with e-cigarette use (Chaffee et al., 2021). A systematic review also revealed that exposure to e-cigarettes was associated with asthma among adolescents, but that this finding was based on observational data and cannot be used to establish causality for each individual case (Li et al., 2022). This uncertainty should be communicated in an honest manner, but no justification for unnecessary respiratory risks.

Frequent large crowds in bars or clubs can exacerbate asthma in several ways. They can be smoke and/or vapour exposure, poor ventilation, perfumes, cleaning chemicals and high concentration of respiratory viruses. Viral infections are important asthma triggers as they damage the airway epithelium and stimulate airway inflammation (Jartti et al., 2020). Respiratory management is not just about managing asthma but also about preventing infections, with airway epithelial immunity playing a key role in the interplay between viral infection and asthma (Kim 2022). These various factors can all be present at a “night out” for an adolescent: vaping exposure, cold air outside of venues, shouting, poor judgement, forgetting inhalers and close contact with infected individuals.

Recording and Tracking Respiratory Function

Regular respiratory data assists adolescents to transition from acute to planned self-management. The highest flow a person can breathe out after taking full breath is called peak expiratory flow. Does not replace clinical assessment or spirometry but can demonstrate changes in the airways on a day-to-day basis when compared to the person's best stable reading. Both symptom monitoring and peak expiratory flow monitoring are useful, since these can help to inform appropriate self-management actions and clinical decisions at the right time, provided they are properly and honestly recorded and the technique is correct (Rhee & Katchamat, 2025). Adolescents should learn to stand or sit up straight, reset the meter, take a deep breath and exhale as vigorously as they can, followed by a seal of their lips around the mouthpiece, typically taking the best of three attempts.

Usefulness of tracking in that a decrease in peak flow may precede severe symptoms. A personalised asthma action plan may include the use of green, amber and red zones with agreed actions, such as continuing preventer therapy, increased monitoring, use of reliever treatment or seeking urgent help, depending on the patient's best reading. Self-management support has been shown to decrease health service utilization and enhance quality of life for people with asthma who are provided with regular review rather than simply being given a one-off explanation (Hodkinson et al., 2020). Now, guideline updates support the idea that managing the treatment should not only be based on acute reliever use, but should also involve assessment of control, shared decision-making and treatment

adjustment. (Cloutier et al., 2020) Standard information like peak flow, waking at night, reliever usage, missing school or work, limiting exercise, and history of exacerbation can be used to determine poor control in the GP clinic. This also helps to make prescribing safer decisions such as checking the technique of the inhaler, adherence and whether preventer treatment should be stepped up or stepped down. If adolescents believe that their negative data is an indictment of them, they may try to conceal bad control; data should not be discussed negatively. A collaborative review can help uncover barriers that may include embarrassment over inhaler use, forgetting to take inhaler doses, cost, not understanding how to use inhalers, or fear of side effects.

Evidence-Based Lifestyle Recommendations

Lifestyle advice should be realistic, youth oriented and should be related to physiology. Adolescents should never smoke, vape or breathe in second-hand smoke, as these exacerbate asthma-induced airway inflammation. Smokers should be explicitly asked about vaping in a non-judgemental way as adolescents may not consider it to be smoking; and asthma education needs to make it clear that vaping could lead to cough, wheeze and breathlessness in susceptible young people (Chatziparasidis & Kantar, 2022). Secondly, patients should be seen to have a written asthma action plan, understand the difference between preventer and reliever inhalers and demonstrate inhaler technique at every review. When medication is given, but it is not given correctly, the medication will not help control the disease, even if it is the correct one.

Third, exercise is to be encouraged and not avoided. Exercising on a regular basis can enhance cardiorespiratory fitness, self-confidence and quality of life if the asthma is controlled and the young person adheres to their asthma action plan, which outlines what to do if they experience symptoms during exercise (Privitera & Privitera, 2023). Sensible precautions are to warm up, carry an inhaler for use in case of a worsening of symptoms, avoid very cold air if possible, and stop if symptoms worsen. Fourth, General health behaviours are important. Balanced nutrition, weight control (if necessary), sufficient sleep and reduced exposure to indoor pollutants are aspects of lifestyle management that can help to support respiratory health but should complement and not supplant appropriate pharmacologic therapy (Born et al., 2024). Lastly, for those attending densely populated areas, it's important for them to have their inhaler with them, find the smoking/vaping areas and seek early help if they are using their inhaler more frequently.

Conclusion

Adolescent asthma is most successfully viewed as a disease where airway inflammation, bronchial hyper-responsiveness and excess mucus and constriction of airway smooth muscle leads to impaired normal ventilation and in severe exacerbations, impaired gas exchange. The respiratory system is

composed of a system of air passages that branches to alveoli that are used for the exchange of oxygen and carbon dioxide with the blood. Asthma makes this more difficult by causing the airways to become constricted, particularly when exposed to those triggers like smoke, vaping aerosols and viral infections. Routine data, especially peak expiratory flow along with symptoms and reliever use, enables adolescents to detect deterioration sooner and allows for safer clinical decisions in the GP clinic. Effective care should therefore include a combination of physiological education, regular monitoring, review of the techniques of using inhalers, a written action plan and practical advice on what lifestyle changes to make to avoid avoidable sources of irritant exposure and to support normal activity and independence.

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